



CNS



2019 SAN
FRANCISCO

MARCH 23 – 26, 2019



Cognitive Neuroscience Society

26th Annual Meeting, March 23-26, 2019
Hyatt Regency Hotel, San Francisco, California

Abstract Book Contents

Poster Session A.....	1
Poster Session B.....	34
Poster Session C.....	69
Poster Session D.....	104
Poster Session E.....	139
Poster Session F.....	174

A Supplement of the Journal of Cognitive Neuroscience
Cognitive Neuroscience Society
c/o Center for the Mind and Brain
267 Cousteau Place, Davis, CA 95616
ISSN 1096-8857 © CNS
www.cogneurosociety.org

Poster Session A

Saturday, March 23, 1:30–3:30 pm, Pacific Concourse

A1 Alerting, orienting, and executive control: post-stroke effects of attention abilities on speech comprehension

Arianna N. LaCroix¹, Corianne Rogalsky¹; ¹Arizona State University

Cognitive deficits often accompany language impairments post-stroke. Most past research has focused on working memory in aphasia, but attention is largely underexplored; to our knowledge no previous study has investigated auditory attention abilities in stroke patients. The present experiment explores the relationship between speech comprehension and three components of attention: alerting, orienting, and executive control, in 25 participants with left hemisphere stroke (all right-handed pre-stroke, native speakers of American English, and at least six-months post-stroke); participants' aphasia diagnoses were heterogeneous and ranged from mild to severe. Participants completed visual and auditory versions of the Attention Network Test to provide measures of alerting, orienting and executive control in each modality. Speech comprehension was measured using a sentence-picture matching task. Regressions indicate attention modality affects the relationship between the three types of attention and sentence comprehension. Orienting in the auditory modality predicted sentence comprehension; participants with faster reaction times due to orienting cues demonstrated higher sentence comprehension accuracy. Neither auditory alerting nor executive control predicted sentence comprehension. Alternatively, alerting and executive control in the visual modality predicted sentence comprehension; participants who benefited less from alerting cues and exhibited slower executive control abilities also had slower sentence comprehension reaction times. Orienting in the visual modality did not significantly predict sentence comprehension. These preliminary findings suggest that alerting, orienting, and executive control support sentence comprehension in dissociable ways, and that measures of auditory attention provide additional information beyond typical visual tests of attention regarding the cognitive resources available to support speech comprehension after stroke.

Topic Area: ATTENTION: Auditory

A2 Cognitive temporal map aids detection of future auditory events and modulates alpha oscillation

Xiangbin Teng¹, Matthias Grabenhorst¹, David Poeppel^{1,2}; ¹Max-Planck-Institute for Empirical Aesthetics, ²New York University

The brain capitalizes on temporal regularities of the environment to predict future events. How does the brain learn the temporal structure of sensory events and generate adaptive behavior? Inspired by the concept of the 'cognitive map' of spatial navigation, we hypothesize that the brain forms a cognitive map along the time axis and navigates mentally in time to prepare for future events. To test this hypothesis, 16 participants were presented with 2-seconds of noise whose onset served as a temporal landmark. Participants were asked to detect a tone which could appear at one of three temporal positions relative to noise onset while undergoing electroencephalography (EEG) recording. After training, participants showed improved performance in the detection task. The amplitude modulation of alpha oscillations indicated that the participants learned a temporal map representing the three possible temporal positions - when no tone was presented in the noise, the power of alpha oscillations waned right before each temporal position. In the following session, the participants learned to associate a visual cue with each of the three temporal positions and were asked to pay attention to the cued position. We found that participants could navigate their attention in time, which was reflected in the corresponding dynamics of alpha oscillations. Our results suggest that the brain forms a cognitive map of time and mentally travels along time to aid detection of future events.

Topic Area: ATTENTION: Auditory

A3 Perceived Speaker Size Drives the Laurel/Yanny Illusion

Psyche Loui^{1,2}, Melisa Olgun², Chris Lucas³; ¹Northeastern University, ²Wesleyan University, ³University of Edinburgh

The viral "Laurel vs. Yanny" illusion of Summer 2018 is a single audio recording of synthesized speech, which gives rise to an illusory percept. Although there are anecdotal reports that age, sex, musical training, and audio equipment used may affect the percept, it is unclear what differentiates those who consistently hear "Yanny" from those who hear "Laurel". Furthermore, while it has been shown that filtering and shifting the pitch of the original stimulus affects the percept (Graves et al, 2018), the switch point is unstable and prone to a hysteresis effect in which the percept depends on recent history. Here we ask whether the Laurel/Yanny percept depends on perceived speaker size (spectral centroid, SC, or fundamental frequency, F0) of the acoustic stimulus. We separately manipulated speaker size by varying spectral centroid and F0 of the original stimulus. Spectral changes elicited an abrupt perceptual switch where higher SC elicited the "Laurel" percept whereas lower SC elicited the "Yanny" percept. In contrast, F0 changes did not elicit a switch. Hysteresis effects were also observed for SC but not F0 changes. To test the neural substrates of this hysteresis effect, we conducted an EEG study (N=19) in which SC was gradually increased or decreased, and subjects indicated when they heard a perceptual switch. Gamma band activity increased during upward shift (from "Yanny" to "Laurel") and decreased during downward shift (from "Laurel" to "Yanny"). Results are consistent with a model of speech perception in which listeners must jointly infer speaker characteristics and word identity.

Topic Area: ATTENTION: Auditory

A4 Preliminary evidence of P3a response from unresponsive palliative patients

Lizzy Blundon¹, Lawrence Ward^{1,2}; ¹University of British Columbia, ²Brain Research Center

We present preliminary evidence of P3a response, but not P3b response, to salient, infrequent, auditory targets from a small sample of unresponsive Palliative care patients. We recorded EEG during an oddball task that featured sequences of identical tone patterns that differed only by a single feature. Using this same modified oddball task, Bekinschtein et al (2009) found that unresponsive TBI patients generated local MMN responses to salient auditory oddballs, but did not generate P300 responses to global auditory pattern changes. They did not investigate P300 subcomponent responses (P3a and P3b) in this unresponsive population. The P3a is observed in response to rare, salient, task-irrelevant oddballs, and may indicate exogenous attention orienting toward novel stimuli. The P3b is associated with target identification, and may reflect stimulus encoding mechanisms associated with context updating. We present data from 9 Palliative care participants, 8 of whom were recorded when they were responsive, and 5 when they were unresponsive. Among responsive palliative care patients we found preliminary evidence of P3a responses to salient auditory oddballs, and P3b responses to auditory pattern changes. Among unresponsive participants we only found P3a responses to salient auditory oddballs. Implications for consciousness assessment are discussed.

Topic Area: ATTENTION: Auditory

A5 Repeated Tactile Brain-Computer Interface Improves Behavioural Responses of Patients with Disorder of Consciousness

Ren Xu¹, Alexander Heilinger², Nensi Murovec², Rossella Spataro³, Woosang Cho², Fan Cao⁴, Christoph Guger^{1,2,4}; ¹Guger Technologies OG, Graz, Austria, ²g.tec medical engineering GmbH, Schiedlberg, Austria, ³ALS Clinical Research Center, BioNeC, University of Palermo, Palermo, Italy, ⁴g.tec neurotechnology USA, Inc.

The accurate diagnosis of Disorder of Consciousness (DOC) is a very challenging task. The Coma Recovery Scale Revised (CRS-R) is widely regarded as gold standard for behavioural assessments. Recently, an EEG based brain-computer interface (BCI) was developed for the assessment and communication for DOC patients, ranging from unresponsive wakefulness syndrome (UWS) to minimally conscious state (MCS). In this study, we repeated a tactile BCI paradigm on five DOC patients (2 MCS and 3 UWS), and attempted to investigate its influence on the level of consciousness. Each patient was evaluated with CRS-R before and after the intervention, which consisted of 10 consecutive tactile-BCI sessions within two weeks. Each session took around 1 hour, including 12 runs. EEG signals were recorded from eight channels (FCz, C3, Cz, C4, CP1, CPz, CP2, and Pz). Three tactile stimulators were placed on the right wrist, left wrist and right foot to provide target and non-target stimuli to the patients. The patients were asked to count for the target vibrations and ignore the non-target ones. A linear discriminant analysis was used to distinguish EEG features between target and non-target stimuli. A cross-validation resulted in a classification accuracy of 20±25% for the first run, and reached the maximal accuracy of 79±13% at the best condition. More importantly, the CRS-R improved in 2 out of the 5 patients, while it did not change in the other 3 patients. This study indicates a promising effect of a tactile BCI on the rehabilitation of DOC patients.

Topic Area: ATTENTION: Auditory

A6 Temporal foreknowledge enhances modulation of lateralized alpha oscillations during spatial attention

Malte Wöstmann¹, Burkhard Maess², Jonas Obleser¹; ¹Department of Psychology, University of Lübeck, Germany, ²Max-Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

Spatial attention induces lateralization of neural alpha oscillations (8–12 Hz): Alpha power increases versus decreases in the hemisphere ipsi- versus contra-lateral to attention, respectively. While the deployment of alpha lateralization in service of spatial attention is well-established, much less is known about human abilities to deploy alpha lateralization in time, and to thus exploit alpha power as a spatio-temporal filter. In a dichotic listening task, participants (N = 20) were simultaneously presented with five spoken numbers on either ear. Spatial attention was triggered by a tone presented on one ear to indicate whether numbers on the left or right side were to-be-attended. Temporal foreknowledge was provided by a visual cue in the beginning of each trial, which was either informative and indicated the to-be-probed number position (70% valid) or uninformative. Behavioral results show that participants used temporal foreknowledge to guide attention: Recognition of a number from the to-be-attended side was enhanced when this position was validly cued, compared to invalid and uninformative cues. In the magnetoencephalogram (MEG), spatial attention induced lateralization of alpha power in trials with both temporal cues. However, modulation of alpha lateralization in temporal synchrony with spoken numbers was stronger following informative compared to uninformative cues. Critically, we found that listeners increased their modulation of alpha power specifically around onsets of cued versus non-cued numbers. Results indicate that the deployment of spatial attention synchronizes with the stimulus and that temporal expectation of a task-relevant event increases the magnitude of synchronized alpha modulation.

Topic Area: ATTENTION: Auditory

A7 A Cellular and Attentional Network Approach to the Neuroscience of Consciousness

Gonzalo Munevar¹; ¹Lawrence Technological University

The purpose of this poster is to propose an approach to the neuroscience of consciousness based on the integrated results of cellular and network studies of attention. Consciousness occurs when, say, a sensory input activates an attention network to the point that the network successfully inhibits other, potentially competing, attention networks. This process can be observed, for example, in the integration of bottom-up salience and top-down selection in the intraparietal sulcus. At different levels, salience will depend on a context that may include not only goals but long-term episodic memories, intuitive cognition and a whole host of other brain functions and regions. Within that context, some brain phenomena will be experienced as being greatly relevant at that particular time, and command attention. The resulting attention network will include those brain functions and regions that contribute to the creation of the context. Studies show that, at the cellular level, neuromodulators such as acetylcholine, dopamine, noradrenaline and serotonin may lead to significant changes in cognitive function, including the contents of consciousness, for they may affect firing rates of both excitatory and inhibitory neurons. The results of Reynolds' experiments, for example, can be understood in terms of competing neuronal populations that often end in a "winner take all." Different modalities are less likely to so compete (e.g. watching a scene while listening to music). Affecting the variability of firing rates reduces noise and improves information, which is crucial to consciousness also. Claims of consciousness without attention involve mistaken interpretations of experiments.

Topic Area: ATTENTION: Other

A8 A technique for evaluating interest in dynamic stimuli using eye-fixation related brain potential.

Kohei Fuseda¹, Jun'ichi Katayama¹; ¹Department of Psychological Science, Kwansai Gakuin University

Interest is considered an emotion related to the attentional activity. The event-related brain potential (ERP) probe technique that measures the allocation attentional resource is an effective method to measure the level of interest in the dynamic stimuli such as videos. In this technique, the level of interest was indirectly evaluated by ERPs to probes, which could interrupt the ongoing task, even though it was task-irrelevant. Eye-fixation related brain potential (EFRP) is an ERP and is time-locked to the end of saccadic eye movement. To investigate whether EFRP can be used as a measure of the level of interest without probe stimuli, we measured the EFRP while participants watched the videos. Twelve men were presented with two video clips for each high and low attractive woman in random order. The electroencephalogram and electrooculography (EOG) signals were recorded while they were viewing the videos and the EFRP was extracted based on EOG signals. The lambda wave amplitude corresponding to P1 in visual ERP that reflects attentional processing was larger when a high attractive woman was observed. The amplitude of the late positive wave revealed the same pattern, whereas there was no observable difference between both videos in EOG activities. The results of the lambda wave and the late positive wave indicate a top-down modulation of attention and the modulation of the motivational attention by the attractiveness of the video, respectively. Therefore, EFRP is effective and can be used without probe stimuli to evaluate the level of interest in a dynamic stimulus.

Topic Area: ATTENTION: Other

A9 Individual differences in alpha lateralization and behavioral performance during probabilistic and fully instructional spatial-cueing attention task

Jiaqi Wang¹, Jianan Wang¹, Junfeng Sun¹, Shanbao Tong¹, Xiangfei Hong^{2,3}; ¹School of Biomedical Engineering and Med-X Research Institute, Shanghai Jiao Tong University, Shanghai, China, ²Shanghai Mental Health Center, Shanghai Jiao Tong University School of Medicine, Shanghai, China, ³J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida, Gainesville, FL, USA

The lateralization of alpha (8–13 Hz) band oscillations has become a canonical marker of visual spatial attention. However, very few studies have observed the relationship between cue-induced alpha lateralization and behavioral effects, which makes the functional significance of alpha oscillations elusive. The underlying reason might be related to individual differences in alpha lateralization as reported, and different cueing strategies further complicate this issue. In the present study, we recorded scalp electroencephalography in two spatial-cueing experiments to investigate the individual differences in alpha lateralization and its relationship with behavioral performance. A classical Posner paradigm with probabilistic cues (~74% valid) was applied in Experiment 1 (N=24), whereas a fully instructional spatial-cueing paradigm was applied in Experiment 2 (N=30). In both experiments, we found significant correlation between pre-cue baseline alpha-power and post-cue alpha lateralization. Furthermore, we equally divided the subjects into 2 sub-groups according to their baseline alpha-power, and found that only the sub-group with higher baseline alpha-power showed significant alpha lateralization. We then assessed the relationship between alpha lateralization and behavior at both between-subject and within-subject levels. The correlation analysis at the between-subject level revealed no significant findings in two experiments. At the within-subject level, however, alpha lateralization and behavior (detection rate) showed a significant positive relationship in Experiment 1, but only in the higher baseline sub-group. Taken together, our results clearly showed substantial individual differences in alpha lateralization, and such differences should be taken into account when investigating the relationship between alpha lateralization and behavioral effects in visual spatial attention.

Topic Area: ATTENTION: Spatial

A10 Prior knowledge of distractor cancels the effect of TMS over dorsolateral prefrontal cortex in visual search

Zhenlan Jin¹, Xuejin Ni¹, Ling Li¹; ¹University of Electronic Science and Technology of China

It has been showed prior knowledge of distractor facilitates visual search and dorsolateral prefrontal cortex (dlPFC) is one of the distractor-related brain areas. The present study aimed to test the role of the dlPFC during visual search when manipulating prior knowledge of distractor by using TMS technique. In the study, a white target and a distractor either in white or in isoluminant red or green (salient colors) appeared and subjects were required to identify the shape of the target. The location of the distractor was either informed at the beginning of the block (location-cued condition) or not (location-uncued condition). TMS was applied over the dlPFC and vertex while performing the search task. We found faster responses in the location-cued condition than in the location-uncued condition. Stimulating the dlPFC accelerated the search only in the location-uncued condition, but not in the location-cued condition. We argue that TMS reduced the distractor-related activation in the dlPFC when no prior information is provided, therefore producing faster search. Besides, we found decreased TMS effect with a salient distractor than with a white distractor, suggesting that the dlPFC activation was possibly increased due to attention capture by salient distractors. However, when the prior information of the distractor was provided, the dlPFC activation was possibly already decreased and no further modulation could be made by the TMS stimulation, resulting in no TMS effect. Taken together, we propose that the dlPFC contributes to distractor

processing and it might integrate all distractor-related information and reflect overall evaluation of distractor.

Topic Area: ATTENTION: Spatial

A11 Reorientation of Spatial Attention is Independent of the Visual Field's Meridians

Simon R. Steinkamp¹, Ralph Weidner¹, Simone Vessel^{1,2}, Gereon R. Fink^{1,3}; ¹Research Centre Jülich, Germany, ²University of Cologne, Germany, ³University Hospital Cologne, Germany

The visual system can shift attention to salient or important locations in space. Changing internal settings or the appearance of salient stimuli in other places requires the reorientation of attention to new locations. Lesions in the right parietal cortex may lead to an inability to orient or reorient attention to the left visual field. As other dimensions of the visual field are often unaffected, the orientation of attention along the horizontal meridian might be unique and depend upon distinct neural mechanisms. In the present study, we compared attentional reorienting along the horizontal meridian with attentional reorienting along the vertical meridian, by using functional magnetic resonance imaging in combination with a variant of Posner's task. Participants (n=27) performed an orientation discrimination task, where a pre-cue indicated the most likely target location with 80% validity. In two separate sessions, targets and cues appeared along the horizontal or the vertical meridian. Reorienting of attention along the horizontal relative to the vertical meridian was compared using various behavioral and functional analysis. We did not observe evidence for a specific mechanism underlying horizontal reorienting, neither concerning behavior, BOLD amplitudes nor effective connectivity (estimated using dynamic causal modeling) within the relevant network of brain regions. This was confirmed by a more sensitive volume of interest (VOI) approach, where logistic regression predicting conditions using VOI level data generalized well across the different directions of attentional reorienting. The data suggest that shifts of attention along different spatial dimensions rely on the same mechanisms.

Topic Area: ATTENTION: Spatial

A12 Spatial Attention in Healthy Cognitive Ageing

Monika Harvey¹, Gesine Maerker¹, Gemma Learmonth^{1,2}, Gregor Thut^{1,2}; ¹School of Psychology, University of Glasgow, UK, ²Institute of Neuroscience & Psychology, University of Glasgow, UK

Young adults tend to overestimate the number, size and luminance of objects located in the left side of space ("pseudoneglect"), a spatial bias deemed to be caused by a right hemisphere dominance for visuospatial attention. Intriguingly, healthy older adults have been shown to lose this leftward bias, yet at present little is known as to whether these behavioural shifts are reflected in hemispheric changes. Here we present two experiments: firstly we aimed to identify an ideal spatial task teasing out age related spatial bias changes. Secondly, we wanted to investigate potential hemispheric alterations with EEG. In the first experiment we found that for a single given task, both young and older participants showed consistent spatial biases across different testing days. However, different tasks generated different biases, with the landmark task (in which participants are instructed to indicate which side of a pre-transsected centrally presented line is shorter/longer) best at potentially teasing ageing biases apart. In the second experiment, we compared young and older adults on this task whilst recording event-related potentials (ERPs). Full-scalp cluster mass permutation tests identified a larger right parieto-occipital response for long compared to short landmark stimuli in young adults, an effect not present in the older group. To conclude we report task and stimulus-driven reduction of right hemispheric control over spatial attention in older adults. Future studies will need to determine whether these hemispheric changes can be mapped for other spatial tasks and methodologies, and

whether they represent normal ageing processes or an early indication of neurodegeneration.

Topic Area: ATTENTION: Spatial

A13 Temporal dynamics of salience information processing: a MEG study

Jianrong Jia¹, Fang Fang¹, Huan Luo¹; ¹Peking University

Visual attention over a multitude of objects is not only modulated by top-down attentional instruction, but also by bottom-up saliency information. Recent studies have shown that multiple locations are sampled in a rhythmic manner and the sampling profile changes according to different task contexts. However, it remains unknown how unattended objects associated with different salience are processed in the brain. In the present MEG study (N = 20), subjects were instructed to perform a central task while at the same time, eight task-irrelevant color discs were presented with equal eccentricity for 5 seconds. All but one discs had the same color, which constitutes the high-salience and low-salience objects. Crucially, the ongoing luminance of high-salience and low-salience color discs were modulated according to two 5 sec random temporal sequences, based on which the temporal response function (TRF) response for them were separated and estimated from the recorded MEG signals. We then compared the TRF response for the high- and low-salience objects (saliency effect) to examine the temporal dynamics of salience information processing. The results demonstrate that the saliency effect first appeared in the right frontal eye field (FEF) with the latency of 250 ms, followed by responses in the right intraparietal area (IPS) and the bilateral V1. Furthermore, the right FEF modulated the V1 response through alpha-band (8-12 Hz) rhythm. Finally, the coupling between the right IPS and V1 activities occurred at difference phase of theta-band for the high-salience and low-salience items.

Topic Area: ATTENTION: Spatial

A14 The time-course of component processes of selective attention

Tanya Wen^{1,2}, John Duncan^{1,2}, Daniel Mitchell^{1,2}; ¹MRC Cognition and Brain Sciences Unit, ²University of Cambridge

Attentional selection shapes human perception, enhancing relevant information, according to behavioral goals. Here, we used multivariate decoding of electrophysiological brain responses (MEG/EEG) to examine real-time representation of the component processes of selective attention. Auditory cues instructed participants to respond to a particular visual target, embedded within a stream of single- and multi-item displays. Although the task logically required items to be compared to an attentional "template", signals consistent with such a template were relatively weak and appeared to transition through an active sensory format before becoming quiescent. Subsequent stimulus processing evoked strong neural representation of multiple target features, evolving over different timescales. Combining single and multi-item displays with different types of distractors, allowed quantification of various components of attention. Following a visual choice display, we observed five distinguishable processing operations with different time-courses. First, visual properties of the stimulus were strongly represented. Second, the location of the candidate target was rapidly represented in multi-item displays, providing the earliest evidence of modulation by behavioral relevance. Third, biased competition continued to enhance the representation of the candidate target, including its identity, relative to distractors. Fourth, only later was the behavioral significance of the target explicitly represented in single-item displays. Finally, if the target was not identified and search was to be resumed, then an attentional template was weakly reactivated. The observation that an item's behavioral relevance directs attention in multi-item displays prior to explicit representation of

target/non-target status in single-item displays is consistent with two-stage models of attention.

Topic Area: ATTENTION: Spatial

A15 Mesostriatal White Matter Integrity Predicts Impulsivity in Adolescents with ADHD

Blake Elliott¹, Prerona Mukherjee², Julie Schweitzer², Samuel McClure¹; ¹Arizona State University, ²UC Davis MIND Institute

Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders. A characteristic of ADHD is inappropriate levels of impulsivity, thought to be manifested by deficits in the dopaminergic reward system. Few studies have investigated the specific white matter structures in the dopamine system and how it may be related to ADHD symptomatology. Additionally, these studies typically investigate the white matter structural connectivity from the frontal cortex to the striatum (frontostriatal pathway), but no known studies have investigated the structural connectivity from the midbrain (VTA/SN) where the dopamine cell bodies are found to the striatum (mesostriatal pathway). The present study collected diffusion tensor imaging (DTI) data, as well as self-report and task-based behavioral measures of impulsivity from a large number of ADHD and typically developing (TD) adolescents (n=159). Probabilistic tractography was used to quantify the structural connectivity of the mesostriatal projections from the midbrain (VTA/SN) to the striatum. We hypothesized that differences in these projections exist between ADHD and TD adolescents, and that DTI derived measures of structural connectivity can predict impulsivity. Behaviorally, ADHD adolescents differed from TD adolescents on all measures of impulsivity. Additionally, we found participants with ADHD had greater structural connectivity between the midbrain and the striatum, and these changes were correlated with behavioral measures of impulsivity. Altogether, the present study demonstrates that structural connectivity of the mesostriatal pathway is disrupted in adolescents with ADHD, and that the disrupted anatomy of this system may underlie behavioral manifestations of impulsivity in adolescents with ADHD.

Topic Area: EMOTION & SOCIAL: Development & aging

A16 Neural Responses to Faces in the First Year of Life

Stefania Conte^{1,2}, John E. Richards^{1,2}; ¹University of South Carolina, ²Institute for Mind and Brain

The aim of this study was to examine the development of brain responses to faces in 4.5-, 6-, 8-, and 12- month-old infants. We recorded event-related potentials (ERPs) in response to human faces and objects, with particular interest to amplitude variations of the N290 ERP component. We investigated the cortical source of this signal using realistic, age-appropriate head models. The N290 amplitude was analyzed as a function of stimulus and participant age at lateral posterior-inferior scalp channels. The N290 response increased with participant age and showed a significantly larger negativity in response to faces than objects on parietal-occipital and parietal channels. The largest variance of the model was explained by PO9 ($\eta^2 = .061$, faces M = -2.750; objects M = -1.329). N290 current density reconstruction (CDR) values were analyzed at anterior, middle, and posterior portions of the fusiform gyrus (aFFG, mFFG, and pFFG). CDR values were significantly larger for faces than objects in all the FFG regions, with the largest variance explained by the mFFG ($\eta^2 = .272$, faces M = 4.647; objects M = 3.582). Moreover, at all ages CDR values were larger for faces than objects ($ps < .047$). With increased age, CDR responses in FFG became larger for faces ($r = .114$), while smaller for objects ($r = -.083$). Overall, these results indicate that infant N290 shows sensitivity to faces and its activity is mainly localized in the mFFG. During the first year of life, the response in FFG increases for faces and decreases for objects.

Topic Area: EMOTION & SOCIAL: Development & aging

A17 Neurobehavioral Responses to Novelty are Altered as a Function of Youth Depression Severity

Emily K. Leiker¹, Harma Meffert¹, Brittany K. Taylor², Laura C. Thornton¹, Heba Abdel-Rahim¹, Niraj Shah¹, Stuart F. White¹, Karina Blair¹, Matthew D. Dobbertin¹, Patrick M. Tyler¹, R. James R. Blair¹; ¹Boys Town National Research Hospital, Boys Town, NE, ²University of Nebraska Medical Center, Omaha, NE

Background: Individuals with depression exhibit reduced neurobehavioral sensitivity to reward across various reinforcement learning tasks (Forbes & Dahl, 2012; Paulus & Yu, 2012; Eshel & Roiser, 2010), but less is known about how this extends to novelty processing. This is surprising, given the putative role of dopaminergic neurocircuitry in depression (Belujon & Grace, 2017; Russo & Neslter, 2013), reward signaling, and novelty detection (Wittmann et al., 2007; 2008). Moreover, because the dopaminergic system and reward and novelty responding undergo substantial neurodevelopmental changes during adolescence, coinciding with heightened vulnerability to depression (Forbes & Dahl, 2012; Davey et al., 2008), any alterations in novelty sensitivity are likely to be particularly pronounced during adolescence. **Methods:** Youth completed a reinforcement learning task involving the periodic introduction of novel associations during fMRI. Behavioral response patterns were modeled to estimate the intrinsic novelty value for each participant, and these values were then related to the neural correlates of novelty and depression severity. **Results:** We identified an interaction between depression severity and intrinsic novel value with the brain response to novelty in ventral striatal, frontal, and posterior cingulate regions. **Discussion:** These data suggest that neurobehavioral responses to novelty are altered as a function of depression severity during adolescence. Given the importance of novelty processing in affective learning (Wittmann et al., 2007; Houillon et al., 2013), these early depression-related impairments in novelty sensitivity may contribute to some of the adverse social and emotional effects associated with adolescent depression.

Topic Area: EMOTION & SOCIAL: Development & aging

A18 Older adults' positive memory biases related to neural activity during the encoding of subsequently forgotten negative information

Ryan Daley¹, Holly Bowen², Eric Fields^{1,3}, Katelyn Parisi^{1,3}, Angela Gutches³, Elizabeth Kensinger¹; ¹Boston College, ²Southern Methodist University, ³Brandeis University

Older adults (OAs) show better memory for positive information compared to younger adults (YAs) (Mather & Carstensen, 2005). It is unclear how neural mechanisms relate to individual differences in the degree of OA positivity biases during self-referential memory tasks. We examined the neural mechanisms supporting OA learning during an emotional and self-referential memory paradigm, and the role of the mPFC during OA positivity biases. While mPFC activation predicts encoding failures for neutral information (Wagner & Davachi, 2001), when information is emotional or self-relevant, activation can signal successful encoding (Gutches & Kensinger, 2018). There may be individual differences in whether the mPFC predicts encoding success or failure, which could relate to individual differences in the positivity bias. OA and YA participants were presented with emotional and neutral images and asked to imagine placing each item in their home or a stranger's home during functional magnetic resonance imaging. Next, participants completed a surprise memory task outside the scanner. Behaviorally, there was an age-by-emotion interaction: OAs showed better memory discrimination for positive than neutral items while YAs showed better discrimination for emotional than neutral items. Across OAs but not YAs, regional activation including the vmPFC corresponded to a stronger positive memory bias. In those with stronger positive memory biases, vmPFC activation related to increased

forgetting of negative items. These findings demonstrate that individual differences in positive memory biases can be traced to the moment of encoding and related to valence differences and whether regions including the vmPFC correspond to successful or failed encoding.

Topic Area: EMOTION & SOCIAL: Development & aging

A19 The neural correlates of psychological well-being in older adults

Marcie King^{1,2}, Joel Bruss², Timothy Kosciak², Natalie Denburg^{1,2}; ¹University of Iowa, ²University of Iowa Carver College of Medicine

Research shows substantial variability in levels of psychological well-being among older adults. While high levels of psychological well-being have been linked with improved mental and physical health outcomes in older adults (e.g., improved inflammatory profiles), low psychological well-being has been associated with poorer outcomes. The effects of psychological well-being on health are thought to be mediated in part by underlying neural circuitry. However, current understanding of the neural correlates of well-being are limited and findings regarding the relationship between psychological well-being and the brain in younger adults have been mixed. To examine the relationship between well-being and the brain in older adults, 45 participants (mean age = 74.51(5.77), age range: 60-88 years; 51% female) completed the Ryff Well-Being Scales and underwent a resting-state functional MRI scan of the brain. The relationships between psychological well-being and the regional homogeneity of a-priori regions of interest (ACC, PCC, OFC, STG, and thalamus) were assessed using a general linear model, with age included as a covariate and gender, education, and handedness as confounding covariates. The right medial OFC as well as the interaction of age and the right medial OFC emerged as significant predictors of overall well-being, autonomy, environmental mastery, personal growth, and self-acceptance. These findings are consistent with work implicating the OFC in psychological well-being in younger adults as well as with a broader literature implicating the OFC in motivation and emotion.

Topic Area: EMOTION & SOCIAL: Development & aging

A20 Brain Activation in Processing Emotional Expression of Voice Utterance: An fMRI-DCM approach

Shih-Tseng T. Huang^{1,2}, Ya-yun Chen¹, Yu Song Haw¹, Chi-Chuan Chen³, Joshua O. S. Goh³, Gary C.-W. Shyi^{1,2}; ¹Center for Research in Cognitive Science, National Chung-Cheng University, Taiwan, ²Department of Psychology, National Chung-Cheng University, Taiwan, ³Graduate Institute of Brain and Mind Sciences, College of Medicine, National Taiwan University

Fifty college students, half were assigned to perform an implicit task and the other half were to an explicit task. For the implicit task, participants were asked to judge the sex of voiced utterances that varied in emotional expression. For the explicit task, participants were asked to judge the emotional intensity of facial stimuli. Results of the explicit task suggested except for the SA>NE all other emotional contrasts exhibited strong and significant brain activations in the bilateral superior temporal gyrus (STG) and significant responses in the bilateral pSTS and insula. The contrasts of AN>NE and HA>NE showed activation in the cingulate gyrus, and the amygdala was significantly activated with the contrasts of AN>NE and DI>NE. For other basal ganglia regions, we found that the putamen was activated with the contrasts of AN>NE and HA>NE; the caudate was activated only with the contrast of AN>NE, whereas the Claustrum yielded activations under all emotional contrasts except for those of HA>NE and SA>NE. Finally, for the cerebellum activations, the contrast of AN>NE exhibited significant activations in the Culmen, Declive and Dentate regions. The brain activation patterns exhibited in the implicit tasks were similar to those identified in the explicit task with a lower strength and magnitude. Contrasts of AN > NE, DI > NE, HA > NE, and SU > NE showed

significant responses on the bilateral pSTS. Results of dynamic causal modeling analysis suggested the flow of auditory information was from STG to pSTS and then deliver into amygdala.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A21 Difference between the recognition of macroexpressions and microexpressions: An EEG study

Gaojie Fan¹, Xunbing Shen², Robin Thomas¹; ¹Miami University, ²Jiangxi University of Traditional Chinese Medicine

Microexpressions are fleeting facial expressions that last for 1/25 to 1/5 seconds. They are used as an important cue to distinguish people's true emotions. How people detect microexpressions has been an interesting topic for psychologists as well. There is a lot of research on macroexpression and macroexpression recognition, but little is known whether and under what circumstances these findings can be generalized to microexpression and microexpression recognition processes. In the current study, we exposed participants with pictures of both macro and micro facial expressions followed by emotional words that may or may not be congruent with the preceding expressions, and recorded electroencephalogram (EEG) data to investigate neural activities underlying recognition of these expressions. Previous research has shown that different parts of the face might play a more important role in recognition when expression varies. We also compared situations in which participants saw a whole face versus only part of the face. By using a variety of techniques such as event-related potentials (ERP), event-related spectral perturbation (ERSP), and independent component analysis (ICA), we were able to find some interesting difference across various latency conditions and word-congruence conditions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A22 Early reactivation of emotional valence in ERPs to neutral retrieval cues

Holly J. Bowen¹, Eric C. Fields^{2,3}, Elizabeth A. Kensinger²; ¹Southern Methodist University, ²Boston College, ³Brandeis University

Much of the research examining why memories of negative and positive events have distinctive behavioral and neural profiles have focused on differences at encoding, with less emphasis on processes that occur at retrieval. Some studies have shown differences in memory and ERP waveforms during retrieval of neutral stimuli previously encoded in a negative compared to neutral context, but few studies have included positive stimuli to examine valence effects directly. In the current study we used ERPs to examine the time course and electrophysiological correlates of valence differences in memory retrieval. At encoding, participants (n = 25) viewed negative, positive and neutral images paired with neutral words. At retrieval, the neutral words were presented alone and participants were asked to make a remember/know judgment while EEG was recorded. The hit rate for items previously encoded with negative images, positive images, and neutral images, did not statistically differ. Valence effects in the ERP data began to emerge around 200 ms after the onset of the retrieval cue in the form of a parietally distributed positivity. Words encoded with positive and negative images elicited a larger positivity than words encoded with neutral images, with no significant difference between positive and negative. This effect occurred before the commonly observed frontal old-new effect (~400 ms) and before the earliest old-new effect observed in the present data, indicating that reactivation of the prior emotional context occurs in the very early phases of memory retrieval and before stimulus recollection.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A23 Effects of Face-Sentence Valence and Event-Sentence Incongruence on Sentence Processing: An ERP Study

Katja Münster¹, Johanna Kissler², Pia Knoeferle^{1,3,4}; ¹Humboldt-Universität zu Berlin, ²Universität Bielefeld, ³Berlin School of Mind and Brain, ⁴Einstein Center for Neurosciences Berlin

Previous eye-tracking research suggests that both referential information and a speaker's emotional facial expression can rapidly modulate real-time language processing. We investigated the functional brain responses associated with these world-language relations. In an EEG experiment, 25 German adults first inspected the face of a speaker and listened to the beginning of a spoken German sentence (e.g., "Ich denke, dass...", lit. transl: I think that...). The speaker's facial expression was either emotionally positive or negative. Subsequently participants inspected an emotionally positive or negative International Affective Picture System picture and listened to the sentence continuation (e.g., "die Blonde die Migräne leidend verflucht.", lit. transl.: the blonde the migraine sufferingly curses.) whereby the adjective/adverb and verb conveyed the strongest emotional valence. Sentence meaning matched (vs. mismatched) the picture. Picture-sentence mismatches (vs. matches) elicited differences in negative mean amplitudes. ERPs were moreover sensitive to incongruence in speaker face valence (matching vs. mismatching picture-sentence valence pairs) after the onset of the adjective/adverb but not before. These effects corroborate and extend previous eye-tracking results, specifying how a speaker's emotional facial expression can rapidly impact real-time sentence processing. Assuming that an increase in negativity can be associated with processing difficulties, participants experienced more difficulty integrating a positive speaker face into negative picture-sentence combinations (vs. integrating negative faces into positive sentences).

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A24 Executive networks under emotional stress

Alana Campbell^{1,2}, Mae Nicopolis Yefimov^{1,2}, Louis Murphy¹, Adelaide Zhao¹, Carina Guerra¹, Andrea Pelletier-Baldelli^{1,2}, Hannah Waltz¹, Aysenil Belger^{1,2}; ¹University of North Carolina at Chapel Hill, ²Carolina Institute for Developmental Disabilities

Adolescence is a critical window in which neuronal activity supporting cognitive, affective, and stress systems undergo significant, and balanced development. The balance, and its limits, under both emotional and stressful conditions and increased working memory load is not well understood, but important for healthy development, with dysregulation imparting risk for psychiatric illness. We present data for a series of studies (n=56, n = 25) from adolescents completing an n-back task under emotional conditions or before and after a social stressor. We recorded ongoing EEG and heart rate variability, to measure the respiratory sinus arrhythmia (RSA to index the stress response). We find that the social stress impacts resting -state alpha activity (8-12Hz) and RSA. Neural oscillatory activity for both power and synchrony in the theta band (4-8Hz) showed an interaction between stress and n-back load, with an associated altered frontal scalp connectivity. Further, valence category differentially impacted theta power and connectivity. These results suggest that both stress and negative emotional valence can disrupt healthy cognition in adolescence, and that added stress may further impair inefficient neural systems in disease.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A25 Increased functional connectivity of the right amygdala can interfere with reading and affect emotional state and cognitive control

Tzipi Horowitz-Kraus^{1,2}, Ohad Nachshon¹; ¹Educational Neuroimaging Center, Faculty of Biomedical Engineering and Faculty of Education in Science and

Introduction: Dyslexia is a reading disorder characterized by significant reading difficulties (RD) as well as social and emotional problems. Based on the relationship between Executive-Functions (EF) and emotional states, this study was designed to establish neurobiological evidence for differences in neural circuitry involved in EF and emotional state in children with RD and typical readers. **Methods:** Sixty 8-12 year-old children, 30 children with RD and 30 age-matched typical readers, participated in the study. Emotional and EF abilities were assessed using the Behavior Rating Inventory of Executive Function (BRIEF). Functional-connectivity analysis during the reading task and in a 10-min functional MRI resting-state condition was carried out using the CONN toolbox. **Results:** Children with RD showed significantly lower emotional and EF abilities compared to typical readers. A significant negative correlation between emotional, EF, and reading abilities was determined between the two groups. Neuroimaging results showed lower global efficiency within the emotional network in children in RDs compared to typical readers. Increased functional connectivity within the emotional network was associated with increased EF and emotional abilities. The functional connectivity analysis between specific regions within the emotional network and the entire brain showed a significantly lower functional connectivity between the amygdala and left and right frontal pole regions in children with RD compared to typical readers. **Conclusions:** The results supports the "vicious cycle" between EF, emotional abilities and reading challenges: EF difficulties may cause emotional stress, which in turn can decrease EF abilities and also reading abilities.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A26 Neural Signature Connecting Tempo of Negatively Valenced Music to Episodic Autobiographical Memory

Christine Rapadas Jimenez¹, Mark Warren Geisler¹; ¹San Francisco State University

Music is a "form of art that lives in the time domain (Troost & Vuilleumier, 2013, p.213). As music "moves through time" (Denora, 2004, p.66), events and time periods in one's lifetime also link to music so that music triggers autobiographical memory. It is unclear what facet of music ties to autobiographical memories. The current study uses electroencephalography (EEG) that highlights musical tempo as "glue" that may connect music to memories. In our within subjects study, participants (N = 47, 18 men) self-selected two songs, one song with negative valence and another with positive valence. EEG was recorded at electrodes F3, F4, P3, and P4 during both the music listening task and reliving task. Autobiographical memories were evoked in the laboratory for most participants as they listened to music with negative valence (80.9%) and positive valence (53.2%). Participants that experienced music-evoked autobiographical memories (MEAMs) during the music listening task were instructed to vividly relive the autobiographical memory that the song evoked (reliving task). Musical tempo (beats per minute) was measured using MIRtoolbox, and the ratio (P4-F4/P4+F4) of EEG activity between the right posterior (P4) and right anterior (F4) areas of the brain was investigated in the gamma band (36-44 Hz) during both tasks. Results showed that faster tempos of music with negative valence evinced greater ratios of posterior to frontal gamma band activity (N = 18, 5 male) during both the music listening task, $F(1,16) = 9.08$, $p = .008$, and the reliving task, $F(1,16) = 6.04$, $p = .026$.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A27 Two components or one? An examination of the relationship between the P300 and emotion-related late positive potential (LPP)

Eric C. Fields^{1,2,3}, Hannah J. Levin¹, Nathaniel Delaney-Busch¹, Gina R. Kuperberg^{1,4}; ¹Tufts University, ²Boston College, ³Brandeis University, ⁴Massachusetts General Hospital

In ERP studies of the effects of emotion, the most consistently modulated waveform is a parietally-distributed late positive potential (LPP). The cognitive function represented by this component is not clear, but many authors have noted its similarity the well-studied P300 component. Both are later parietal positivities that are highly sensitive to probability and task-relevance within the broad experimental context. Some authors have suggested that the P300 and LPC are the same component, but this hypothesis has not been directly tested. In the present work we orthogonally manipulated the factors that classically influence each component: stimulus Valence (LPP) and stimulus Probability (P300) via a classic oddball task with neutral and negative words as the stimulus categories. As expected, ERPs showed large main effects of Valence and Probability. These effects appeared on very similar parietally distributed positivities. However, the effect of Probability began and peaked somewhat later than the effect of Valence. The key finding was the absence of an interaction between Valence and Probability. This suggests that these effects were independent. While it remains possible that Probability and Valence independently modulate the same cognitive process, or that the P300 and LPP reflect similar underlying computational principles, these results fail to provide strong evidence that the P300 and LPP are the same component with the same underlying neural sources.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A28 Using representational similarity analysis to assess the development of novel affective associations over time

Mana Ehlers¹, James Kryklywy¹, Andre Beukers², Sarah Moore¹, Adam Anderson³, Rebecca Todd¹; ¹University of British Columbia, ²Princeton University, ³Cornell University

The basic principles of classical conditioning and the underlying neural circuits are well established. Recently, the emergence of multivariate analyses for neuroimaging data allows more nuanced investigation of the temporal dynamics and neural correlates underlying learning of novel emotional association – including the identification of individual differences contributing to the effectiveness of conditioning. In addition, there is, to date, no direct comparison of appetitive and aversive conditioning. Thus, in the current study participants complete two conditioning task while undergoing functional magnetic resonance imaging. In an aversive conditioning task, neutral faces are paired with pressure pain to the thumbnail, while an appetitive conditioning task pairs faces with a brush stroke to the forearm. We applied representational similarity analysis to the BOLD data obtained from 85 participants from six regions of interest in order to determine the temporal development of conditioned associations over the course of learning. Using this innovative approach allows us to identify when and where in the brain, faces as initially neutral stimuli are represented as a conditioned stimulus. Notably, conditioned associations are represented in part in regions comprising the salience network, such as the ventromedial prefrontal cortex and the insula, while sensory regions maintain some representation of the sensory category even after conditioning. Moreover, preliminary data suggest that the ability of participants to develop conditioned associations is represented in the brain at early stages of stimulus pairing. Taken together, the current study gives us novel insight into the temporal development of conditioned association representations in the brain.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A29 Within-Subject Reliability and between-Subject Variability of tACS effects: A multi-session EEG-tACS study and simultaneous EEG-fMRI-tACS study

Kevin Clancy¹, Melissa Meynadasy¹, Nika Kartvelishvili¹, Wen Li¹; ¹Florida State University

tACS-induced modulations of neural oscillations and subsequent behaviors have elicited substantial support for its application in cognitive neuroscience research and clinical interventions for neuropsychiatric disorders characterized by aberrant neural oscillations (“oscillopathies”). However, success in such tACS applications is contingent upon the reliability of its effects both within and between individuals. Here, we examined within-subject test-retest reliability and between-subjects variability in two studies applying alpha-tACS (at the posterior midline at individual alpha peak frequency in the range of 8-12 Hz). Study I applied tACS over four consecutive days and tested changes in alpha power and posterior-to-frontal Granger Causality (GC) at 6 times points. Group-level effects—alpha power/GC increases and anxiety reduction—validated the effectiveness of tACS. Importantly, within-subject changes in these measures were highly reliable across multiple time points (r 's > .51, p 's < .037). Nonetheless, between-subjects variability was also notable, with 14% subjects showing no effects, 23% small effects, 53% medium effects, and 10% strong effects. Applying simultaneous EEG-fMRI-tACS (fMET), Study II (ongoing) furthers the examination of between-subject variability of tACS along the axis of individual differences in trait anxiety, given the demonstrated tACS effects on anxiety. Preliminary data indicate post-stimulation reductions not only in the visual cortex (pre-/cuneus) but also in regions of the salience network (amygdala, anterior insula, dorsal anterior cingulate cortex) that have been strongly implicated in anxiety and related disorders. These findings provide initial evidence for between-subject variability of tACS effects on neural processes associated with anxious arousal and hypervigilance as a function of trait anxiety.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

A30 Age Differences in Second-Order Rule Learning: an fMRI Study of the Cerebellum in Advanced Age

T. Bryan Jackson¹, Joseph M. Orr¹, Sydney M. Eakin¹, James R.M. Goen¹, Jessica A. Bernard¹; ¹Texas A&M University

Age differences in cognitive and motor function are inter-related. To date, most of the research in aging has focused on cortical systems and networks, though recent work has implicated the cerebellum. Critically, older adults (OA) show marked differences in cerebellar volume and functional networks, suggesting it may play a key role in the behavioral differences observed in advanced age. OA may be less able to recruit cerebellar resources due to network and structural differences, impacting performance across domains. Here, 26 young adults (YA) and 25 OA performed a second-order learning task, known to activate the cerebellum and cerebello-cortical networks, in the fMRI environment. Before and after scanning, participants performed the task under dual-task conditions to evaluate the degree of automaticity due to learning. Brain imaging data were preprocessed and analyzed using FSL; task performance was measured using accuracy. A repeated measures ANOVA showed an interaction between learning run and age group, indicating that YA performed significantly better and learned more quickly compared to OA. In addition, the dual-task cost was larger in YA, though YA still outperform OA during the post-task, with no difference in the pre-task. Preliminary functional imaging results robust parietal and cerebellar activity across both groups during learning, and forthcoming analyses will determine differences in activation both within and between groups to determine age differences in the neural activation patterns associated with second-order rule learning. These results will elucidate the degree to which the cerebellum and cerebello-cortical networks contribute to higher order learning in older adults.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A31 Alpha Klotho Protein correlates with Hippocampal Volume related cognitive changes induced by aerobic exercise in older adults

Andreas Becke^{1,2}, Anne Maass^{1,2}, Michael Kreuz³, Emrah Düzel^{1,2}; ¹German Center for Neurodegenerative Diseases, Magdeburg, Germany, ²Institute of Cognitive Neurology and Dementia Research, Otto-von-Guericke University, Magdeburg, ³Leibniz Institute for Neurobiology, Magdeburg, Germany

Aerobic exercise is an important component to delay neurodegeneration in old age. One mediating factor is the expression of neurotrophic and vascular growth factors as well as life extension factors namely Alpha-Klotho protein. A reduced level of Alpha-Klotho is related to cognitive decline, while increased values with slowing progression of Dementia, possibly induced by a down regulation hippocampal neurogenesis. Yet the relation of exercise induced Alpha-Klotho level changes on the effect of hippocampus volume and memory Performance remained unclear. Forty healthy older humans (mean age=68.4±4.3, 55% female) were pseudo-randomly assigned to either an aerobic exercise group (indoor treadmill, n=21) or to a control group. Hippocampus Volumes were gained from manual segmentations of 7Tesla-T1 images (0.6 mm isometric voxels) which were acquired along a cognitive test battery, serum fasting blood samples for analysis of human soluble Alpha-Klotho and ergospirometry measures (volume of oxygen consumption) at the beginning and the end of a 3-month aerobic exercise intervention. Mean values of individual changes of hippocampal volumes, memory scores for delayed memory recognition in complex figure task (RCF), Alpha-Klotho and oxygen consumption at ventilatory threshold were compared between groups and further used for regression analysis, corrected for age and gender. Residuals show a significant positive correlation between RCF scores and Alpha-Klotho levels as well as a positive correlation of hippocampal volume and Alpha-Klotho. These findings were irrespective of fitness changes but more prominent in the exercise training group. The results provide additional evidence for the function of Alpha-Klotho mediating adult hippocampal neurogenesis.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A32 Classification of age by default mode network connectivity

Mason Price¹, Michael Rezych¹, Tony Wilson¹; ¹University of Nebraska Medical Center

Evidence of age-related changes in the brain relating to both structure (i.e. cortical thickness; tractography) and function (signal amplitude; connectivity) are well documented in cognitive neuroscience and experimental psychology. These physiological measures are often accompanied by age-related changes in cognition, primarily taking the form of reduced accuracy and processing speed. Previous studies leveraging machine learning methods have shown that age can be reliably decoded using large samples of whole-brain or multi-network measures of connectivity. The current study sought to investigate the extent to which age can be accurately decoded based solely on the connectivity profile of the default mode network. Resting-state fMRI was collected in 83 individuals and time courses from 58 nodes within the default mode network (Power et al, 2011) were used to construct functional connectivity (FC) matrices. The FC matrices were submitted to a leave-one-out cross-validation pattern classifier trained to distinguish older (average age = 53 years) from younger (28 years) adults. The classifier obtained above-chance performance at decoding the target age group (67%; $p=.02$). Averaging across the DMN revealed a significant age associated decline in functional connectivity ($r=-.39$, $p<.001$). To further quantify the relationship between DMN and age, feature weights and connectivity profiles of individual nodes were examined, revealing distinct topographic contributions inherently driving classifier performance. These results provide additional support for the

relevance of this functional network in age-related reorganization of brain connectivity and degradations of cognition.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A33 Functional connectivity profiles for cognitive control over the adult lifespan

Jenny Rieck¹, Giulia Baracchini^{1,2}, Daniel Nichol¹, Hervé Abdi³, Cheryl Grady^{1,4}; ¹Rotman Research Institute at Baycrest, ²University of Padova, ³University of Texas at Dallas, ⁴University of Toronto

Cognitive control is considered to have three core factors: inhibition, shifting, and working memory. But the degree to which these factors represent common versus distinct domains of cognition is unclear. Neuroimaging studies reveal broad cognitive control regions in the brain, but evidence for domain-localized activity is sparse, suggesting this might be better addressed at the brain-network level. Therefore, we examined functional connectivity patterns associated with cognitive control to determine network connectivity profiles associated with each domain. Furthermore, because healthy aging is characterized by reductions in cognitive control, we recruited an adult lifespan sample in order to investigate potential age differences in connectivity profiles. Participants (ages 20-85) underwent functional magnetic resonance imaging while completing go/no-go (inhibition), task switching (shifting), and n-back (working memory) tasks. We used a multivariate technique (DSTATIS) to identify connectivity profiles across tasks and age. Younger adults exhibit distinct connectivity patterns for the three domains, however, in middle-aged and older adults, functional connectivity patterns do not differ between shifting and inhibition, suggesting an integration of these processes. Furthermore, we find evidence for (a) network reconfiguration (temporoparietal networks are distinct in young, but integrated in older adults), (b) network dedifferentiation across tasks in older adults (e.g., in visual and fronto-parietal networks), and (c) task dedifferentiation with aging (e.g., connectivity patterns in default and frontal networks are more similar during 2-back). These results offer new evidence for unique network connectivity profiles during inhibition, shifting, and working memory, but these patterns of connectivity are modulated by cognitive domains and age.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A34 Functional differences in a cognitive control network in older adults with exceptional memory

Ian Kahrilas¹, Emma Sims¹, Nicole Dosamantes¹, Shana Ward¹, Rebecca L. Silton¹, Robert G. Morrison¹; ¹Loyola University Chicago

While the ability to learn new information is critical for successful aging, less is known about the factors that contribute to its variability during healthy aging. However, researchers have hypothesized that executive functions (EFs) may support the preservation of memory function. Research with older adults with exceptional memory (SuperAgers; Geffen et al., 2016) suggests that differences in the anterior cingulate cortex (ACC), an essential structure in the cognitive control network, may be important. To investigate whether medial frontal cortical structures are functionally related to memory preservation we applied a discrete regional source model to high-density EEG data to characterize the functional activity in rostral ACC and pre-SMA. The source model included five regional sources based on a meta-analysis of visual Go-Nogo tasks (Simmonds et al., 2007) and a prior fMRI study with the SuperAgers. EEG data were recorded during a visual go-nogo task from 43 healthy individuals (65 to 91 years) with a broad range of memory ability (RAVLT-Delay). Analyses were conducted with multilevel modeling to account for the repeated-measures design (Go-Nogo) with continuous predictors (Age and RAVLT). A three-way interaction between trial (Go-Nogo), age, and RAVLT score was observed for pre-SMA (250-450ms; $p < .001$) and rostral ACC (250-500ms; $p = .004$). Older participants with higher memory scores

(SuperAgers) showed enhanced pre-SMA activity in the Go vs. Nogo trials and enhanced rostral ACC activity in the Nogo vs. Go trials. These results suggest that functional differences in this cognitive control network contributes to preserving memory function in old age.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A35 Individual aging effects on white matter integrity and time-varying network connectivity: A combined EEG and DTI study.

Thomas Hinault¹, Travis Kroeker¹, Eda Incekara¹, Arnold Bakker², Alain Dagher³, Susan Courtney¹; ¹Johns Hopkins University, ²Johns Hopkins School of Medicine, ³McGill University

This study aimed to better understand individual aging effects on network connectivity of cognitive control, and how it is underpinned by white matter integrity. We studied the inhibition of irrelevant arithmetic knowledge (i.e., correct rejection of a false solution when it is the correct product of another operation; e.g., $8 \times 4 = 12$) and its interaction with the maintenance or updating of arithmetic rules (i.e., addition, multiplication) in working memory. We analyzed DTI, resting-state fMRI, and EEG data in 40 young adults (20-35 years) and 40 older adults (60-75 years). In young adults, EEG results revealed transient gamma power in frontal and posterior regions during updating while sustained gamma activity was observed during rule maintenance. Modulations of the alpha band were observed during arithmetic interference. Source reconstruction of EEG data was cortically constrained to anatomical data and revealed frequency-specific fronto-posterior connectivity involving the the angular gyrus, the anterior cingulate cortex and the inferior frontal gyrus during both working memory updating and inhibitory phases. Older adults showed larger behavioral interference performance together with larger, sustained activation in the gamma band during updating compared to young adults. Older adults also showed lower white matter integrity and reduced activation of the frontal-parietal network compared to young adults. Individual levels of alteration of fronto-posterior tracts were associated with lower intensity of functional coupling, larger variability of the maintenance of activation over time, and larger behavioral interference. Results improve our understanding of how age-related decline in cognitive control is associated with differences in functional and structural network integrity.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A36 Socioeconomic status, minority status, and neighborhood deprivation effects on brain structure and cognitive function: A multivariate analysis of the ABCD study dataset

Carlos Cardenas-Iniguez¹, Marc Berman¹; ¹The University of Chicago

Childhood low socioeconomic status (SES), widely associated with increased psychosocial and environmental stress, has been previously associated with differences in brain morphometry and cognitive function. The current study aims to investigate these findings further by also exploring the contribution of various social and neighborhood environmental factors on cognitive function and cortical volume. To accomplish this goal, we used Canonical Correlations Analysis (CCA), a multivariate analysis approach that allows us to find linear combinations of two sets of variables that have maximum correlation with each other, termed Latent Variables ("LVs"). For this study, we used a subset of participants from the first release of the ABCD Study for which a full set of data were available (3150 subjects, 1488 female, average age: 120 months). We implemented CCA to relate cortical volume estimates for 68 regions (34 per hemisphere) according to Freesurfer's Desikan-Killiany atlas to measures in the following categories: demographics (race/ethnicity, age, gender, and SES), cultural and social environment, residential neighborhood conditions (using the Area Deprivation Index) and cognitive function (from the NIH Toolbox Cognitive Function Battery). Our CCA yielded two LVs, together accounting for 60% of the variance, that showed a strong positive relationship

between cortical volume across all regions and better cognitive performance, and identifying as White, being male, having higher parental education and income, and having better residential neighborhood conditions, and a strong negative relationship with being Black and experiencing greater neighborhood deprivation. These results suggest a benefit to multivariate approaches on SES and cognitive function.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A37 The Impact of Ageing on the Characteristics of and Interaction between Voluntary and Involuntary Inhibition

Erik Chang¹, Condro Wati¹, Tzu-Ling Li¹; ¹National Central University, Taiwan

Inhibition is at the core of executive control. Depending on the task context, it can theoretically have voluntary and involuntary origins. Here we report two studies exploring the impact of aging on these two types of inhibition. In Study One, both young and elderly groups were tested in voluntary (Stop Signal Task [SST] and Go-NoGo Task, [GNGT]) and involuntary (Negative Priming [NP] and Inhibition of Return [IOR]) paradigms. The young group showed shorter stop-signal RT and Go-RT in general than the elderly, yet there was no between-group difference in NP or IOR effects. Correlation matrix among four paradigms revealed a pattern supporting the dissociation between voluntary and involuntary inhibition. In Study Two, we examined the interaction between voluntary and involuntary inhibition by implementing GNGT in both the prime and probe of the NP task. Electroencephalography was measured and assessed with event-related potentials (ERP). The behavioral results showed larger NP effect of No-go than Go prime in the young than the elderly group, while the ERP results showed smaller N1 amplitude of response to probe following a No-go than a Go prime in both age groups. We propose that selective attention is more adaptive in the young than in the elderly, and is modulated by the context of how voluntary and involuntary attention interact. Taken the results from both studies together, the theoretical construct of separate streams of inhibitory processing is valid, and the interaction between voluntary and involuntary inhibition is sensitive to the impact of ageing.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A38 The impact of working memory training on theta power and reasoning in the group of elderly people.

Wanda Zarzycka¹, Aleksandra Bramorska^{1,2}, Natalia Jakubowska^{1,2}, Olga Alicja Matysiak^{1,2}, Aneta Brzezicka^{1,3}; ¹University of Social Sciences and Humanities, Warsaw, Poland, ²Polish-Japanese Academy of Information Technology, Warsaw, Poland, ³Cedars-Sinai Medical Center, Los Angeles, USA

Working memory (WM) has been shown, among others, to determine efficiency in learning new skills. At the neurophysiological level, the processes associated with WM are reflected in frontal theta band (4-8 Hz), the rhythm related to attention and multitasking abilities (Hering et al., 2017). Currently, it is suggested that WM training can exert a positive influence on performance in both trained and non-trained tasks (e.g. Buschkuhl et al. 2011), but its efficacy as a tool for improving cognitive abilities is still a matter of debate. The main aim of our study was to examine the impact of WM training on cognitive functioning and EEG theta band of older adults. Precisely, it was meant to establish if such training can induce the change in theta power. 55 adults (age range: 55-80) participated in one-month training. The experimental group practised dual n-back task and the control group - general knowledge quiz. First and second measurement sessions were organized before and after training and the third - 3 months after training completion. The results did not show group differences. The analysis, however, revealed that the better the performance of the training tasks, the higher the correctness in the cognitive task in post-training measurement. Furthermore, the reduction in theta power is associated with post-training increase in cognitive tasks performance. Our

analysis confirmed relation between oscillations in theta frequency and the quality of cognitive task performance. Surprisingly, we found that decrease – not increase – in theta power was beneficiary for training effects.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A39 Visual cortex activity during non-visual tasks is “cross-modal” in late but not congenital blindness.

Rita Loiotile¹, Marina Bedny¹; ¹Johns Hopkins University

Studies of blindness provide a window into the timecourse of plasticity. In congenitally blind individuals, “visual” cortices are highly active during auditory and tactile tasks (Wanet-Defalque et al., 1988; Sadato et al., 1996). Some “cross-modal” activity is observed even in late blind and blindfolded sighted adults (Merabet et al., 2008, Burton et al., 2002). Do visual cortices support similar cognitive functions in these populations, albeit to different degrees? Alternatively, does cortex have distinctive cognitive potential early in life? Sighted (N=21), congenitally (N=21) and late blind (N=9; age of vision loss >= 17y) participants performed an auditory go-no/go task, while undergoing fMRI. Participants made fast button presses (within 900ms) in response to two “go” sounds (75% of all trials, frequent-go 50%, infrequent go 25%) and withheld responses to infrequent “no-go” sounds (25% of all trials). Resting state data were also collected. We observed a right-lateralized response-inhibition effect (no-go > infreq-go > freq-go) in the “visual” cortices of congenitally but not late blind or sighted groups and in the inferior frontal cortices of all groups. Crucially, “visual” cortices of sighted and late but not congenitally blind groups responded like sensorimotor cortices: all go i.e. with button press > no-go trials. We hypothesize that visual cortices are more functionally tethered to non-visual sensory-motor systems in sighted and adult-onset blind than in congenitally blind individuals. “Visual” cortices assume higher-cognitive functions in congenital blindness, but show “cross-modal” responses in late blindness.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A40 We all make mistakes: Consistent error-related activity across children and adolescents

Mary Abbe Roe¹, Laura E. Engelhardt¹, Tehila Nugiel¹, Mackenzie E. Mitchell¹, Jenifer Juranek², K. Paige Harden¹, Elliot M. Tucker-Drob¹, Jessica A. Church¹; ¹The University of Texas at Austin, ²The University of Texas Health Science Center at Houston

A meta-analysis of adults' error-related brain activity suggests there is a consistent set of brain regions from task control networks that coactivate during incorrect trials (Neta et al., 2015). The current study investigated whether a similar set of error-related regions coactivate during error processing in children. Data came from 232 typically developing children and adolescents ages 8-17 years (mean=10.60y) who participated in one of three fMRI projects. We investigated whole brain maps of incorrect vs. correct trials to identify regions of overlapping error-related activity across a stop signal task (N=214), switching task (n=95), and sentence comprehension task (N=109). We then compared sites of overlapping child regions to those found in the adult meta-analysis; correlations with whole-brain error activity, age, and task accuracy were also investigated. In children, error-related activity consistently occurred in bilateral anterior insula and dorsal anterior cingulate, regions that constitute the cingulo-opercular control network. Regions implicated in adult error processing that did not overlap across tasks in our child sample included bilateral frontal regions from putative fronto-parietal and salience networks; however, fronto-parietal regions were active during individual tasks. Error-related areas of three-task overlap in children that were not found in the adult meta-analysis include a region in the default mode network. Age and task accuracy did not consistently relate to brain activation across the three tasks. Preliminary results suggest that, by middle childhood, cingulo-opercular

activity during errors is qualitatively similar to activation reported in adult meta-analyses; error-related activity in other networks may not be as mature.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A41 White Matter Correlates of Musical Training and Verbal Ability in Children

Lauren Raine¹, Laura Chaddock-Heyman², Arthur Kramer¹, Charles Hillman¹, Psyche Loui¹; ¹Northeastern University, ²University of Illinois at Urbana-Champaign

The superior longitudinal fasciculus (SLF) is a white matter tract that connects lateral frontal and superior temporal lobes, regions that are important for functions involving auditory perception and action such as speech and music. We hypothesized that children who have musical training will have greater integrity and coherence in the SLF. 100 children aged 7.9 to 9.9 (mean age 8.7) were surveyed for their musical activities, completed neuropsychological testing for general cognitive abilities, and underwent DTI as part of a larger study. Children who play a musical instrument for more than 0.5 hours per week ($n = 34$) had higher Fractional Anisotropy (FA) in the Right SLF than those who did not play a musical instrument ($n = 66$) ($F(1,98) = 4.25, p < .05$). Furthermore, the intensity of musical practice, quantified as the number of hours of music practice per week, was correlated with Axial Diffusivity (AD) in the Left SLF ($r = .36, p < .01$). Verbal ability (standardized scores from Woodcock Johnson Test) was also significantly correlated with musical practice intensity, ($r = .35, p < .01$), and also with AD of the Left SLF ($r = .35, p < .05$). These associations remained significant after controlling for differences in age and socioeconomic status (partial correlations: both $r_{\text{partial}} > .35, p_{\text{partial}} < .01$). Results suggest that the relationship between musical practice and verbal ability is related to the coherence of axonal fibers in white matter pathways in the auditory-motor system.

Topic Area: EXECUTIVE PROCESSES: Development & aging

A42 Effect of comorbid learning and neurodevelopmental disorders on resting-state functional and effective connectivity in adolescents.

Audreyana Jagger-Rickels¹, Gregory Rose¹, Michelle Kibby¹; ¹Southern Illinois University

The goal of this study was to describe how within- and between-network resting-state functional connectivity develops during adolescence, and to determine whether the developmental trajectory differs in individuals with comorbid neurodevelopmental and internalizing disorders. In particular, previous studies have suggested that the salience network has a top-down influence over other resting-state networks and potentially may be sensitive to differences between adolescents with and without neurodevelopmental disorders. The participants in this study included 172 adolescents, 13-20 years of age, who were divided into two groups: a typically developing group ($n = 128$) and a mixed clinical group ($n = 44$). Both groups were age- and gender-matched. Data for the typically developing adolescent group was extracted from the ABIDE I and II databases (Di Martino et al., *Mol. Psychiat.*, 2014), while data from the mixed clinical group was acquired from students enrolled at the Brehm Preparatory School in Carbondale, IL. Resting state data were analyzed using CONN, v. 17f (Whitfield-Gabrieli and Nieto-Castanon, *Brain Connect.*, 2012). We found that connectivity between the salience and default mode networks was significantly predicted by age in the typically developing adolescent group ($p = 0.02$), but not in the mixed clinical adolescent group. Overall, the mixed clinical adolescent group displayed higher between network connectivity ($p < .001$) and lower within network connectivity ($p = .009$) compared to the typically developing adolescent group. Dynamic causal modeling is used to evaluate whether there is top-down influence of the salience network on other resting-state networks.

Topic Area: EXECUTIVE PROCESSES: Other

A43 Examining the Role of Learning in Cognitive Flexibility

Hayley E. O'Donnell¹, Evangelia G. Chrysiou¹; ¹Drexel University

A key question in the cognitive control literature involves determining the executive functions that mediate cognitive flexibility (CF) and the brain regions that support them. Recent perspectives have offered persuasive evidence suggesting that CF may be guided by low-level associative learning mechanisms. Empirical data have further shown that learning preferences may capture individual differences in CF. For example, when solving problems that capture CF, individuals who approach a learning task using reinforcement learning (RL), outperform those who approach the task using supervised learning (SL). Based on this evidence, we hypothesized that CF is a function of individual differences in learning preference (i.e., whether one tends to employ a supervised relative to a reinforcement learning strategy) and task demands. We examined this prediction in healthy native English speakers who were administered three CF tasks that incorporated either (i) a shifting component, or (ii) a divergent thinking component, or (iii) both shifting and divergent thinking elements. Participants were then administered a classic reward-based learning task, that could be approached either through a reinforcement or a supervised learning strategy. Using computational modeling, we determined each participant's learning style based on their response selection history on this task, which we used to predict CF performance. Results showed that different CF task components (i.e., whether the task involved the generation of novel strategies) interacted with participants learning preferences as captured by the independent learning task. We discuss how learning preferences might capture individual differences in CF, while revealing the possible neural mechanisms that support it.

Topic Area: EXECUTIVE PROCESSES: Other

A44 P3b as a function of visibility, accuracy, decision, and confidence

Lara Kriss¹, Steven J. Luck¹; ¹Center for Mind & Brain, University of California, Davis

Previous research has shown that the P3b ERP component is associated in some ways with conscious perception, but researchers have debated whether the P3b is a neural correlate of consciousness, whether it can occur outside of awareness, and whether it is associated with post-perceptual processes that are distinct from consciousness (e.g., decision processes, task relevance, metacognition). To address these issues, we manipulated stimulus visibility via backward masking during an oddball task. For each participant, target luminance was adjusted during pretesting to yield 75% correct performance with a mask SOA of 50 ms. SOAs of 0, 17, 33, 50, and 200 ms were used in the main experiment. Participants reported the direction of the stimulus (right/left arrows) and rated the confidence of each response. One stimulus was rare (.10) and the other was frequent (.90). We found that P3b amplitude was modulated by SOA, response accuracy, decision processes, and confidence: P3b amplitude was greater for longer than shorter SOAs, greater for correct than for incorrect responses, greater for 'hits' than for 'false alarms', and larger on high-confidence than low-confidence trials. P3b was absent for missed oddballs, indicating that participants were unable to produce a P3b response unless they were aware of the stimulus, arguing against the idea that P3b can occur outside of awareness.

Topic Area: EXECUTIVE PROCESSES: Other

A45 Relationship Between Media Multitasking and Executive Function Growth

John David Lorentz¹, Jessica Younger¹, Adam Gazzaley¹, Anthony Wagner², Melina Uncapher^{1,2}; ¹University of California, San Francisco, ²Stanford University

Recent research provides evidence for relatively consistent negative relationships between chronic media multitasking (MMT) and executive function performance (EF), yet the direction of influence has not been established. Some insight into the causal direction of this relationship may be gained from longitudinal investigations of MMT and EF in younger populations, as media use begins to increase. In this study, we assess the relationship between MMT and longitudinal change in EF in children 8 to 13 years old (N=709). As part of Project iLEAD (In-school, Longitudinal, Executive Function & Academics Database), we used an adaptive, tablet-based version of the Vogel change detection task with distractors to assess EF at three time points over two years. This task allowed us to assess two components of EF: working memory capacity and distractor filtering. We also administered self-report questionnaires to determine participants' engagement with various streams of media, as well as their Media Multitasking Index (MMI): the average number of media simultaneously used during one hour of media use. Linear mixed effects analysis of latent growth curves revealed a significant negative relationship between MMI and change in working memory capacity, such that participants reporting a higher MMI at timepoint 1 showed less change across the three timepoints. However, there was no significant relationship between MMI and change in distractor filtering. These results signify initial traction in the effort to determine whether, and to what extent, chronic MMT behavior causes observed differences in EF, or if underlying attentional differences predispose individuals toward MMT behavior.

Topic Area: EXECUTIVE PROCESSES: Other

A46 Resting State Clustering Analysis of Insular Cortex in Experienced Meditators

Brittany Strauss¹, Shahmeer Hashmat², Biao Cui², Jeremy Cohen¹, Jeffrey Rouse², Yu-Ping Wang²; ¹Xavier University of Louisiana, ²Tulane University

Previous literature indicates a correlation between meditation experience and increased connectivity in attentional and executive networks and in bilateral dorsolateral prefrontal cortices. Individuals less experienced in focused attention meditation experience higher rates of mind wandering, thus more activity in their default mode network. The insular cortex is an important "switch" in shifting brain resources between default mode and executive networks, and anterior insula shows structural changes according to meditation experience. Our study used voxel clustering analysis to define subregions of functionally similar areas of the insula in open source resting state fMRI scans of fourteen subjects with varying levels of experience in meditation. Similar to previous studies, we found three distinct functional insular clusters in each hemisphere. A significant negative correlation revealed that individuals with larger right anteroventral insular clusters experienced more negative affect. Furthermore, individuals with greater rightward asymmetry of anteroventral cluster size expressed significantly more negative affect. Individuals with larger right anterodorsal insular clusters reported greater mindfulness in daily life. These results are consistent with known insular subregion connectivity. Anteroventral insula is anatomically connected with amygdala, ventral tegmental area, superior temporal sulcus, and posterolateral orbitofrontal cortex and is heavily involved in affective processing. Anterodorsal insula, anatomically connected to anterior cingulate and dorsolateral prefrontal cortices, is a critical hub of the salience network responsible for switching between default mode and executive networks. Among meditators increased rightward dominance of anteroventral insular clustering is associated with greater negative emotional experiences while increased right anterodorsal clustering is associated with greater mindfulness.

Topic Area: EXECUTIVE PROCESSES: Other

A47 Studying executive functions during mental fatigue using functional near infrared spectroscopy (fNIRS)

Hans-Georg Kuhn¹, Simon Skau¹, Birgitta Johansson¹, Ingibjörg Jonsdottir², Lina Bunketorp-Käll³; ¹Department of Neuroscience & Physiology, University of Gothenburg, Sweden, ²Institute of Stress Medicine, Gothenburg, Sweden, ³Center for Advanced Reconstruction of Extremities, Sahlgrenska University Hospital, Gothenburg, Sweden

Mental fatigue after mild traumatic brain injury (TBI-MF) and in patients with Exhaustion Disorder (ED) is characterized by pronounced decline in cognitive performance after moderate cognitive activity. In this study, we investigated brain activity in the frontal cortex during prolonged mental activity in TBI-MF patients (n=20), ED patients (n=20) and controls (n=20). We chose a test-retest design of six neuropsychological tests in conjunction with fNIRS to study brain activation changes in the frontal cortex during prolonged cognitive activity. The TBI-MF group performed comparatively worse than the controls during the Stroop-Simon test and did not improve as much as the controls on Digit Symbol Coding (DSC). ED patients felt subjectively more fatigued during the procedure and performed worse in the mental control task PASMO compared to controls. For fNIRS imaging, a Stroop-Simon test showed no change over time, but the controls had more activity in larger parts of the frontal cortex compared to TBI-MF and ED patients. For the Symbol Search and DSC, the TBI-MF group had more frontal brain activation than controls. ED patients activated the PFC more in the sustained attention task OPATUS-CPTA. In the Symbol Search the ED patients had higher activity in left PFC and in the Digit Symbol Coding more activation in the right frontal cortex. As the TBI-MF subjects were studied more than 5 months after injury and ED subjects were diagnosed more than 3 years earlier, our data indicate that the problems persist longer after initial diagnosis than previously known.

Topic Area: EXECUTIVE PROCESSES: Other

A48 Feature segregation or integration in visual working memory?

Elena Galeano Weber¹, Haley Keglowsky², Arin Fisher², Silvia A. Bunge^{1,2}; ¹Helen Wills Neuroscience Institute, University of California, Berkeley, USA, ²Department of Psychology, University of California, Berkeley, USA

Mnemonic quality, or the precision which items can be stored in working memory (WM), is an important aspect of visual WM capacity. Previous studies focused on the precision for a single feature of an item (e.g., color); how different features of an item are represented is unclear – as is the role of each hemisphere in WM precision. Here, we used a continuous multiple feature recall task in adults (n=29) to investigate WM precision for both color and size. We found that increases in feature load within a dimension reduced precision (color: t=8.8; size: t=7.8, both p<.05). Additionally, WM for the two features interacted, such that size precision diminished as color feature load increased (t=8.2, p<.05); no such effect was found for color precision (t=0.12, p=0.9). To test whether feature integration occurs in a specific hemisphere, we are using a lateralized version of this task, wherein stimuli are encoded only in left or right hemisphere (LH or RH), or one and then the other. The preliminary pattern of results for RH encoding (n=6) mirrors those in the first experiment, supporting the hypothesis of RH dominance in visual WM. Further, LH showed a decrease with an increase in overall feature load; by contrast, RH showed increased precision when the two stimuli had no overlapping features (two colors, two sizes) relative to when they shared one feature – i.e., a lower overall feature load. These results suggest that distinct visual features are maintained separately in the LH, but integrated in the RH.

Topic Area: EXECUTIVE PROCESSES: Working memory

A49 How neural representational similarity between categorical visual stimuli affects working memory in young and older adults

Carolyn Guay^{1,2}, Bradley Buchsbaum^{1,2}; ¹University of Toronto, ²Baycrest Hospital

The inhibitory deficit hypothesis suggests that older adults fail to suppress irrelevant information at encoding, resulting in impaired memory for task-relevant items and increased priming of distracting information (Hasher et al., 1988). In contrast, younger adults filter out extraneous distractors, ultimately remembering targets better. We set out to explore the neural underpinnings of these differences by investigating how relevant and irrelevant items are represented in the brains of younger and older adults during visual working memory. Groups of 19 older (65-80) and 20 younger (18-35) adults were presented with two images each from two different semantic categories (faces, scenes, bodies, objects). One category was retroactively cued, indicating to participants which two images to retain in memory for an upcoming old/new recognition probe. Using a pattern classifier trained to discriminate between image categories, we computed a confusion matrix for each participant that showed how similar their neural representations of each category were. While younger adults' working memory performance was unaffected by the neural similarity of simultaneously presented categories, older adults counterintuitively performed better when similarity between target and distractor categories was higher. This contradicted our hypothesis that greater representational similarity would result in increased interference between stimuli, straining the older adults' already weaker inhibitory mechanisms and further impairing their memory for targets. Instead, these data suggest that older adults may benefit from more representationally similar targets and distractors, possibly due to a grouping strategy or to conservation of neural resources when two categories with greater feature overlap must be simultaneously maintained.

Topic Area: EXECUTIVE PROCESSES: Working memory

A50 Real-time triggering reveals that sustained attention and working memory lapse together

Megan T. deBettencourt¹, Paul A. Keene¹, Edward Awh¹, Edward K. Vogel¹; ¹University of Chicago

Attention and working memory are clearly intertwined, as shown by covariations in individual ability and their recruitment of similar neural substrates. Both processes fluctuate over time, and these fluctuations may be a key determinant of individual variations in ability. Theories suggest attention and working memory rely upon a common cognitive resource but do not address whether attention and working memory fluctuate together moment to moment. The goal of this study was to determine when attention and working memory fluctuate in synchrony, and then to leverage fluctuations of attention to optimize memory encoding. To examine this, we developed a novel hybrid task that interleaved a sustained attention to response task and a whole report working memory task. In Experiment 1, we established that performance fluctuations on these tasks correlated across and within participants, as attention lapses led to worse working memory performance. Experiment 2 extended this finding using a real-time triggering procedure that monitored attention fluctuations to probe working memory during optimal (high attention) or suboptimal (low attention) moments. We demonstrated that participants in a low attention state stored fewer items in working memory. Experiment 3 ruled out task-general fluctuations as an explanation for these covariations by showing that the precision of color working memory was unaffected by variations in attentional state. In sum, these findings highlight the utility of adaptive experimental designs to probe the relationship between attention and memory. We demonstrate that attention and working memory lapse together, providing new evidence for the tight integration of these cognitive processes.

Topic Area: EXECUTIVE PROCESSES: Working memory

A51 The Developmental Trajectory of Musical Working Memory in Children with Neurodevelopmental Disorders

Gwenaëlle Philibert-Lignières¹, Barbara Tillmann², Armando Bertone¹, Eve-Marie Quintin¹; ¹McGill University, Canada, ²Université Lyon 1, France

Music perception tends to be a strength in neurodevelopmental disorders. However, musical working memory has yet to be investigated. Our aims are to: 1) assess performance on a musical working memory task, and 2) investigate the developmental trajectory of performance on a musical working memory task in children with neurodevelopmental disorders. Participants (N=97) were separated into three different age groups: Younger (8-10 years old), Middle (11-14 years old), and Older (15-17 years old). Each participant completed three musical working memory tasks (3-, 4-, and 5-pitch sequence conditions). Performance on the musical working memory task was calculated as Hits minus False Alarms. Results demonstrate that participants in the younger group performed above chance on the musical working memory task for the 3- and 4-pitch conditions, and below chance-level on the 5-pitch condition. However, participants in both the middle and older groups performed above chance on the 3-, 4-, and 5-pitch conditions. Furthermore, we established that participants in the younger and middle groups performed significantly better on the 3-pitch condition in comparison to 4- and 5-pitch conditions, while older participants performed significantly better on the 3- and 4-pitch conditions in comparison to the 5-pitch condition. This may speak to a developmental trajectory of cognitive load capacity in working memory. Findings from this study reveals that using a different version of traditional working memory test (e.g. digit span) can potentially capture the developmental stages of working memory in children with neurodevelopmental disorders. Finally, this holds promise as an alternative measurement tool using a strength-based approach.

Topic Area: EXECUTIVE PROCESSES: Working memory

A52 EEG power differs in toddlers with versus without autism during natural social interaction with their parent

Elizabeth Norton¹, Brittany Manning¹, Silvia Lam¹, Sean McWeeny¹, Maranda Jones¹, Alexandra Abowd¹, Lauren Wakschlag¹, Megan Roberts¹; ¹Northwestern University

Most studies of the neural basis language and social development use artificial experimental tasks rather than true-to-life interaction. The goal of this study was to investigate the neural correlates of social engagement during a naturalistic face-to-face parent-child interaction, and whether these differed in children with autism spectrum disorder (ASD). We predicted that during moments of social engagement as compared with non-social engagement, typical toddlers would demonstrate increased theta power (representing greater social attention/cognitive engagement) and reduced of alpha and mu power (reflecting more general attention and motor processing); these effects were expected to be attenuated in ASD. Participants included toddlers age 24-44 months, 5 typically-developing (TD) children (3 girls) and 4 diagnosed with ASD (2 girls). 32 channels of EEG were recorded (Biosemi ActiveTwo). The parent and child sat next to each other and engaged in two activities: playing with a puzzle, and watching a nonsocial movie. Sessions were videotaped and coded offline to separate moments of social engagement (child engaged exclusively with their parent or in an activity jointly with their parent) and nonsocial engagement (child engaged with object/movie without interaction). Each subject had >30 clean 1s epochs per condition. Results: TD children had greater theta in the social vs. non-social engagement condition (M=5.7% increase, p=.026), and this difference was greater than the ASD group (M=-1.2%; p=.038). Alpha and mu activity did not differ significantly. These findings hint at early differences in social engagement in the brain in ASD that could provide insights for etiology and diagnosis of ASD.

Topic Area: LANGUAGE: Development & aging

A53 Exploring event-related potentials by subjective report as insight into explicit and implicit second language grammatical knowledge

Kara Morgan-Short¹, Alicia Luque¹, Irene Finestrat¹, David Abugaber¹; ¹University of Illinois at Chicago

An important issue in second language (L2) research is whether L2 knowledge and processing is explicit or implicit in nature. To address this issue, behavioral research has analyzed judgment data by subjective report, i.e., participants report the source of their judgment (rule, memory, intuition, guess). Judgments based on rule and memory purportedly reflect explicit knowledge and judgments based on intuition and guess purportedly reflect implicit knowledge (Deines, 2008). We explore whether analyzing event-related potentials (ERPs) by subjective report can provide further insight into the nature of L2 processing. We recorded EEG from 12 L2 Spanish learners (L1 English) as they judged the grammaticality of 120 Spanish sentences, half violations (word order and subject-verb agreement) and half correct. Participants provided a subjective report for each judgment. ERPs for target words were analyzed by subjective report (following Voss and Paller, 2009, for example), specifically for reports of 'rule' and 'intuition,' which were the most commonly reported sources. When learners reported judgments based on rule, ANOVAs yielded a significant, late-anterior positivity for word order and N400 trends for both word order and subject-verb agreement. No clear ERP effects were evidenced for intuition. Although data collection is ongoing, differences in ERPs by source might indicate that L2 grammar is processed differently when learners are relying on explicit or implicit knowledge as reflected by rule or intuition source reports. Conversely, similarities in ERPs for different source reports might indicate that L2 processing is largely independent of the type of knowledge that learners may have.

Topic Area: LANGUAGE: Development & aging

A54 Infant modulation of cortical mapping, discriminatory abilities and speech processing efficiency as a function of non-speech early acoustic intervention

Silvia Ortiz-Mantilla¹, Teresa Realpe-Bonilla¹, April A. Benasich¹; ¹Rutgers University-Newark NJ

During early development, the infant brain is highly plastic and sensory experiences modulate emerging cortical maps, enhancing processing efficiency as infants set up key linguistic precursors. We previously showed that early interactive acoustic experience (IAE) with spectrotemporally modulated non-speech stimuli facilitates optimal acoustic processing and generalizes to novel non-speech at 7-months-of-age. This study explores whether such experience-dependent effects also impact speech processing, discriminatory abilities and cortical mapping. At 9-months, infants who had received active (AEx) or passive (PEx) non-speech acoustic experience between 4-6 months were presented with a consonant-vowel contrast using a passive oddball paradigm and compared to 9-month-old naïve controls. Dense-array EEG/ERP was mapped onto an age-appropriate brain template. Source modeling placed dipoles in both auditory cortices. Temporal-spectral analyses were conducted in source space within the 2-90 Hz frequency range. Group differences were evaluated by changes in spectral power. AEx infants showed increased high-gamma (>70Hz) power within auditory cortices to the standard syllable, indicating IAE fosters processing of native speech thus facilitating advanced establishment of long-term phonemic representations. Left-lateralized gamma (>30Hz) power enhancement to the deviant syllable suggests IAE promotes phonemic discrimination abilities. Higher left beta power may reflect increased linking of sensory information and corresponding articulatory patterns. Bilateral decrease in theta power to standards suggests more mature automatized speech processing given that less neuronal resources were required to resolve the frequent syllable. Theta power increase in right auditory cortex, known for favoring slow-rate decoding, implies that

acoustic experience facilitates the more demanding processing of the infrequent deviant syllable.

Topic Area: LANGUAGE: Development & aging

A55 Morpholexical processes in visual word recognition across the adult life span: Major cross-sectional changes

William D. Marslen-Wilson¹, Melek Karadag¹, Alex Clarke¹, Lorraine Tyler¹, Caroline Whiting²; ¹University of Cambridge, UK, ²University of Glasgow, UK

Reading involves a complex set of analysis processes, where orthographic processing is followed by morphemic analysis and access to specific word meanings. Do these skills change over the adult lifespan, and if so how? We address these issues using spatiotemporally resolved MEG imaging methods on a sample from the CamCan population-derived cohort of 700 healthy individuals aged 18-88 years. Previous MEG studies with young adults identify reading-related regions in occipital, temporal and frontal cortex (Whiting et al., 2014). The current study investigates the timing and location of these processes across three groups of participants (Younger (n=25, ages: 22-38), Middle (n=25, ages: 46-60) and Older (n=25, ages: 70-88). Participants read silently 380 visual stimuli: simple words (e.g., biscuit), consonant strings (e.g., hywc), and morphologically complex words (jumped, darkness). MEG data were source localised using subjects' structural MRI scans. Early visual evoked responses showed parallel responses bilaterally in the occipital pole, slowing slightly with age (~10 ms). Striking cross-sectional changes emerged, however, in multivariate representational similarity analyses (RSA) testing for brain regions involved in cognitively complex morpholexical processes. The Younger group, consistent with earlier research, showed strong activation (from 250-450 ms post onset) along left ventral and lateral temporal lobes. The Older group showed no stable activation in these regions, with a contrasting pattern of later (400-550 ms) activation in left posterior parietal and inferior frontal regions. Although CamCAN behavioral data shows preserved reading proficiency across the adult lifespan, these spatiotemporally resolved data suggest age-related divergences in the neural systems involved

Topic Area: LANGUAGE: Development & aging

A56 Speech encoding in background noise is related to receptive language skills in infants 7-9 months of age

Cynthia Roesler¹, Silvia Ortiz-Mantilla¹, Julie Morgan-Byrne¹, Gabriella Musacchia^{2,3}, April Benasich¹; ¹Rutgers University, ²University of the Pacific, ³Stanford University Medical School

Maturation of speech perception ability depends on efficient neural encoding of rapid auditory changes in syllables, both in quiet and noisy background conditions. However, the impact of a noisy environment on language development at early stages is unknown. The brain response to speech sounds has been reliably recorded and analyzed across the lifespan via the complex Auditory Brainstem Response (cABR) to the speech syllable /da/. The response comprises two major auditory mechanisms: response to consonant onset (Waves V and A) and the frequency following response (FFR), which encodes the vowel periodicity. Collectively, these measures provide insight into the complexity of auditory processing involved in normal communication. We recorded monaural cABRs to /da/ with awake 7- to 9-month-olds in quiet (DaQ) and embedded in background noise (DaN). All peaks in DaN were delayed and some peaks were attenuated, compared to DaQ. This suggests that syllable perception at the brainstem level is vulnerable to disruption as a result of background noise. Latency and amplitude measures of the consonant onset (Wave V) in the noise condition were significantly correlated with receptive communication scores on the Bayley Scales of Infant Development. Significant correlations were also observed for latency and amplitude within and across onset and FFR measures, suggesting that the mechanisms for encoding transient and

sustained features are not yet independent. Results indicate that infants with more robust speech encoding in noise have better language comprehension. This suggests that the cABR is likely a behaviorally relevant measure of auditory integrity during early language acquisition.

Topic Area: LANGUAGE: Development & aging

A57 Effect of Cognate Status on Lexical Selection Competition: A Theta-Based Study

Jamie Renna¹, Yazmin Medina¹, Katherine J. Midgley¹, Phillip J. Holcomb¹, Ksenija Marinkovic^{1,2}; ¹San Diego State University, USA, ²University of California, San Diego, USA

While a fluent bilingual individual is speaking in one language, their other language may also be activated indirectly via orthographic or semantic cues creating selection competition. False cognates are unique words which are similar in form but different in meaning across languages (e.g., English “sunrise” translates to “amanecer” in Spanish, while Spanish “sonrisa” means “smile” in English). The aim of the study was to examine cross-language interference in a group of nineteen L1 Spanish / L2 English bilingual speakers (21.4 ± 2.6 years of age). Participants were instructed to verbally translate individual, visually presented words as EEG data were recorded with a 32-channel system. English and Spanish words were intermixed and included 100 of each, false cognates, real cognates (“map - mapa”), and regular words (“dog - perro”). Performance was the lowest and reaction times were the slowest for false cognates compared to cognates and regular words. Data were analyzed in the time-frequency domain with Morlet wavelets in theta frequency (4-7 Hz) which is sensitive to semantic retrieval as well as cognitive conflict. Longer latencies of event-related theta power to false cognates compared to cognates and real words suggest a delayed retrieval of the false cognate meaning due to interference by orthographically related words. In contrast, cognates and regular words may be easier to translate as lexical selection is not impeded by an erroneous translation candidate, as is the case for false cognates. These findings further suggest event-related theta power may be suitable for studying retrieval in real time.

Topic Area: LANGUAGE: Lexicon

A58 Language Development in Deaf Children with Cochlear Implants

Kurt Winsler¹, Laurie Lawyer², Sharon Coffey-Corina³, Kristina Backer⁴, Lee Miller³, David Corina³; ¹Department of Psychology, University of California, Davis, ²University of Essex, U.K., ³Center for Mind and Brain, University of California, Davis, ⁴Dept. of Cognitive and Information Sciences University of California, Merced

Deaf children who have received a cochlear implant(s)(CI) early in life often show gains in the development of spoken language, however great variability in language outcomes exist (Tobey et al., 2012). Few studies have provided neurophysiological data on the development of language abilities in these children. As part of a longitudinal study we examined ERP responses elicited during the ambient listening of auditory sentences. We examined ERP responses from typically hearing adults and children, and congenitally deaf children with cochlear implants. We report P1 cortical evoked potentials to auditory stimuli and examine the lexical effects of word frequency. Hearing adults (n = 21) and children (n = 31, ages 1.9 mos. - 8.8 years) showed reliable P1 responses, with expected age-related changes in the hearing cohorts. Hearing adults and children showed greater negativities for low frequency words in a N-400 time window (p. < 01; p. < .001 respectively). Developmentally this effect became larger with age (p < .001). Children with CI (n = 38, ages 1.8 mos -8.9) showed a P1 that was reduced in amplitude and was variable as a function of time in sound (TIS). Children with CI's showed that low frequency words elicited a more left-hemisphere positivity (p

= .007). This pattern of responses suggests a more immature profile. We consider developmental changes across time using item-level linear mixed effects models to predict EEG amplitudes from lexical characteristics of these stimuli.

Topic Area: LANGUAGE: Lexicon

A59 Re-Learning to Be Different: Neural Differentiation Supports Post-stroke Language Recovery

Jeremy Purcell^{1,2}, Robert Wiley¹, Brenda Rapp¹; ¹Department of Cognitive Science, Johns Hopkins University, USA, ²Maryland Neuroimaging Center, University of Maryland, USA

Little is known about the changes in neural representations that support post-stroke recovery. Recent work suggests that the local differentiation of neural responses reflects representational integrity and learning, with differentiation increasing with expertise and learning (e.g., Jiang et al., 2013). We apply a novel technique – Local-Heterogeneity Regression (Local-Hreg) - to examine neural representations before and after behavioral treatment in 20 individuals with acquired dysgraphia due to stroke. For treatment, individuals were trained to spell an individualized word list for approximately 3 months. fMRI with a spelling task was carried out pre- and post-training. A whole-brain, Local-Hreg searchlight and traditional GLM analysis were performed. Local-Hreg measures local neural differentiation by quantifying the relative dissimilarity in the BOLD response across adjacent voxels within a search light. Overall, we found converging evidence that high neural differentiation in the left ventral occipitotemporal cortex (vOTC) was related to better performance and predicted future improvements due to treatment. We also found that there were selective increases in neural differentiation within the left vOTC and that the amount of increase was related to the magnitude of behavioral improvements. Finally, we did not observe any changes in mean BOLD response within the left vOTC, nor did we observe any relationship with behavior. This work provides a novel approach for quantifying neural re-differentiation of local representations, and reveals that this measure can be used to index performance, predict response to treatment and quantify neural changes due to re-learning in post-stroke recovery.

Topic Area: LANGUAGE: Lexicon

A60 Relationships between attention, cognitive control, and within- and between-language control in bilingual persons with aphasia

Teresa Gray¹, Sarah Villard², Chaleece Sandberg³; ¹San Francisco State University, ²Boston University, ³Penn State University

This study examines the relationships among attention, cognitive control, bilingual language control, lexical access, and semantic control in bilingual aphasia. Data from seven English dominant Spanish-English bilingual persons with aphasia (BPWA) has been collected. Participants completed: 1) a nonlinguistic attention task requiring inhibition of visual/auditory stimuli, 2) a cognitive control task requiring inhibition of stimuli based on color/shape, 3) a Spanish-English language control task involving both within- and between-language conditions, 4) a semantic control task requiring inhibition of unrelated /related distractors (in English as well as in Spanish), 5) the Bilingual Aphasia Test (BAT), and 6) a category fluency task. Spearman correlations (alpha = .05) identified significant relationships among the variables. Significant correlations between the language control task and category fluency and the BAT indicate that the ability to control languages is associated with lexical access and language skill in each language. Significant correlations between the Spanish semantic association task and Spanish and English category fluency and the BAT subtests suggest that in the weaker language, the related distractor may facilitate lexical access, rather than inhibit lexical access. Finally, a significant correlation between attention and lexical access indicates that better attention was associated with better lexical access. These

preliminary results provide evidence for a relationship between language control and lexical access, that language dominance may influence lexical access and semantic control, and that nonlinguistic attention may be linked to lexical access.

Topic Area: LANGUAGE: Lexicon

A61 Transforming acoustic input into a hierarchy of linguistic representations

Laura Gwilliams^{1,2}, Jean-Remi King³, David Poeppel^{1,4}; ¹New York University, ²NYU Abu Dhabi, ³Facebook AI Research, ⁴Max Planck Institute

Language comprises multiple levels of representation, from phonemes (e.g. /b/ /p/) to lexical items (e.g. bear, pear) to syntactic structures (e.g. bears [SUBJECT] eat [VERB] pears [OBJECT]). Here we address two research questions that arise in online processing of naturalistic speech: 1) which representational states are encoded in neural activity; 2) what overarching algorithm orchestrates these representations to ultimately derive meaning? Participants listened to spoken narratives while magnetoencephalography (MEG) was recorded. From those recordings we decode and localise phonological, lexical and syntactic operations using machine learning approaches. First, acoustic-phonetic features (e.g. voicing, manner, place of articulation) could be successfully discriminated from a sequence of neural responses unfolding between ~100 ms to ~400 ms after phoneme onset. Second, part of speech (e.g. verb, noun, adjective), indicative of lexical processing, was decodable between ~150 ms and ~800 ms after word onset. Third, we could track proxies of both syntactic operations (e.g. number of closing nodes) and syntactic states (e.g. depth of tree). Interestingly, some of these syntactic representations were clearly present several hundreds of ms before word onset, whereas others maximally peaked ~300 ms later. These sustained and evoked MEG responses suggest that the human brain encodes the representations proposed by linguistic theories. Importantly, the corresponding neural assemblies overlap in space and time, possibly facilitating concurrent access across these low-to-high-level representations, in a cascade-type architecture. Finally, our study demonstrates how the combination of machine learning and traditional statistics can bridge the gap between spatiotemporally-resolved neuroimaging data and rich but tractable naturalistic stimuli.

Topic Area: LANGUAGE: Lexicon

A62 Comparing embodiment of action verbs in first and second language: a chronometric TMS study

Elisa Monaco¹, Monica Lancheros Pompeyo¹, Sylvain Harquel^{2,3}, Eric Schmidlin⁴, Jean-Marie Annoni^{1,5}; ¹Laboratory for Cognitive and Neurological Sciences, University of Fribourg, Switzerland, ²Laboratory of Psychology and NeuroCognition, National Center for Scientific Research, University of Grenoble Alpes, France, ³IRMAGE Neuroimaging facility, National Center for Scientific Research, University of Grenoble Alpes, France, ⁴Laboratory Of Neurophysiology Of Action And Hearing, University of Fribourg, Switzerland, ⁵Neurological Unit, Fribourg cantonal Hospital, Switzerland

According to embodied theories of cognition, understanding sensorimotor related words entails activating the corresponding sensorimotor brain areas. While many studies investigated such a sensorimotor involvement in the first language (L1), only few studies did it in a second language (L2), showing either that L2 is as embodied as L1 or that L2 is embodied to a lesser extent than L1. Our aim was to directly compare the embodiment of semantic representations between a L2 acquired late and L1, both in terms of magnitude and timing. To this end, we investigated the effect of single-pulse transcranial magnetic stimulation (TMS) on the excitability of the motor cortex for L1 and L2 motor-related (e.g., "grasp") and non-motor related action verbs (e.g., "believe") presented to 32 late bilinguals (L1=French, L2=English) while

performing a semantic task. We applied the TMS at four different latencies known to encompass early and late word lexico-semantic processing (from 125 to 500 ms post word onset) and recorded the TMS-induced motor evoked potential (MEP) amplitudes. Results revealed a smaller amplitude of the MEPs for motor as compared to non-motor verbs in L1 when stimulating at 350 ms post word onset. Furthermore, independently of the type of verbs, L1 and L2 showed different motor cortex excitability depending on the timing of the stimulation. These findings provide further evidence that L1 and L2 are differently embodied, and open to the possibility that this difference is explained in terms of different timing of the motor involvement.

Topic Area: LANGUAGE: Other

A63 Testing the perceptual locus of the word superiority effect

Micha Heilbron^{1,2}, David Richter¹, Matthias Ekman¹, Floris de Lange¹, Peter Hagoort^{1,2}; ¹Donders Institute for Brain, Cognition, and Behaviour, Nijmegen, The Netherlands, ²Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands

Letters are more easily identified when embedded in a word. Historically, two accounts have been proposed to explain this 'word superiority effect'. Under the guessing-based account, letter identification occurs in a bottom-up fashion, and the advantage offered by word contexts is merely a post-perceptual advantage in guessing. Alternatively, perceptual accounts explain the word-superiority phenomenon as a top-down effect, proposing that higher-order (lexical/phonological) knowledge can enhance perception itself. Although decades of behavioral work consistently tended to support top-down models, neuroscientific evidence for the top-down nature of the word superiority effect is lacking. Here, we present a novel paradigm to distinguish between top-down and bottom-up accounts, by testing for the perceptual locus of the effect. We presented streams of 5-letter word or non-word items with a fixed middle letter. Neural network simulations of the task confirmed that in a recurrent architecture, sensory representations of the middle character are enhanced in word versus non-word contexts, whereas in a bottom-up architecture there is no difference between the two. In a subsequent fMRI experiment (n=34), orthographic judgements were faster and more accurate for word than non-word items. Moreover, we were able to decode middle-letter identity with high fidelity from early visual cortex. Strikingly, representational letter information was enhanced in words compared to nonword contexts. These results suggest that word superiority is (at least in part) a perceptual effect, and support influential 'interactive' models of reading.

Topic Area: LANGUAGE: Other

A64 Left frontal lobe and propositional language

Adithya Chandregowda¹, Joseph Duffy¹, Mary Machulda¹, Val Lowe¹, Jennifer Whitwell¹, Keith Josephs¹; ¹Mayo Clinic

A 72-year-old right handed male presented with two and a half year history of communication difficulty. On a detailed speech and language examination, he had significant difficulty with propositional language, but well-preserved auditory comprehension, grammar, naming and repetition. There was no evidence of behavioral dyscontrol. MRI scan showed mild frontal lobe atrophy, and a fluorodeoxyglucose PET scan showed left lateral frontal hypometabolism. His profile was most consistent with the clinical entity known as dynamic aphasia. The detailed speech and language, neurological, neuropsychological and neuroimaging testing sheds light on the features of primary progressive dynamic aphasia.

Topic Area: LANGUAGE: Other

A65 The “Cost-free” Code-mixing in Trilinguals: A Revision to the Adaptive Control Hypothesis

Mingyu Yuan^{1,3}, Nga Yan Hui^{2,3}, Manson Cheuk-Man Fong^{2,3}, William Shi-Yuan Wang^{2,3}; ¹Department of English, The Chinese University of Hong Kong, ²Department of Chinese and Bilingual Studies, The Hong Kong Polytechnic University, ³Research Centre for Language, Cognition, and Neuroscience, The Hong Kong Polytechnic University

Bilingual speakers frequently juggle two languages that are co-active during language processing. Switching back and forth between two languages, therefore incurs great cognitive cost. Whether language switching is particularly less or more effortful in certain bilinguals remains unclear. The present study zooms into trilingual speakers in Hong Kong, proposing that intra-sentential code-switching (i.e., code-mixing) between L1 and L2 is less taxing for this population. Seven Cantonese(L1)-English(L2)-Mandarin(L3) trilinguals were recruited. A language history questionnaire was administered to investigate their use of code-mixing. A cognitive battery consisting eight tasks was conducted to assess inhibition, attention, working memory and executive control. Task results and participants' frequencies of code-mixing in different contexts were put into a regression model. Results suggest that the frequency of code-mixing between L1 and L2 with peers significantly predicts better performance in working memory and attention, but has little influence on inhibition control. A possible explanation is that code-mixing frequency between L1 and L2 is way higher than that between L1/L2 and L3. Further, participants do not deliberately code-mix between L1 and L2, rather, code-mixing is a product of spontaneous communication because most Cantonese(L1) equivalents of English(L2) that they code-mix is rarely used in daily communication. Although switching between two languages activates general processing in BA44/45, switching is not particularly effortful for this population. Taken together, the dense code-switching context that Green and Abutalebi (2013) proposed in Adaptive Control Hypothesis to account for switching cost should be further revised to fit the Hong Kong context.

Topic Area: LANGUAGE: Other

A66 The Foreign Language Effect on Social Attitudes: An ERP study of Emotional Processes of Chinese-English Bilinguals

Yi-Lin Chen¹, A. K. Tzeng¹; ¹Chung Yuan Christian University

Previous studies revealed that people tended to make more unbiased decision and utilitarian judgments and decisions when problems were presented in a foreign language (FL) rather than in the native language (NL). This “foreign language effect (FLe)” was repeatedly found in a wide variety of studies in the area of decision-making such as moral judgment and economic paradoxes. The present study aimed to investigate the mechanism of FLe, specially the impact of emotion. A priming ERP experiment was conducted to investigate how emotion and language interact with each other to influence Chinese-English bilinguals' attitudes toward social issues. Participants were randomly assigned to two language groups. They first saw emotion-oriented primes in either Chinese or English, and were then asked to make positive or negative judgments on possibly controversial social issues. N400 and LPP indicated the meaning construction and emotional responses, respectively. Results revealed that participants in English group were less affected by emotion-oriented primes, and therefore, social and personal attitudes were more consist than in Chinese group. N400 was modified by languages and emotion valence of the primes. N400 amplitudes were more negative-going in Chinese than in English. On the other hand, LPP were more pronounced in positive-prime condition than in negative-prime condition. Overall, emotion was more influential in NL than in FL. In line with previous studies, we proposed that emotional connotation was weak in retrieving negative association in FL. Hence, the present study supported that emotion was a key factor of the FLe.

Topic Area: LANGUAGE: Other

A67 Tracking the subprocesses of pronoun resolution during naturalistic comprehension

Jixing Li¹, John Hale²; ¹New York University Abu Dhabi, ²University of Georgia

The current study aims to disentangle the complex process of linking a pronoun to its antecedent during naturalistic comprehension. We correlated brain activity associated with the three layers of a neural network model for pronoun resolution while participants listened to an audiobook during fMRI recording. 49 English speakers (30 females, mean age=21.3) listened to “The Little Prince” for about 100 minutes. BOLD functional scans were acquired using a multi-echo planar imaging sequence with online reconstruction (TR=2000 ms; TE's=12.8, 27.5, 43 ms; FA=77; matrix size=72x72; FOV=240.0x240.0 mm; 2x image acceleration; 33 axial slices, voxel size=3.75x3.75x3.8 mm). The audiobook contains 446 third person pronouns, and for each pronoun, three 100-dimension vectors were generated by a feed-forward neural coreference model trained on the CoNLL-2012 corpus. The input layer encodes word embeddings and discourse-level features. We then modeled the observed BOLD signals using the first five principal components of the three layers time-locked at the offset of each pronoun in the audiobook. We also included four control regressors: presence of the pronouns, word rate, word frequency and RMS intensity. The results revealed significant left Precuneus activity for the first component, and significant right Precuneus activity for the fourth component. The third component is associated with the largest cluster in the left Inferior Frontal Gyrus ($p < 0.05$ FWE, $k > 50$, see Figure 1). Taken together, our results suggest a functional neuroanatomy of pronoun resolution where the Precuneus supports discourse-level processing (e.g., Kuperberg et al., 2006) and the left IFG subserves morpho-syntactic processing (e.g., Hammer et al., 2007).

Topic Area: LANGUAGE: Other

A68 Colored by language? The role of latent decision processes and left anterior temporal cortex in categorical color perception

Seda Akbıyık^{1,2}, Şerife Leman Runyun², Egemen Genç², Tilbe Gökşun², Fuat Balci²; ¹Harvard University, ²Koç University

Evidence suggests that cross-category hues are differentiated easier and more accurately than otherwise equidistant hues that belong to the same linguistic category. However, there is not yet a consensus regarding the nature of these effects in color perception, whether it is due to a modification of the perceptual space or due to an advantage during online processing. To address this issue, we investigated color naming and discrimination via binary choice task paradigms with the aim to elucidate the latent decision-making processes and neural mechanisms underlying these phenomena. In Experiment 1, we collected data from a binary color naming task to trace how parameter estimates of Diffusion Decision Model (DDM) change as a function of color typicality. Model fits for the naming task provided a more coherent picture than the standard descriptive psychophysical function. In Experiments 2-3, we used 2AFC successive and simultaneous same-different task paradigms, respectively, to trace the category-advantage in two theoretically-relevant parameters of the DDM; drift rate and non-decision time. While an increase in drift rate (rate of evidence accumulation) characterized the category-advantage, no such change was observed in non-decision time. In Experiment 4, we applied double-blind, sham-controlled transcranial direct current stimulation to investigate whether inhibiting the activity of the left anterior temporal lobe, an area which plays a key role in semantic based top-down modulation on visual perception, would disrupt category-advantage in color discrimination. Altogether, our findings provide insights for evaluating theoretical perspectives on language-color interaction.

Topic Area: LANGUAGE: Semantic

A69 Common neural system for sentence comprehension across languages: A Chinese-Japanese bilingual study

Zhengfei Hu¹, Shuhei Nishida¹, Yuxiang Yang¹, Carol Madden-Lombardi², Jocelyne Ventre-Dominey², Peter Ford Dominey², Kenji Ogawa¹; ¹Hokkaido University, ²INSERM

Common semantic representations for individual words across languages have been identified, but a common meaning system at sentence-level based on the grammatical construction of words has not been determined. In this study, fMRI was used to investigate whether an across-language sentence comprehension system exists. Chinese-Japanese bilingual participants (n = 32) were asked to determine whether two consecutive stimuli were related (congruent) or not (incongruent) to the same event. Stimuli were displayed with three different modalities (Chinese written sentences, Japanese written sentences, and photographs). The behavioral results showed no significant difference in performance among the three modalities. Multi-voxel pattern analysis (MVPA) of fMRI data was used to classify the semantic relationship (congruent or incongruent) across the stimulus modalities. The classifier was first trained to determine congruency within Chinese sentences, and then tested with Japanese sentences, and vice versa. A whole-brain searchlight analysis revealed significant above-chance classification accuracy (chance level = 50%) across Chinese and Japanese sentences in the supramarginal gyrus (BA40), extending into the angular gyrus (BA39), and the opercular (BA44) and triangular (BA45) part of the inferior frontal gyrus in the left hemisphere (cluster-level FWE corrected $p < 0.05$). Significant above-chance classification accuracy was also found across Japanese sentences and photographs in the supramarginal (BA40) and angular gyrus (BA39). These results indicate that a common meaning system for sentence processing across languages and modalities exists, and it involves the left inferior parietal gyrus.

Topic Area: LANGUAGE: Semantic

A70 Lexical-semantic and executive deficits revealed by computational modelling: a drift diffusion model perspective

Lara Todorova¹, David Neville¹, Vitoria Piai^{1,2}; ¹Radboud University, Donders Institute for Brain, Cognition and Behaviour, Donders Center for Cognition, Nijmegen, ²Department of Medical Psychology, Radboud University Medical Center, Nijmegen

When asked to match a word to a picture, participants are slower and less accurate for related word-picture pairs (word: banana, picture: apple) relative to unrelated pairs (word: banjo, picture: apple). The underlying nature - semantic or executive - of this interference effect is still debated. We analyzed the word-picture matching (WPM) performance of patients with stroke-induced lesions to the left-temporal (N = 6) or left-frontostriatal cortex (N = 6) and matched controls (N = 12) using drift diffusion model (DDM). DDM considers decision making as a process of stochastic evidence accumulation described by model parameters (i.e., decision boundary and drift rate), which have established cognitive interpretation. The model parameters were compared between controls and patients to investigate the mechanisms of WPM interference. WPM performance in controls tapped into the amount of information (decision boundary) needed to make a decision: a higher threshold was associated with related relative to unrelated word-picture pairs, but there was no difference in the quality of the evidence (drift rate). This suggests an executive rather than semantic mechanism underlying WPM interference. Patients with lesions to left-temporal cortex showed no differences either in drift rate or decision boundary between conditions. By contrast, patients with frontostriatal lesions exhibited both increased drift rate and decision boundary for unrelated relative to related pairs. Thus, left-frontostriatal and temporal damage affects the computations required by WPM differentially, resulting in systematic deficits across lexical-semantic memory or executive functioning. These results support a neuronal dissociation between lexical-semantic memory and semantic control mechanisms.

Topic Area: LANGUAGE: Semantic

A71 Neural specialization of reading in young children

Avantika Mathur¹, Fatima Sibaii^{1,2}, Yingying Wang^{1,2}; ¹Neuroimaging for Language, Literacy and Learning Lab, Department of Special Education and Communication Disorders, University of Nebraska-Lincoln, NE 68583, ²Biomedical Engineering, University of Nebraska-Lincoln, NE 68503

The specialization of language network is not well defined in preschoolers. As children transition from preschool to elementary school, they show dramatic changes in their reading ability as they gain phonemic information (auditory processing of speech sounds) and semantic knowledge (storage and retrieval of word meaning) of language. This study aims to identify the early specialization of brain regions for phonological and semantic processing in young children. 20 typically developing children underwent behavioral testing to assess their IQ (KBIT) and reading ability (WRMT III). A familiarity task was conducted, during which children were required to read 3-5 letter words and choose a picture that best represents the word. Seven children with > 70% accuracy in this task underwent functional magnetic resonance imaging (fMRI) scans (age: 6.1 [0.9], FIQ: 109.34 [7.64]). fMRI tasks include a visual rhyming judgment and a semantic judgment task. Specifically, for the rhyming task, children recruited dorsal temporo-parietal regions including the left posterior superior temporal gyrus and angular gyrus. Contrarily, for the semantic task, children recruited the ventral occipito-temporal regions including the left sup. occipital, fusiform and inferior temporal gyrus. For both tasks, children recruited bilateral fronto-temporo-parietal regions, including the bilateral IFG. Our findings suggest that by the age of 4-6 years, typically developing children already have some brain regions specialized for phonological and semantic processing. The involvements of brain regions in both hemispheres suggest that the left lateralized language network is yet not fully developed in this age range.

Topic Area: LANGUAGE: Semantic

A72 The dynamic construction of narrative structure

Claire Hui-Chuan Chang¹, Christina Lazaridi¹, Yaara Yeshurun², Kenneth A. Norman¹, Uri Hasson¹; ¹Princeton University, ²Tel-Aviv University

This study investigated how narrative structure builds up over time. We created a narrative with two seemingly unrelated story lines, A and B, that merged in the C part into a unified narrative. The narrative consisted of 45 segments. A and B segments were presented in an interleaved manner in the first 30 segments followed by 15 C segments (ABABCC). The text was authored for the specific experiment by a professional screenwriter (Lazaridi) with a focus on capturing the audience's attention. Furthermore, in A and B segments, the author incorporated unique memory plants (e.g. a pot of chili) that recurred in the C part to bridge specific events. Functional magnetic resonance imaging data from 25 subjects was collected while they listened to the narrative. With representational similarity analysis, we found, in the first 30 segments, higher similarity between segments from the same (A or B) than different story lines in precuneus, bilateral posterior superior/middle temporal gyrus, and bilateral insula. This distinction between story lines increased as the narrative unfolded over time. In contrast, we found that neural patterns evoked by the C segments were more similar to patterns evoked by the A and B story lines than the A and B patterns were to each other. Furthermore, in part C, we found that the memory plants triggered specific activation patterns observed during the encoding of the memory plants in the A and B segments. Our results shed light on how the brain retains and integrates information as a narrative unfolds.

Topic Area: LANGUAGE: Semantic

A73 Age-related changes in neural event processing and segmentation

Zachariah Reagh^{1,2,5}, Charan Ranganath^{2,3,4,5}; ¹Department of Neurology, ²Center for Neuroscience, ³Department of Psychology, ⁴Memory and Plasticity Program, ⁵University of California, Davis

The way we segment experience into distinct events critically relates to our ability to represent and remember meaningful pieces. However, this aspect of daily life is not captured by the majority of laboratory tasks. Event segmentation is remarkably consistent across individuals, but becomes less so with advanced age, suggesting that a fundamental process for representing real-world experiences may be vulnerable to the aging process. Here, a sample of 552 healthy adults ranging from 18 to 88 years old passively viewed a short film while brain activity was measured using functional MRI. We found that brain activity in early visual areas, corresponding to rapid visual changes in the film, was minimally affected by aging. Conversely, a network of cortical regions and the hippocampus showed increased activity at event boundaries, but this activity differed across the range of ages. Activity in posterior medial cortex, angular gyrus, parahippocampal cortex, and the hippocampus decreased with age, whereas activity in medial prefrontal cortex and middle temporal gyrus increased with age. Moreover, older individuals featured a breakdown of event boundary-related hippocampal correlations with angular gyrus present in younger adults. Finally, this event boundary-related neural activity predicted memory for stories, but did not predict measures of other cognitive abilities. These results provide insight into the way our ability to perceive and utilize meaningful shifts in dynamic real-world experiences may be affected by aging.

Topic Area: LONG-TERM MEMORY: Development & aging

A74 Age-related impairments for memory updating in healthy older adults

Branden Kolarik¹, Shauna Stark¹, Craig Stark¹; ¹University of California, Irvine

Updating memories with new information often requires discriminating between similar inputs to detect changes relative to the initial memory. This process relies on hippocampal structures, which are highly susceptible to age-related changes. Based on a task used with rodents, we developed a task to assess how age-related hippocampal changes impact memory updating in older adults. During encoding, pairs of identical fractals appeared in two of 8 locations on a touchscreen (6 pairs, 20x each). On each trial, the first fractal appeared in location A1 and participants tapped the screen where the second fractal would appear (A2). Over multiple presentations, accuracy improved as participants learned and remembered the location pairs. After a 20-minute filled delay, we again presented fractal pairs. While the first image location remained the same (A1), the second image location for half of the pairs changed (A3), requiring participants to update previously learned information (A1-A2) to incorporate the new location (A1-A3). At test, a fractal was shown at A1 and again, participants tapped the screen where they believed the second image would appear. By comparing performance at the chosen location on updated pairs, we calculated an Updating Index (updated/original location). Younger (18-24) and older (60-78) individuals were equally able to perform the task in the No Update condition. However, older adults demonstrated a decrease in the Updating Index for the updated locations, indicating an age-related impairment in memory updating. This task provides an important bridge for evaluating age-related hippocampal dysfunction in both humans and rodents.

Topic Area: LONG-TERM MEMORY: Development & aging

A75 Age-related modulation of functional connectivity along the long-axis of the hippocampus

Shauna Stark¹, Amy Frithsen¹, Craig Stark¹; ¹University of California, Irvine

A number of lines of evidence, from neuroanatomical through functional imaging, have supported the notion that the hippocampus demonstrates circuit-level specificity of function, both when segmented based on subfields (CA1, CA3, DG, and subiculum) and along the longitudinal axis. There is also evidence that aging may have differential effects across subfields (e.g., DG/CA3) and along the longitudinal axis. For example, there is evidence for an age-related shift in functional connectivity in the hippocampus from anterior to posterior regions (Blum et al., 2014; Damoiseaux et al., 2016). However, the ratio of hippocampal subfields varies along the longitudinal axis of the hippocampus and may better capture these age-related alterations in connectivity. Here, we sought to evaluate the functional connectivity profile between the hippocampus and the medial temporal lobe to determine how these segmentation models capture age-related changes in this circuit. We calculated subfield-level volume and functional connectivity during an incidental recognition memory task in 31 young (20-39 years) and 31 older (70-87 years) adults, controlling for differences in regional volume. We replicated the age-related functional connectivity shift (e.g., hippocampus to parahippocampal cortex) from the anterior to the posterior hippocampus. The degree of this shift also predicted mnemonic discrimination performance in older adults. Critically, the DG/CA3 is most represented in the anterior portions, suggesting that the anterior to posterior shift can be accounted for, in part, by subfield-specific computations as they are disproportionately represented along the long axis of the hippocampus.

Topic Area: LONG-TERM MEMORY: Development & aging

A76 Compensatory Neural Networks for Object Memory Recognition in Early Parkinson's Disease

Brenda Hanna-Pladdy¹, Li Jiang¹, Samantha Williams¹, Paul Fishman¹, Rao Gullapalli¹; ¹University of Maryland School of Medicine, Baltimore

Cardinal features of idiopathic Parkinson's disease (PD) include motor features, although non-motor features such as cognitive impairment are common early in the disease process and can dominate in advanced stages creating significant disability. The neural mechanisms mediating variable cognitive deficits and their progression in PD are poorly understood. To evaluate the utility of task-activated fMRI as a probe for mild cognitive deficits, we evaluated early stage PD patients on a novel object memory task. Patients were evaluated with an fMRI event-related memory task using fractal images to examine neural patterns during encoding, immediate and delayed object recognition. BOLD patterns across memory conditions displayed agreement with previously established object memory literature. However, PD patients with lower memory performance recruited additional frontal regions bilaterally during delayed recognition. These findings are consistent with previously reported frontally mediated recruitment in aging for memory compensation prior to significant cognitive deficits. Further investigation of compensatory networks has potential to elucidate variability in cognitive performance in aging and neurodegeneration, and allow for early detection of patients at risk for future cognitive progression.

Topic Area: LONG-TERM MEMORY: Development & aging

A77 Early-life stress and habitual responding in instrumental learning

Alexander Gordon¹, Tara Patterson¹, Barbara Knowlton¹; ¹University of California, Los Angeles

Exposure to early-life stress is associated with widespread negative effects in adulthood, including substance abuse, addiction and obesity. One potential mechanism of this association is an over-reliance on habitual rather than goal-directed behavior. To assess the link between early-life stress and tendency for habitual responding we developed an instrumental learning paradigm in which participants must learn to make correct responses to warning fractal images to avoid losing points from one of two paired banks. Responding to the warning fractal after it had been devalued indicated a habitual response. Early-life stress, measured by the short form Childhood Trauma Questionnaire, was not associated with responses during extinction after devaluation; however, scores on the physical neglect subscale were. Binary logistic regression found early-life exposure to physical neglect to be significantly associated with habitual responding while controlling for levels of depression, perceived stress, trait and state anxiety and the Big Five personality factors. The odds of habitual responding among people who have experienced early-life exposure to physical neglect are 3.01 times higher than people who have experienced no early-life physical neglect. These results suggest that exposure to some forms of early-life stress bias people towards habitual behavior in adulthood, which may mediate the association between early-life stress exposure and negative health outcomes in adulthood.

Topic Area: LONG-TERM MEMORY: Development & aging

A78 Nonverbal declarative memory in older adults: effects of age, sex, and education

Jana Reifegerste^{1,2}, João Verissimo³, Michael D. Rugg⁴, Mariel Y. Pullman⁵, Laura Babcock⁶, Dana A. Gleit⁷, Maxine Weinstein⁷, Noreen Goldman⁸, Michael T. Ullman¹; ¹Department of Neuroscience, Georgetown University, Washington DC, USA, ²Institute for Psychology, Westfälische Wilhelms-Universität Münster, Germany, ³Potsdam Research Institute for Multilingualism, University of Potsdam, Germany, ⁴University of Texas Southwestern Medical Center, TX, USA, ⁵New York-Presbyterian/Columbia University Medical Center, USA, ⁶Department of Neuroscience, Karolinska Institutet, Sweden, ⁷Center for Population and Health, Georgetown University, Washington DC, USA, ⁸Office of Population Research, Princeton University, New Jersey, USA

The medial-temporal-lobe-based declarative memory system is critical for everyday life. Evidence suggests that learning verbal information in declarative memory declines with age, but that sex and early-life education may moderate these weaknesses. However, the status of nonverbal declarative memory in aging remains unclear. We examined nonverbal memory in 704 older adults (aged 58-98 years, 0-17 years of education) in a non-Western population, in Taiwan, by probing recognition memory following incidental encoding. Items were drawings of real objects (e.g., hairbrush) and made-up objects. Mixed-effects regression revealed that age negatively impacted nonverbal memory (only linear effects), though this decline was moderated by sex and object type. It was steeper for males than females (leading to a female advantage beginning at age 70), though only for real objects. Remembering made-up objects showed shallow declines with no sex differences. In contrast, education was positively associated with memory, but also interacted with sex (education benefited women more than men) and object type (education benefited remembering real more than made-up objects). In men, the overall memory gains associated with each year of education were two times larger than the losses experienced during each year of aging; in women, they were five times larger. The evidence suggests that age-related nonverbal memory declines may be countered by education, though both effects are modulated by sex, as well as by whether learning relates to pre-existing knowledge or new information. The findings elucidate neurocognitive accounts of declarative memory in aging, and suggest possible downstream benefits from education, especially for girls.

Topic Area: LONG-TERM MEMORY: Development & aging

A79 Relationship between aerobic capacity and mnemonic discrimination in older adults

Lluvia A. Gonzalez¹, Nicole M. Henderson¹, Michael S. Ricasa¹, Lucy K. Khuu¹, Valerie A. Carr¹; ¹San Jose State University

Numerous studies demonstrate that episodic memory declines with age, yet there is considerable variability in the degree to which individuals experience age-related memory decline. Emerging evidence suggests that differences in cardiorespiratory fitness may contribute to differences in memory performance. Research in aged rodents, for example, demonstrates that aerobic exercise benefits the hippocampus, a region critically important for episodic memory, as well as performance on tasks of hippocampal-dependent memory. In humans, however, the relationship between aerobic capacity and processes supported by the hippocampus, such as pattern separation (the ability to form separable memory representations), remains unclear. Here, we investigated whether individual differences among older adults in aerobic capacity were associated with performance on the Mnemonic Similarity Task (MST), a task that requires mnemonic discrimination. Aerobic capacity was assessed via continuous heart-rate monitoring during the six-minute walk test. Analyses indicated a significant negative correlation between task performance and heart-rate, such that individuals with a lower heart rate (and thus higher aerobic capacity) performed better on the MST than those with a higher heart rate. This relationship held true regardless of task difficulty, defined as degree of similarity between lures and targets. Taken together, these results indicate that variability among older adults in episodic memory, specifically in mnemonic discrimination, is associated with variability in aerobic capacity. These findings will help to inform future intervention-based studies in older adults that aim to slow episodic memory decline.

Topic Area: LONG-TERM MEMORY: Development & aging

A80 Scene complexity visual alpha modulations facilitate memory development

Qin Yin¹, Elizabeth L. Johnson^{1,2}, Lingfei Tang¹, Eishi Asano¹, Noa Ofen^{1,3}; ¹Wayne State University, ²University of California, Berkeley, ³Weizmann Institute of Science, Rehovot, Israel

Maturation of high-level visual regions is associated with developmental gains in the encoding of complex visual stimuli such as scenes. However, it is unknown whether low-level visual processing in the occipital cortex supports the development of memory for visual stimuli. Alpha rhythms are the most prominent feature in occipital regions and have been shown to support visual processing. We provide rare intracranial evidence from 21 subjects (6.2-20.5 years) undergoing direct cortical monitoring (ECoG) for seizure management, which reveals that occipital alpha activity during visual processing supports memory formation in children. Subjects studied pictures of scenes classified as high- or low-complexity defined by the number of unique object categories, in preparation for a recognition test. Recognition accuracy for high-complexity, but not low-complexity, scenes increased with age. Peak alpha frequencies (9.6 ± 2.0 , mean \pm SD) were calculated per-subject across all occipital electrodes ($n = 99$) using fast Fourier transform, and task-induced alpha power time-series were analyzed using Hilbert-bandpass for each 3-s scene encoding trial, z-scored on a 300-ms pre-stimulus baseline via statistical bootstrapping. Outputs were tested on the group level using linear mixed-effects models and ANCOVA. Task-induced alpha increases were lower for high-complexity than for low-complexity scenes. Critically, complexity effects in select epochs were sensitive to individual differences in age and recognition accuracy. Subsequent memory effects were observed for high-complexity but not low-complexity scenes. A complementary analysis of 6-20-Hz time-frequency representations revealed consistent results of complexity and subsequent memory effects. These results suggest that visual alpha supports memory formation in children.

A81 The influence of catecholamine function on reward-related memory in aging

Anne S. Berry¹, Theresa M. Harrison¹, A.J. Whitman¹, Kaitlin N. Swinerton¹, Ming Hsu¹, William J. Jagust¹, Anne Berry; ¹UC Berkeley

The hippocampus receives dopamine and norepinephrine inputs that may influence memory encoding. Aging is accompanied by parallel declines in neurochemical systems and in memory function. However, memory for positive information may be relatively preserved, or even enhanced compared to young adults. Defining the mechanisms underlying such positive memory biases in aging is an area of active investigation. Our prior research using the PET tracer 6[18F]fluoro-L-m-tyrosine revealed that dopamine synthesis capacity ([18F]FMT Ki) in the striatum is elevated in older adults, rather than reduced. Here, we examined relationships between hippocampal [18F]FMT Ki, which reflects both dopamine and norepinephrine synthesis capacity, and memory enhancement for reward-related stimuli. We examined subsequent memory for houses presented simultaneously with monetary reward, loss, or neutral feedback in young (n = 21) and cognitively normal older adults (n = 36). Older adults, but not young adults, showed better memory for houses paired with rewards relative to neutral outcomes. PET analyses were performed on a subset of amyloid negative older adults (n = 28) who had undergone both [18F]FMT imaging and [18F]AV1451 imaging, which measures aggregated tau. While previous studies have linked [18F]AV1451 binding with memory, we found no significant relationships for the current incidental encoding task. However, higher hippocampal [18F]FMT Ki was associated with greater reward-related memory enhancement (reward-neutral; adjusted $r^2 = .21$, $B = 168.71$, $SE = 76.96$, $p = .04$; controlling for age and sex). These findings provide preliminary evidence that age-related memory enhancement for positively-valenced information is associated with higher catecholamine synthesis in the hippocampus.

Topic Area: LONG-TERM MEMORY: Development & aging

A82 An electroencephalographic investigation of trial-by-trial updating of knowledge structures

Franziska Richter¹; ¹Leiden University

Knowledge structures such as memory schemas efficiently store large amounts of information without the cost of memorizing every detail of previous experiences. The usefulness of schemas, however, critically depends on their adaptability: how flexibly a schema can be updated according to changing environmental conditions. Yet, how schemas may be updated when conflicting information is encountered is not well understood, as it is difficult to track the dynamic updating of knowledge structures with traditional memory measures. Here, combining a continuous-report paradigm with electroencephalogram (EEG) recordings, I investigate the trial-by-trial relationship between event-related potentials (P300), schema-based prediction errors (PEs), and their effect on schema-updating. Twenty-five participants completed a 3-day experiment: on day 1 they learned object-location associations by making predictions and receiving feedback about object locations on a circular dial. This way participants formed location-schemas for four object categories (animals, clothes, food, furniture). On day 2, participants studied new objects, but unbeknownst to them the location schema for two of the categories changed to a new, inconsistent location. On day 3, participants' memory for all items was tested. EEG was recorded on day 2, while participants received feedback on objects that were either consistent or inconsistent with the pre-established schema. Behaviourally, PE at day 2 predicted schema updating on day 3. Higher P300 potentials were observed in the inconsistent compared to the consistent condition and PE size correlated with P300 amplitude. The results demonstrate that memory schemas, similar to more short-lived belief structures, are updated via prediction-based learning.

A83 Assessing the reliability of fMRI measures in characterizing memory development

Lingfei Tang¹, John France¹, Qijing Yu¹, Qin Yin¹, Homayouni Roya¹, Bryn Thompson¹, Sruthi Ramesh¹, Noa Ofen¹; ¹Wayne State University

The ability to reliably identify the memory network with fMRI in children is the foundation on which neural correlates of memory development can be examined. Modest levels of reliability in the identification of task-based memory-related effects using fMRI are suggested based on scant data from reliability investigations in adults, yet the reliability in the identification of memory-related effects in a developmental sample has not been directly tested. In this study, we used a well-established subsequent memory paradigm to investigate the reliability of fMRI. Twenty-four participants ages 9 to 20 years (mean = 13.3 years, SD = 3.1; 54% female) arrived for two visits one-month apart (mean gap = 29.7 days, SD = 3.3). During each visit, participants were scanned (with a 3T Verio scanner) while they studied a unique set of 120 indoor/outdoor visually presented scenes and were administered a subsequent recognition test. Data were analyzed in SPM12, and reliability was quantified with ICC(2) absolute agreement. Good test-retest reliability was found for memory accuracy between visit 1 and visit 2 (ICC(2) of $d' = .62$). In a whole-brain analysis, fair to good reliability was shown in bilateral inferior frontal gyrus, parahippocampal gyrus, and lateral occipital lobe ($.40 < ICC(2)s < .75$). In contrast, test-retest reliability was particularly poor in the hippocampus ($ICC(2) < .40$). Overall, we found good test-retest reliability in identifying subsequent memory activations in a developing sample over a one-month period. However, poor reliability of hippocampal subsequent memory activations may limit interpretations of hippocampal contributions to memory development.

Topic Area: LONG-TERM MEMORY: Episodic

A84 Creating false memories: Investigating visual recall of multiple exemplars in a single category

Elizabeth H Hall^{1,2}, Wilma A Bainbridge², Chris I Baker²; ¹University of California, Davis, ²National Institute of Mental Health

Recent work has shown that drawings of real-world scenes during free recall contain detailed object and spatial information, with few errors (Bainbridge et al, 2018). However, little is known about the specific detail recalled when episodes are highly similar and competing in memory. The current study probes the nature of errors in competing memories by asking participants to remember multiple exemplars across a single scene category (e.g., office). Participants (n=30) were shown 8 complex real-world scenes (4 from a repeated category, 4 from unique categories), for 10 seconds each, and their eye-movements were recorded. After a distractor task, participants drew as many scenes as they could remember on a digital tablet that recorded timing and stroke order. Participants then completed an old/new recognition task for the original images intermixed with 8 matched foils. Results revealed that participants drew 83.8% of the images across the study, and recognized category-unique images significantly better than repeated category items. Online observers (n=964) used to score recall performance were much better able to match category-unique drawings to their original studied images than repeated category drawings, implicating more inaccurate information in competing memories. Furthermore, when looking at the detail in the drawings, 25.6% of the drawings contained inaccurate information, with significantly more intrusion errors in repeated category drawings than the category-unique drawings. Overall, these results suggest the difficulty in accurately retaining and recalling multiple complex representations of a single category, and show the nature of intrusions that can occur with competing memories.

Topic Area: LONG-TERM MEMORY: Episodic

A85 Data-driven analysis of whole-brain connectivity reveals post-encoding network dynamics.

Jessica A. Collins¹, Bradford C. Dickerson¹, J. Benjamin Hutchinson²; ¹Massachusetts General Hospital and Harvard Medical School, ²University of Oregon

Previous work from our own lab has provided evidence that reactivation mediated memory consolidation (reviewed in Tambini et al., 2010) modulates connectivity between brain regions selective for the encoding of faces and scenes (Collins & Dickerson, 2018). In the present study, we followed up on this work using Full Correlation Matrix Analysis (FCMA), a method for performing unbiased multivariate analysis of whole-brain functional connectivity. Participants completed a baseline resting-state scan followed by two encoding tasks in which they responded to images of faces or scenes. Each encoding task was followed by an additional resting state scan. The temporal correlation of BOLD activity for every voxel pair in the brain was calculated for the baseline, post-face encoding, and post-scene encoding resting state scans. These matrices were then submitted to multivoxel pattern analysis to identify regions where whole-brain connectivity discriminated between conditions. The connectivity of clusters in perirhinal and posterior cingulate cortex discriminated post-face encoding from baseline rest with 85% accuracy. The connectivity of clusters in parahippocampal gyrus, angular gyrus, and retrosplenial cortex discriminated post-scene encoding from baseline rest with 85% accuracy. A follow-up analysis using network based statistics identified a domain-general brain network, centered on angular gyrus, where connectivity discriminated both post-face encoding and post-scene encoding resting state scans from baseline rest. Our results support the existence of both category selective and domain general brain network changes following the encoding of visual stimuli. In addition, our results support the utilization of unbiased multivariate analysis for studying state-dependent changes in whole-brain connectivity.

Topic Area: LONG-TERM MEMORY: Episodic

A86 Decoding biases between memory encoding and retrieval induced by recent experience

Alexandra G. Tremblay-McGaw¹, Brice A. Kuhl¹, Nicole M. Long²; ¹University of Oregon, Department of Psychology, ²University of Virginia, Department of Psychology

Recent memory decisions can create lingering biases—either toward encoding or retrieval—that influence how new stimuli are processed and, ultimately, remembered (Duncan et al., 2012). Here, we tested whether these biases can be decoded from patterns of neural activity (Richter et al., 2016) and whether decoded evidence of memory biases predicts how new events will be remembered. In a behavioral study (n = 18), participants were first familiarized with a series of common objects. Afterwards, subjects completed a continuous recognition task that included ‘old’ and ‘new’ objects. The order of stimulus presentation was controlled such that half of the new objects were preceded by an old object and half were preceded by a new object. Following continuous recognition, participants completed a post-test that required discriminating objects from the continuous recognition task vs. perceptually similar lures. Critically, new objects from the critical recognition task were more likely to be subsequently remembered (at post-test) if they had been preceded by a new object than if they had been preceded by an old object. That is, memory formation for new stimuli was influenced by lingering encoding/retrieval biases from the prior trial (Duncan et al., 2012). In an EEG version of the study (n = 8), we show that (1) encoding vs. retrieval states can be decoded from spectral EEG patterns and (2) these decoding measures reflect biases induced by prior trials. Collectively, these findings provide a critical link between behavioral and neural measures of memory biases induced by recent experience.

Topic Area: LONG-TERM MEMORY: Episodic

A87 Differential consolidation of detail and sequence structure in memory for a one-shot real-world event

Nicholas B. Diamond^{1,2}, Brian Levine^{1,2}; ¹University of Toronto, ²Rotman Research Institute, Baycrest Health Sciences

Most of our knowledge about episodic memory transformation comes from rodent models and studies with laboratory stimuli, which suggest that memories lose episodic specificity as they shift from hippocampal to cortical representation over time (Winocur & Moscovitch, 2011). In humans, however, episodic memory entails recovery of (1) perceptual details and (2) temporal context (Tulving, 1972), both of which depend on the hippocampus. How do these components of episodic memory, for complex real-world experiences, transform over hours, days, and weeks? In this study, we developed a paradigm for measuring memory for the perceptual details and sequence structure of a single extended real-world event. Participants (N=55) underwent a tour of artwork at Baycrest Hospital, controlled with a museum-style audio guide. At four timepoints (1 hr, 24 hrs, 1 week and 4 weeks post-encoding), they responded to trial-unique true/false statements concerning the details (e.g. colours) and sequence of tour elements. Consistent with predictions, detail memory declined over time whereas sequence memory remained stable. Overnight (from 1 to 24 hours), sequence memory increased significantly, consistent with evidence from rodents that the hippocampus replays event sequences in their original order during sleep. Finally, while sequence memory accuracy scaled with the distance between items, even the finest-grain sequence judgements remained stable across tests. This suggests that the difference in forgetting curves for detail and sequence structure is not merely a matter of resolution, but rather that consolidation preferentially stabilizes representations of event sequences, allowing us to retrace trajectories through past experiences long after they occurred.

Topic Area: LONG-TERM MEMORY: Episodic

A88 Expectations modulate shifts between memory encoding and retrieval states

Darya Frank¹, Alex Kafkas¹, Marcelo Montemurro¹, Daniela Montladi¹; ¹Division of Neuroscience and Experimental Psychology, University of Manchester

Top-down expectations play a significant role in guiding adaptive behaviour. Recently, there has been growing interest in how they affect memory performance and the underlying neural mechanism supporting it. One suggestion is that top-down expectations shift hippocampal dynamics towards encoding or retrieval states. Here we examine this notion using fMRI and a pattern separation memory task. In the scanner, participants encoded images of objects. Next, they learned a contingency between a cue and an object’s category (man-made or natural) with a new set of objects. At retrieval, participants were briefly presented with a cue before making an ‘old/new’ judgment for targets and parametrically-manipulated similar foils. Critically, 30% of the cues were misleading, resulting in an unexpected retrieval trial, though participants were unaware of this manipulation. We examined how this implicit violation of expectation modulated memory decisions and their neural correlates. Behaviourally, we found an interaction between expectation and similarity level in affecting memory decisions. Expected targets that followed an unexpected highly similar foil (F1) benefited from a higher hit rate. A complementary effect was observed for F1, with expected foils correctly rejected when following an unexpected target. As similarity between target and foils decreased, these effects diminished. Neurally, interactions between expectations and memory decisions were associated with increased activations in the hippocampus, midbrain regions and precuneus. These results suggest unexpected events result in a shift towards an encoding state,

supporting better memory performance. Importantly, this effect occurs only when the current input and existing representations are highly overlapping.

Topic Area: LONG-TERM MEMORY: Episodic

A89 How do we optimize learning of episodes?

Rachel Newsome¹, Chris Martin¹, Morgan Barense^{1,2}; ¹Department of Psychology, University of Toronto, ²Rotman Research Institute

The best way to study and learn information is an important area of research. Many studies have found that sleep is critical to memory consolidation, and that studying over a longer period of time is better for memory performance than cramming over a short period of time. However, many of these studies have focused on elements of semantic knowledge – i.e., list learning. How can we optimize learning of episodic information? In the present study, we systematically investigated episodic memory for a naturalistic stimulus – an episode of “Poirot.” After initial viewing, participants were administered a study session where they re-watched several scenes (“replay”). Participants continued to replay the same scenes over the course of a week between study and free recall test. We manipulated the amount of time between initial viewing and the very first replay session – 1) short delay of 1-4 hours, 2) long delay 10-14 hours with no sleep, 3) long delay 10-14 hours including sleep. We compared the three groups’ memory performance of all scenes in the episode to performance of controls, who had the same initial viewing and test, but no replays. Although all replay participants benefitted from study compared to controls, we found differential improvements in performance such that participants in the long delay no sleep condition had the most benefit over other delay conditions ($p < 0.05$), both in replayed as well as non-replayed content. These results suggest that the timing of first study session after initial exposure is crucial to later memory performance.

Topic Area: LONG-TERM MEMORY: Episodic

A90 Individual differences of self-report spatial memory are associated with theta rhythm during the encoding of source memory

Ulises Caballero Sanchez¹, Talia Vianney Roman Lopez¹, Monica Mendez Diaz¹, Oscar Prospero Garcia¹, Alejandra Evelyn Ruiz Contreras¹; ¹UNAM

Episodic memory allows to remember specific events with a specific context of our past. Theta rhythm amplitude has been reported to be higher during encoding phase associated to successfully retrieved information than when it is forgotten (i.e., subsequent memory effect (SME)). The self-report Survey of Autobiographical Memory (SAM) has been used to measure mnemonic abilities in everyday life, across subtypes (episodic memory, semantic, spatial and prospective memory). However, it is unknown if the SAM score is associated with SME of theta rhythm in a source memory task. Electroencephalogram was recorded while participants responded a source memory task; for the encoding phase, images, that could appear above or below a fixation point, were shown to participants separated by two independent blocks or series. Participants classified images in natural or artificial. During retrieval, context was evaluated (spatial and temporal). At the end of the experimental session, participants responded the SAM instrument, and they were separated in two groups, based on median score, such as good or poor memory. The poor memory group for spatial subtype, but not for good memory group, showed a decrease synchronization of theta rhythm on occipital region during the successful encoding of spatial context, in comparison with the SME of other information. Our study shows that the score of the SAM has a correspondence with electrophysiological activity during encoding of source memory and, therefore, it can be useful to detect individual differences on the SEM of a source memory.

Topic Area: LONG-TERM MEMORY: Episodic

A91 Memory for decision outcomes increases throughout childhood

Matthew Fain¹, Christina Hlutkowsky², Susan Perlman², Vishnu Murty¹; ¹Temple University, ²University of Pittsburgh

Previous research shows that in order to successfully navigate our social environment, adults need to form episodic memories of not only who they have previously encountered but also the outcome of those encounters. However, there are dynamic changes throughout childhood in episodic memory systems, leaving open questions about the development of these processes throughout childhood. The current study investigates the developmental trajectory of how children form memories of previous social encounters (item memory, $n=137$) and the subsequent outcomes (feedback memory, $n=119$). Children completed a task wherein they emulate a baker by selecting cakes for 20 unique characters. Participants were then shown the character’s response to the selected cake which was either positive or negative. Immediately following this session, participants completed a memory test assessing item memory and feedback memory. We found age-related enhancements in item memory ($p < 0.001$), and we saw a trend towards an age-related enhancement in feedback memory ($p = 0.06$). Despite age-related differences, we see significant item memory and feedback memory amongst a subset of the youngest participants ($p < 0.001$; 4-years-old); suggesting that these processes are intact during early childhood and are refined as they progress into pre-adolescence. Notably, the valence of feedback did not influence our measures of episodic memory or developmental changes. Together, these findings suggest that children not only form episodic memories about social interactions but also demonstrate an ability to remember the outcome of those interactions. Furthermore, the results suggest that these processes are observable at 4-years-old and performance continues to improve with development.

Topic Area: LONG-TERM MEMORY: Episodic

A92 Neural activity associated with counterfactual thinking and perspective shift of autobiographical memories

Leonard Faul¹, Peggy St. Jacques², Jacqueline DeRosa¹, Natasha Parikh¹, Felipe De Brigard¹; ¹Duke University, ²University of Alberta

Imagining alternate versions of autobiographical memories (AMs) is a natural tendency humans engage in when revisiting past events. Often, these episodic counterfactual thoughts (eCFT) depict past events as if they could have led to better (upward) or worse (downward) outcomes. The constructive episodic simulation hypothesis postulates that imagining hypothetical events elicits stronger recruitment of core regions engaged during AM retrieval. Recent work has also demonstrated that adopting a novel visual perspective recruits a similar system. Yet, although both eCFT and perspective shift (PS) are associated with altered memory contents, no study has directly contrasted these effects, and few studies have specifically assessed neural differences with better or worse eCFT. In the current study participants generated and rated phenomenological characteristics of 120 negative memories. A week later, participants were cued on their memories during fMRI and instructed to simply remember the event, simulate an upward or downward counterfactual, or shift perspective to a third-person observer. The following day, participants returned to rate the memories again. Preliminary results reveal changes in memory characteristics and distinct patterns of brain activation separating better/worse eCFT from PS/remembering via a mean-centered spatiotemporal partial least squares analysis. GLM results support the constructive episodic simulation hypothesis, revealing greater precuneus recruitment for PS and greater dorso/ventromedial prefrontal recruitment for eCFT conditions, modulated by directionality. Although eCFT and PS did show some overlap in core AM regions, these results suggest differential restructuring of past events, which has important implications for understanding how memories are changed and distorted over time.

A93 Spontaneous generalization following paired-associate training

Stefania Ashby¹, Caitlin Bowman¹, Dagmar Zeithamova¹; ¹University of Oregon

Memory studies typically focus either on memory for individual experiences (specificity) or the ability to link information across events (generalization). However, experiences in daily life are rarely separated into specificity vs. generalization tasks. Instead, we have to make different judgments based on the same experiences. Do we spontaneously extract generalized knowledge even when the task at hand demands specificity? We assessed behavioral and neural measures of memory specificity and generalization during a task where participants learned face-name associations. To create an incidental category structure, face stimuli were constructed as 50/50 blends of never-seen "parent" faces. Three parent faces were selected to determine category membership (family names Miller, Wilson, Davis) and blended with other parent faces to create multiple family members. Each blended face was assigned a unique first name and participants were instructed to memorize the full name for each face during fMRI. Behavioral results showed that participants successfully acquired memory for specific faces but were also able to generalize last names to new faces. Neural pattern analyses during face-name training showed representations of individual faces in the ventromedial prefrontal cortex and category (family) representations in parietal cortex. Both item and category representations predicted subsequent generalization performance. These results demonstrate the multiple types of representations that may form in parallel for the same experiences to support decision making.

Topic Area: LONG-TERM MEMORY: Episodic

A94 Testing the causal role of theta rhythms in hippocampal memory processing using simultaneous theta-burst TMS and fMRI

Molly S. Hermiller¹, Rachael A. Young¹, Zhi-De Deng², Yu Fen Chen¹, Todd B. Parrish¹, Joel L. Voss¹; ¹Northwestern University Feinberg School of Medicine, ²National Institutes of Mental Health

Synchronous theta-band (4-8-Hz) activity among hippocampal-cortical network (HCN) regions is thought to support episodic memory. We sought to causally test this in humans by applying noninvasive transcranial magnetic theta-burst stimulation (TBS) during an interleaved TMS/fMRI episodic memory encoding task. Subjects encoded scenes immediately following 2-second TBS. Control conditions included scenes without TBS as well as odd/even number judgments either with or without prior TBS. Stimulation targeted the HCN (left parietal-cortical) for half the trials and an out-of-network control site (left motor cortex) for the other half. This allows us to compare the effects of TBS on hippocampal-relevant scene versus hippocampal-irrelevant number processing, and to test the selectivity of effects for HCN-targeted versus out-of-network TBS. Preliminary voxel-wise fMRI analysis (N=8) indicates that left hippocampal activity increased significantly due to TBS for scene relative to number processing. This effect was specific to HCN-targeted stimulation, without any effects on hippocampal activity from out-of-network stimulation. Subsequent scene memory testing indicates significantly better recollection for scenes with prior TBS relative to scenes without TBS. This effect was also specific to HCN-targeted stimulation, without any recollection benefit for out-of-network stimulation. Thus, HCN-targeted TBS led to greater hippocampal activity evoked by scenes during encoding and was more effective for subsequent recollection. These preliminary findings suggest that TBS can modulate hippocampal memory processing and provide causal evidence to support the role of theta in episodic memory. Additional results from a control condition involving the same paradigm but with alpha-frequency (12.5-Hz) stimulation will also be discussed.

A95 Arousal Modulates the Temporal Structure of Episodic Memory

David Clewett¹, Camille Gasser², Lila Davachi^{2,3}; ¹New York University, ²Columbia University, ³Nathan Kline Institute

Although everyday life unfolds continuously, we tend to remember our experiences as being more discrete and episodic. But what creates an 'episode' in episodic memory? Research suggests that a stable context supports the ongoing integration of sequential information, compressing experience into memories of tight-knit events. By contrast, when the current context changes, a theoretical 'event boundary' disrupts sequential integration, instead separating experiences into more distinct memory representations. Although increasing evidence shows that boundaries influence episodic memory organization, little is known about the brain mechanisms that support these processes. Across three studies (N = 34; N = 35; N = 30), we found that event boundaries expanded estimates of temporal distance between item pairs, impaired order memory for recent item pairs, and enhanced item-source memory binding. Using eye tracking, we also found that boundaries elicited significantly greater pupil dilation, an index of physiological arousal, than other novel item presentations. A principle component analysis revealed distinct temporal profiles of this pupil response that were modulated by boundaries. Moreover, distinct pupil components also predicted different effects of boundaries on temporal memory, with parasympathetic inhibition being related to greater time dilation effects in memory and sympathetic activation being related to greater impairments in temporal order memory. In a fourth experiment, we are combining high-resolution fMRI of the medial temporal lobe/brainstem with eye tracking to see how neural memory representations are modulated by arousal at event boundaries. Taken together, these findings shed new light on how arousal mechanisms modulate memories of time and everyday events.

Topic Area: LONG-TERM MEMORY: Episodic

A96 Choice-induced preference predicts delayed but not immediate decision-related memory benefits

Elizabeth Eberts¹, Sarah DuBrow², Vishnu Murty¹; ¹Temple University, ²University of Oregon

Agency has been shown to enhance memory, such that when individuals have the opportunity to choose what they learn, they form stronger memories. Previous research shows that giving individuals the opportunity to choose increases the value of selected options, and this mechanism could generalize to learning environments and drive memory enhancements. Fifty-three participants completed rating, encoding, and recognition phases of a choice-memory task. The ratings were used to determine preexisting preferences for the hiragana characters that were used as occluder screens in the encoding task. During encoding, participants either actively selected (choice trials) or were instructed to select (fixed) occluder screens to reveal object images that were intentionally encoded for a later memory test. Memory was tested at a 24-hour delay test, and a subset also completed a test immediately after encoding. We found that the opportunity to choose increased both memory ($p < 0.001$) and selection-induced preference for occluder screens ($p < 0.001$). There was a significant positive relationship between choice-memory benefits (choice>fixed) at the delayed test and choice-related increases in selection-induced preference (choice>fixed; $p < 0.05$). However, this relationship was not apparent at the immediate test ($p = 0.76$) suggesting a role for consolidation-related processes. These results suggest that giving individuals agency increases value for learning, which in turn drives consolidation-dependent memory enhancements.

Topic Area: LONG-TERM MEMORY: Episodic

A97 Cholinergic modulation enhances hippocampally-dependent spatial relational attention

Nicholas Ruiz¹, Mariam Aly¹; ¹Columbia University

Attention stabilizes representations in the human hippocampus (Aly & Turk-Browne, 2016a,b). We explore a mechanism by which this might occur: cholinergic modulation. Acetylcholine enhances afferent input from entorhinal cortex and suppresses recurrent connections in CA3 (Newman et al., 2012); this biases hippocampal processing toward environmental input, as must occur for externally-oriented attention. We examined cholinergic modulation on a modified version of a task we previously used to demonstrate hippocampal representations of attentional states (Aly & Turk-Browne, 2016a,b). On each trial, participants viewed two images (rooms with paintings). On 'room relational' trials, they judged whether the rooms had the same spatial layout from a different perspective. On 'art relational' trials, they judged whether the paintings could have been painted by the same artist. 'Control' trials had no demands on relational processing: participants simply had to detect identical paintings or rooms. We predicted that cholinergic modulation would enhance room relational attention, given our past findings that hippocampal representations correlated with behavior on this task. Cigarette smokers came in for two sessions: once after they had abstained from nicotine for 12 hours, and once after they had just ingested nicotine. Nicotine enhanced performance on room relational trials and had no effect on the other tasks. If nicotine enhances room relational attention via the hippocampus, performance on this task should be selectively impaired following hippocampal lesions. This was confirmed in a patient with selective hippocampal damage. These results suggest that cholinergic modulation enhances hippocampally-dependent spatial relational attention, perhaps by sharpening input from entorhinal cortex.

Topic Area: LONG-TERM MEMORY: Episodic

A98 Investigating the role of the striatum in stimulus-response learning during priming: Evidence from Parkinson's Disease

Elizabeth Race¹, Hope Tobin¹, Mieke Verfaellie²; ¹Tufts University, ²VA Boston Healthcare System and Boston University

Accumulating evidence suggests that learned associations between stimuli and responses make important contributions to priming. An important outstanding question is the neural basis of S-R contributions to priming. One possibility is that the striatum supports response learning through its established role in encoding associations between stimuli and responses (Heibert, 2014). To investigate this hypothesis, we tested a group of Parkinson's Disease (PD) patients and healthy controls on a repetition priming paradigm that isolates S-R learning from priming effects due to learning at other levels of representation. PD patients demonstrated robust S-R learning, evident in faster reaction times to repeated stimuli when responses repeated compared to when responses switched. Importantly, PD patients demonstrated equivalent reaction time facilitation compared to controls when responses repeated across stimulus repetitions even when decisions switched. In addition, priming in PD patients was equivalent to controls when associations between stimuli and more abstract representations (e.g., stimulus-task or stimulus-decision associations) could contribute to performance. Together, these results reveal that striatal binding mechanisms that support the encoding of other types of S-R associations, such as those acquired during instrumental learning, are not necessary for S-R learning during priming.

Topic Area: LONG-TERM MEMORY: Priming

A99 Degree of Feature Overlap Modulates Subsequent Memory Effects in Medial and Anterior Temporal Lobe Structures in the Fast Mapping Paradigm

Ann-Kathrin Zaiser¹, Regine Bader¹, Patric Meyer^{2,3}; ¹Saarland University, Saarbrücken, Germany, ²Central Institute of Mental Health, Heidelberg University, Mannheim, Germany, ³SRH University of Applied Sciences, Heidelberg, Germany

Contrary to traditional theories, it recently has been shown that novel associations can be rapidly integrated into cortical networks by means of a learning procedure called fast mapping (FM), possibly bypassing time-consuming consolidation processes. In the FM paradigm, a picture of a previously unknown item is presented next to a previously known item and participants answer a question referring to an unfamiliar label, thereby creating associations between the unknown item and the label. Among other critical operations, this task requires the exact discrimination between complex objects. Discriminating between especially highly similar objects is a central function of the perirhinal cortex, a key component of the anterior temporal network. We therefore proposed that strong engagement of the perirhinal cortex, operationalized through a high degree of feature overlap between the unknown and the known item, might be decisive for successful FM learning by triggering anterior temporal encoding mechanisms. In line with our hypotheses, in the present fMRI experiment (N=48) we observed larger subsequent memory effects in the anterior temporal network (i.e., perirhinal, anterior temporal, and anterior hippocampal regions) if the items shared many features than if they shared few features. In the context of previous behavioral results showing rapid semantic integration only in a high feature overlap condition, we conclude that due to its computational mechanisms during the processing of complex picture-label associations, the perirhinal cortex as part of the anterior temporal network might be especially qualified to support encoding and integration of these associations into cortical networks within the FM paradigm.

Topic Area: LONG-TERM MEMORY: Semantic

A100 A universal biomarker predicting sleep-loss vulnerability across the human brain and body

Samika Kumar¹, Eti Ben Simon¹, Adam Krause¹, Rachel Mak-Mccully¹, Liang-Tien Hsieh¹, Matthew P. Walker¹; ¹University of California, Berkeley

Discovering biomarkers that predict human susceptibility/resilience to sleep loss is of fundamental importance at a societal and professional level (e.g., medicine, aviation, military). Here, we tested the hypothesis that delta activity from non-rapid eye movement (NREM) sleep during a rested night of sleep represents a universal biomarker predicting sleep-deprivation-vulnerability across numerous brain and body axes. Healthy adults (n=35) entered a repeated-measure study involving two experimental sessions: (1) a sleep-rested night, and (2) sleep-deprivation night. After each session: (i) mood, anxiety and fMRI resting-state (rs-fMRI) brain activity, and (ii) peripheral-body measures of immune and cardiovascular heart-rate-variability (HRV) systems were quantified. Sleep-deprivation triggered significant: (1) worsening of anxiety and mood, and a functional breakdown in 4 (of 17) discrete intrinsic brain-networks linked to executive top-down control, and (2) increased pro-inflammatory interleukins and impaired cardiovascular HRV (all P<0.05). Confirming biomarker sensitivity, the amount of NREM-delta-EEG activity in the sleep-rested night commonly and positively predicted inter-individual differences in the degree of sleep-loss vulnerability across all of these functional domains of the brain and body (all P<0.02). Thus, NREM-delta-EEG activity represents a universal biomarker predicting a human being's vulnerability to sleep deprivation, and it does so commonly across multidimensional axes of the brain and body. This discovery may help identify "at-risk" individuals in professional circumstances involving unavoidable sleep deprivation. Conversely, such data lead to an intriguing hypothesis: increasing

NREM-delta-EEG activity before sleep deprivation offers a prophylactic “treatment” that diminishes the impact of sleep loss on brain and body.

Topic Area: METHODS: Electrophysiology

A101 How to test for a modulation of perception and behaviour by the phase of neural oscillations

Benedikt Zoefel¹, Matthew H Davis¹, Lars Riecke²; ¹MRC Cognition and Brain Sciences Unit, University of Cambridge, UK, ²University of Maastricht, The Netherlands

The question whether perception or behavior depends on the phase of neural oscillations is a research topic that is rapidly gaining popularity. Importantly however, it is unknown which methods are optimally suited to evaluate the hypothesized phase effect. We tested the ability of different methods to detect such an effect and reject an absent one. Using a simulation approach, we tested how different parameters that shape the effect (its size, width, or asymmetry) or concern the experimental design/analysis (number of trials, number of phase bins, parametric vs permutation-based statistical tests) affect the general ability of various methods to detect neural phase effects, and reveal the optimal method for different combinations of parameters. We found that sensitivity to detect neural phase effects (1) increases linearly with the number of trials; (2) is highest for an intermediate number of phase bins (six to twelve); and (3) is enhanced for permutation-based (vs. parametric) methods. In particular for parametric methods, the identity of the optimal method depended on a combination of several parameters. This finding does not only highlight the need of carefully selecting statistical methods. In the light of the increasing number of pre-registered studies, it also suggests that we can only select appropriate methods if the shape of the hypothesized effect is known. In sum, our study lays a foundation for optimized experimental designs and analyses in future studies investigating the role of neural phase for perception and behavior.

Topic Area: METHODS: Electrophysiology

A102 mindHIVE: An accessible cognitive neuroscience research platform for students and researchers

Suzanne Dikker¹, Henry Valk¹, Dano Morrison, Kimberly Burgas, Steven Azeka¹, Teon Brooks, Wendy Suzuki¹, Ido Davidesco¹, David Poeppel¹; ¹New York University

Recent technological developments have made electroencephalography (EEG) equipment increasingly affordable and accessible. For example, our group has successfully introduced low-cost EEG devices into schools both for research and educational purposes, engaging students in scientific inquiry in a hands-on manner. However, EEG experimentation still requires extensive in-person support from someone with an advanced neuroscience degree and substantial programming skills: Each step—study design, data collection, analysis—is typically handled by different applications, often without a graphical user interface (GUI). To bridge this hardware-software gap, we developed an all-in-one GUI-based platform that guides users through the process of conducting cognitive neuroscience research via (a) intuitive experiment design features (e.g., sliders and ‘drag-and-drop’ components to adapt stimuli, duration, etc.); (b) a data visualizer that supports automatic and visual cleaning; (c) a simple analysis engine that computes Event-Related Potentials (ERPs), frequency spectra, and behavioral results; (d) a workspace that assists in generating research reports. The platform is offered alongside a comprehensive neuroscience curriculum, BrainWaves, currently implemented in 30 underserved schools in New York. We also developed a ready-to-use wireless EEG device (OpenBCI amplifier) that addresses remaining limitations of existing low-cost hardware (data access, accommodation for all hair/head types, electrode locations, fragile components). Initial testing demonstrates its ability to obtain several canonical

ERPs and a signal-to-noise ratio comparable to research-grade EEG equipment. In sum, mindHIVE is a comprehensive software/hardware solution that enables students to independently conduct neuroscience/behavioral studies, paving the way for a range of real-world citizen science research and educational applications.

Topic Area: METHODS: Electrophysiology

A103 Modulation of auditory gamma-band responses using transcranial electrical stimulation

Kevin Jones¹, Zoë Tauxe¹, Elizabeth Johnson^{2,3}, Donald Rojas¹; ¹Colorado State University, ²University of California, Berkeley, ³Wayne State University

Auditory gamma-band (>30 Hz) activity in the electroencephalogram (EEG) is widely studied as a marker of cortical excitation and inhibition balance in disorders such as autism and schizophrenia, and in recovery from depression. Specifically, reduced gamma-band activity is considered a marker of reduced inhibition and hyperexcitability. By applying very weak electrical currents to the brain, non-invasive neurostimulation techniques such as transcranial alternating current stimulation (tACS) and transcranial direct current stimulation (tDCS) have been shown to temporarily modulate cortical excitation and inhibition levels. Importantly, it stands to reason that this clinical gamma-band biomarker could be altered with the use of non-invasive neurostimulation. Here, we investigated whether gamma-band responses can be directly modulated with tACS and/or tDCS, as compared to sham stimulation, in a sample of 45 healthy undergraduates. Participants underwent 200 trials of 40-Hz auditory clicks while scalp EEG data were collected to measure gamma activity. Participants then received 10 minutes of 1 mA tACS (40 Hz), tDCS, or sham stimulation to the left auditory cortex. Immediately following stimulation, participants underwent the auditory task while EEG data were collected a second time. Participants who received tACS exhibited widespread increases in gamma power and phase-locking to the auditory stimulus. These effects were absent in the tDCS and sham groups. These results demonstrate that one of the most prominent biomarkers of clinical disorders can be directly modulated with gamma tACS. We suggest that augmenting treatment regimens with non-invasive neurostimulation may lead to improved outcomes in clinical populations.

Topic Area: METHODS: Electrophysiology

A104 Relationship between phonology, semantics and past tense inflection in post-stroke aphasia

Aneta Kielar¹, Sara Mohr¹, Leah Rice¹, Phoebe Lughes¹, Katie McConville¹, Aneta Kielar; ¹University of Arizona

In the present study, we used convergence of language assessments, cross-modal priming task and Event-Related Potentials (ERPs) to examine contribution of phonological and semantic deficits to the impairment of regular and irregular past tense inflection in patients with stroke-induced aphasia (n=10), compared to age-matched controls (n=15). For age-matched controls, priming effects reflected the degree of phonological and semantic overlap between words. Patients with semantic deficit displayed facilitation for the word pairs that overlapped in phonology (regulars: pressed-press, irregulars: sang-sing, and phonological: belly-bell), but not for words that overlapped only in meaning (couch-sofa). In contrast, patients who had phonological impairment, with relatively preserved semantic processing, exhibited inhibition for all prime-target pairs that overlapped in phonology, but presented significant facilitation for semantically related words. Interestingly, the correlational analysis revealed a significant relationship between phonological scores and regular past-tense inflection ability, and semantic scores and irregular past-tense inflection performance. For control participants, we found significant N400 priming effect, indicated by larger negativity to the unrelated compared to the related conditions. Patients with aphasia also showed

significant N400 responses, indicating on-line sensitivity to the sound-meaning relationship between words. However, the ERP responses for patients were significantly delayed in latency as compared to controls. In conclusion, our results suggest that patients with aphasia can access phonological and semantic information about words, but this process is slow and less efficient, leading to verb inflection impairment. Degraded processing of regular and irregular inflection was related to the degree of phonological and semantic impairments.

Topic Area: METHODS: Electrophysiology

A105 A functional near-infrared spectroscopic investigation of the hemodynamic response function across resting and listening conditions

Joel Skaria¹, Ronald Gillam¹; ¹Utah State University

The current study was designed to examine the hemodynamic response function during resting and listening conditions using Functional Near-Infrared Spectroscopy (fNIRS) measures of cortical hemodynamics and functional connectivity. Participants performed three resting state conditions (open-eyed rest, motor rest, and closed-eyed rest) and two listening task conditions (passive listening and active dichotic listening) while undergoing fNIRS imaging. Based on previous resting state fNIRS literature, regions of interest (ROIs) were chosen relative to frontal and perisylvian regions active during the resting state. Absolute value area under the curve (AUC) analyses of the hemodynamic response functions (HRFs) were calculated for oxygenated concentration values (HbO) and deoxygenated concentration values (HbR). Repeated measures ANOVAs (rmANOVAs) were conducted on HbO and HbR HRFs for each condition across six ROIs using three different baseline conditions (open-eyed rest, motor rest, and closed-eyed rest). There was a main effect of ROI, but not condition type, for all three baseline conditions. However, additional functional connectivity analyses revealed more diffuse connectivity for motor rest, followed by closed-eyed and open-eyed rests, respectively. This suggests that the motor rest condition resulted in greater disruption of information flow across frontal and perisylvian regions as compared to the closed-eyed and open-eyed rest conditions. Further exploration of rest types are needed to explore whether this effect exists across groups.

Topic Area: METHODS: Neuroimaging

A106 Activity or Connectivity? Comparing neurofeedback training approaches in Huntington's disease

Marina Papoutsis¹, Joerg Magerkurth^{1,2}, Oliver Josephs¹, Sophia Pepes³, Temi Ibitoye¹, Ralf Reilmann^{4,5}, Nikolaus Weiskopf^{1,6}, Doug Langbehn⁷, Geraint Rees¹, Sarah Tabrizi¹; ¹University College London, UK, ²Birkbeck, UK, ³University of Oxford, UK, ⁴George Huntington Institute, Germany, ⁵University of Tuebingen, Germany, ⁶Max Planck Institute for Human Cognitive and Brain Sciences, Germany, ⁷University of Iowa, USA

Huntington's disease (HD) is a genetic neurodegenerative condition causing severe motor and cognitive impairment. Starting from the striatum, neuronal function is disrupted throughout the brain leading to atrophy, connectivity loss and dysregulation of brain activity. Neurofeedback training (NFT) could support cognitive symptom management in HD by training patients to regulate the activity of specific regions or networks which are disrupted by the disease and are linked to cognitive impairment. In our recent work using real-time fMRI NFT we tested whether HD patients can learn to regulate their brain activity using NFT and which NFT target is suitable for our patient population. In earlier work we have shown that HD patients can learn to regulate the activity of the Supplementary Motor Area (SMA), but that improvements in cognitive performance after training are associated with an increase in striatal activity and SMA-striatal connectivity. Here, we set out to compare two different NFT targets, SMA activation and SMA-striatum connectivity, to establish which one

is more appropriate. HD patients were randomized to the two different approaches and matched control groups (sham neurofeedback). The SMA activity-based NFT group was the only one that showed both successful learning and transfer. Our results therefore suggest that SMA-activity NFT is a more promising approach than SMA-striatal connectivity-based NFT and provide additional information to inform the design of future larger trials to measure efficacy.

Topic Area: METHODS: Neuroimaging

A107 Characterizing Individual Variation in Multivariate Connectivity and Behavior Along the Psychosis Spectrum

Jie Lisa Ji¹, Joshua Burt¹, Katrin Preller^{1,2}, Brendan Adkinson¹, Antonija Kolobaric¹, Morgan Flynn¹, Rick Adams³, Aleksandar Savic^{1,4}, John Murray¹, Alan Anticevic¹; ¹Yale University, ²University of Zurich, ³University College London, ⁴University of Zagreb

Understanding how neural processes give rise to the behavioral variation observed in patients is a key challenge in the field of neuropsychiatry. Notably, a great deal of heterogeneity in key cognitive domains, including working memory, social and emotional processing, and goal maintenance, exists even within patients with the same diagnosis. Here, we describe a multivariate neurobehavioral framework under which cognitive performance and behavioral variation in psychosis spectrum disorders can be mapped to features of specific neural systems and used to inform the identification of genetic/molecular targets associated with particular cognitive/behavioral deficits. We leverage fMRI-derived neural and behavioral data from 202 healthy controls and 436 patients from the Bipolar-Schizophrenia Network for Intermediate Phenotypes study. We first identify dimensions of symptom and cognitive variation and then demonstrate that variation along these dimensions relates robustly to variation in the global brain connectivity of specific neural systems. Importantly, these behavioral dimensions are not parallel to traditional symptom and cognitive scales from pre-existing clinical instruments; do not reflect conventional diagnostic boundaries; and are highly stable and robust to site and sample effects. We then demonstrate that these neurobehavioral relationships can be readily mapped to neural/cellular properties such as gene expression, thus informing the identification of pharmacological targets aimed at treating specific behavioral phenotypes in the psychosis spectrum at the individual subject level. We propose the Neuro-Behavioral Relationships In Dimensional Geometric Embedding (N-BRIDGE) framework as a key step towards unified mapping between the geometry of behavioral variation and the geometry of neural variation in psychiatry.

Topic Area: METHODS: Neuroimaging

A108 Extensions of Multivariate Dynamical Systems for Simultaneous Explanations of Neural and Behavioral Data

Qingfang Liu¹, Alexander A. Petrov¹, Zhong-Lin Lu¹, Brandon M. Turner¹; ¹The Ohio State University

A recent approach to study how brain performs cognitive functions and produces overt behaviors is to model behavioral measures and neural measures simultaneously. However, current simultaneous modeling studies fail to provide a whole picture of underlying cognitive mechanisms, because they often do not consider the important temporal dynamics of the neural measures and ignore the brain functional networks for completing cognitive tasks. To address these issues, we investigated and extended the Multivariate dynamical systems (MDS; Ryali et al., 2011) to model both behavioral and neural measures simultaneously. The MDS framework is constructed in a way such that the temporal dynamics and brain functional connectivity are explicitly contained in the model structures. We explored the ability of MDS to account for patterns of neural (functional magnetic resonance imaging) and behavioral (choice and response time) data in a random dot motion task of perceptual

decision-making, and examined the ability of current algorithms to estimate the parameters within the MDS model. Two simulation studies with the perceptual decision making MDS model illustrated the ability of the model to capture key characteristics of both behavioral and neural measures of experimental data. A parameter recovery study suggested the identifiability of the model parameters with a likelihood approximation algorithm. Such an extension could facilitate the development of completely integrative systems of brain-behavior relationships.

Topic Area: METHODS: Neuroimaging

A109 Within- and Between-Network Connectivity in Aging: How Correlation Direction Affects Discovery of Age Effects

Eleanna Varangis¹, Christian G. Habeck¹, Qolamreza Razlighi¹, Yaakov Stern¹; ¹Columbia University

Studies examining functional connectivity have found a reduction in within-network connections, and an increase in between-network connections with aging. However, many of these studies focused only on positive correlations between regions/nodes. The present study examined the effect of age (N=245 adults age 20-80) on positive and negative correlations within and between predefined neural networks during 5 functional magnetic resonance imaging (fMRI) scan conditions: resting state and task-based scans in four domains (vocabulary, processing speed, fluid reasoning, and episodic memory). fMRI data were extracted from 264 regions of interest (ROIs) according to the Power et al. (2011) network taxonomy. Average positive and negative correlations were calculated within each network, and between networks for each of the five scan conditions. Results showed an interaction between age, scan, and correlation direction (within/between) for positive and negative correlations, such that advancing age was associated with lower positive within-network correlations and negative between-network correlations across most scan conditions, but had no effect on positive between-network correlations or negative within-network correlations. Further, a three-way interaction revealed that some networks exhibited an age-by-scan interaction, such that an effect of age on functional connectivity was only present during specific scan conditions. These results suggest that the effect of aging on functional connectivity may be driven by age-related reductions in positive correlations within networks, and reductions in the negativity of negative correlations between networks across resting and task-based scan conditions. Additionally, the effect of age may be more pronounced within certain cognitive networks, and under specific task-based scan conditions.

Topic Area: METHODS: Neuroimaging

A110 Neural correlates of aesthetic judgment on Chinese calligraphy and scenery photos in nonreaders of Chinese

Joyce Cheng¹, Makayla Chen¹, Leo Dong¹, Diana Shih¹, Denise Wu¹; ¹National Central University, Taiwan

Our previous neuroimaging research showed that aesthetic judgment performed on Chinese calligraphy and on scenery photos was associated with specific brain activation in the word- and place-related regions, respectively. To determine whether such category-specific results were due to characteristics of the stimuli per se or to life-long experience of reading Chinese characters, we recruited 24 nonreaders of Chinese to perform aesthetic ratings on the same set of Chinese calligraphic characters and scenery photos with different aesthetic values. Behavioral results revealed that foreign participants were sensitive to the manipulation of aesthetics in Chinese calligraphy, though to a lesser degree than to that in scenery photos. Simultaneous functional magnetic resonance imaging (fMRI) recording showed that aesthetic judgment on Chinese calligraphy was associated with higher brain activation in the areas supporting basic visual processing than that on scenery photos, while the reversed contrast was associated with

bilateral parahippocampal areas. Critically, the brain activation in the category-selective regions was parametrically modulated by aesthetic ratings performed by individual participants. Replicating our previous findings, the association between the activation of the reward system in the ventromedial prefrontal cortex (vmPFC) and the perceived aesthetics either in words or in scenes was not significant. The present findings indicate that aesthetics is one fundamental feature that is being processed in the brain regions specific to different stimulus categories. Because foreigners are unfamiliar with Chinese calligraphy, they mainly relied on the brain regions processing basic visual features rather than the visual word-form area to perform aesthetic judgment.

Topic Area: OTHER

A111 Characterization of hyperbrain networks during joint piano playing

Hector Orozco Perez¹, Debanjan Borthakur¹, Laurel J Trainor¹; ¹McMaster University

When two or more people engage in interpersonal action coordination (IAC)—such as playing music together—physiological responses have been reported to coordinate, including heart rate and body sway (Vickhoff et al., 2013; Müller & Lindenberger, 2011; Chang et al., 2017). Recently, researchers have tried to extrapolate these findings to the study of oscillatory cortical activity. Electrophysiological (EEG) studies of hyper-brain networks have been described in which information flows between two or more brains during joint music playing (Sänger et al., 2012; Sänger et al., 2013). However, it is unclear whether these represent IAC, or if correlations in dynamics are simply a by-product of shared perception. We combined an alternating social roles paradigm with information theory statistics and advanced signal decomposition techniques (Staniek & Lehnertz, 2008; Limpiti et al., 2006) to characterize hyperbrain networks while pianists play together. EEG results show stable within-individual networks at early timescales of interaction (10ms) including areas such as the temporal lobe, insular cortex, and prefrontal cortex. Networks between individuals peaked at later timescales (1s) and included information flowing from leaders' prefrontal cortices to followers' occipital areas, and information flowing from followers' prefrontal cortices to leaders' temporal areas. Complementary analyses of movement interaction from video recordings are underway. These findings support the idea of using hyperbrain networks as an index of IAC and suggest the possibility of operationalizing social interaction from advanced EEG data processing techniques for both research and clinical purposes.

Topic Area: PERCEPTION & ACTION: Audition

A112 Directional brain-to-brain coupling of music ensemble performance

Andrew Chang¹, Philip Chrapka¹, Dan Bosnyak¹, Laurel Trainor^{1,2}; ¹McMaster University, ²Baycrest Hospital

Humans coordinate with others during many activities, such as having a conversation, jointly moving a heavy object, and performing music together. The neural correlates of interpersonal coordination remain unclear due to limitations of previous research. First, many studies were conducted in a small isolated laboratory settings, making it unclear whether the findings generalize to real-world situations. Second, most of the hyperscanning studies that simultaneously measured coactors' brains during coordination reported similarity measurements between the brains (e.g., phase-locking index). However, similarity measurements cannot exclude the confounding influence that both brains receive similar sensory input during coordination, so the results may not reflect actual coordination. Further, similarity measurements cannot assess directional influences among coactors. The current study aimed to overcome these limitations. We measured body sway and EEG in two professional string quartets in a concert hall setting as a real-world example of

interpersonal coordination. We experimentally manipulated leadership, assigning a different musician as leader on each short performance. We used Granger causality to investigate the magnitude of directional interpersonal coordination among performers. Behaviourally, body sway analyses revealed that leaders influenced follower more than vice versa, and the higher the total entrainment strength among the performers, the better the performance quality. For the EEG analyses, preliminary results show that leaders influence followers more than followers influence leaders or other followers. Thus we have shown that interpersonal coordination is represented in EEG activities and reflects directional influences between people.

Topic Area: PERCEPTION & ACTION: Audition

A113 Dysregulation of auditory object representations in prematurely born children

Chrysa Retsa¹, H el ene Turpin², Fran ois Ansermet³, Carole M uller-Nix², Sebastien Urban², Ayala Borghini², Micah Murray^{1,4,5,6}; ¹The LINE (Laboratory for Investigative Neurophysiology), University Hospital Center and University of Lausanne, Switzerland, ²Department of Child and Adolescent Psychiatry, University Hospital Center and University of Lausanne, Switzerland, ³Department of Child and Adolescent Psychiatry, University Hospital of Geneva, Switzerland, ⁴EEG Brain Mapping Core, Center for Biomedical Imaging (CIBM), Lausanne, Switzerland, ⁵Department of Ophthalmology, Fondation Asile des Aveugles, Lausanne, Switzerland, ⁶Department of Hearing and Speech Sciences, Vanderbilt University, Nashville, TN, USA

Prematurely born children are more prone to manifest developmental difficulties such as sensory and cognitive functioning impairments. Research on prematurely-born infants and young children has demonstrated impairments in auditory responses to simple stimuli as well as discrimination of environmental sounds. To date, most prior work has been conducted in early childhood and therefore it is not clear if these deficits persist into adolescence and adulthood. The present study investigated the long-term impact of premature birth on auditory sensory and semantic processing in prematurely-born preteens. Specifically, we measured ERPs during auditory object recognition and discrimination of sounds of living and man-made objects in 10 year-old children. Participants selectively responded to sounds of either living or man-made objects counterbalanced across blocks. 64-channel ERP data from 17 prematurely-born children and 15 full-term children were analyzed within an electrical neuroimaging framework. The results indicated generally impaired early sensory responses as well as impaired auditory discrimination in terms of both response strength and topography in prematurely-born children compared to full-term children. We observed differences in auditory processing between the two groups of children starting as early as 40ms post-stimulus. Furthermore, the way that full-term and pre-term children discriminated between semantic categories of sounds itself differed between groups as early as 100ms post-stimulus. These results demonstrate for the first time how premature birth can have long-lasting effects on sensory processing and semantic representations that may in turn contribute to behavioral and cognitive impairments.

Topic Area: PERCEPTION & ACTION: Audition

A114 Engaging the dorsal stream in the processing of new words

Keith Doelling¹, Wy Ming Lin², Bijan Pesaran¹, David Poeppel^{1,3}; ¹New York University, ²Universit at T ubingen, ³Max Planck Institute for Empirical Aesthetics

Speech perception fundamentally requires the mapping of highly variable acoustic input to specific linguistic units. A debate has persisted as to the role of those areas critical for speech production in this perceptual process. Recent work has suggested that such motor regions may be recruited only when phonemic judgments are required and, critically, not for typical speech

comprehension. Still, how this function is used outside of the lab remains unclear. We suggest that one understudied case where such judgments (and thus motor activity) would be useful is the processing of new or unknown words. To test this hypothesis, we use pronounceable nonwords to test for activity in motor cortex relative to words. We find in a behavioral memory task that using a blocked design elicited a facilitative and selective interaction between nonword processing and repetition, suggesting shared pathways. To understand the temporal dynamics of this interaction, we ran an MEG study and used multivariate decoding to study phonemic processing in words and nonwords. The analysis revealed that differences in phonemic information between words and nonwords co-occur with an increase in motor activity for nonwords around word offset. The timing of these effects is consistent with a role of phonemic grouping potentially triggered by a failure to reach a lexical target. We discuss how such a function should be critical in the context of word learning and in the processing of multi-syllabic words.

Topic Area: PERCEPTION & ACTION: Audition

A115 The Dynamic and Task-dependent Representational Transformation Between the Motor and Sensory Systems

Xing Tian¹, Wenjia Zhang¹; ¹New York University Shanghai, China

The motor and sensory systems need to work collaboratively in various action and perceptual tasks, such as speech. For example, it has been hypothesized that neural signals generated in the motor system can transfer directly to sensory system along a neural pathway (termed as motor-to-sensory transformation). Previous studies have demonstrated that the motor-to-sensory transformation is the key mechanism for speech production and online control. However, it is still unclear how the neural representation dynamically evolves among distinct neural systems and how such representational transformation depends on the task demand and the degrees of motor involvement. The present fMRI study combined univariate analysis with representational similarity analysis (RAS) and used three speech tasks - articulation, silent articulation and imagined articulation to systematically investigate the representational formats and their dynamic evolution in the motor-to-sensory transformation. The univariate analyses showed that the frontal-parietal-temporal neural pathway was observed in all three speech tasks, but the extent of this motor-to-sensory transformation network differed when the degrees of motor engagement varied among tasks. More importantly, the RSA results showed that primarily articulatory information was represented in motor regions and acoustic information was represented in somatosensory and auditory regions for all three tasks. However, articulatory information was also cross-represented in the somatosensory and auditory regions for articulation and silent articulation tasks. These consistent results provided evidence for the dynamic evolution and task dependent transformation between representational formats in the motor-to-sensory transformation.

Topic Area: PERCEPTION & ACTION: Audition

A116 Top-down Inhibitory Mechanisms Underlying Auditory-motor Integration For Speech Production: Evidence by TMS

Dongxu Liu¹, Guangyan Dai¹, Yichen Chang¹, Hanjun Liu¹; ¹Department of Rehabilitation Medicine, The First Affiliated Hospital of Sun Yat-sen University, China.

There is evidence that compensatory adjustment of speech motor behaviors can be inhibited by top-down mechanisms to prevent speech production from being excessively influenced by auditory feedback. The prefrontal regions may play an important role in this inhibitory process, but there is no direct evidence to support this hypothesis. To address this question, we applied a transcranial magnetic stimulation (TMS) protocol, continuous theta-burst stimulation (ctBS), to depress activity in the left dorsolateral prefrontal cortex (DLPFC) as

participants vocalized the vowel sounds while hearing their voice unexpectedly pitch-shifted +200 or +500 cents. Vocal and event-related potential (ERP) responses to pitch perturbations were measured and compared between the cTBS and sham (control) conditions. The behavioral results showed that, as compared to the sham condition, cTBS led to significantly larger vocal compensations for pitch perturbations. At the cortical level, significantly smaller P2 amplitudes in the frontal regions were found for the cTBS condition relative to the sham condition. These findings indicate that disrupting prefrontal function may impair inhibitory control over compensatory vocal adjustment, resulting in enhanced vocal compensations for feedback perturbations. This is the first study showing the cTBS-induced effect of DLPFC on the neurobehavioral processing of vocal pitch regulation, providing the first direct evidence that speech motor control can be modulated by prefrontal-mediated inhibitory mechanisms.

Topic Area: PERCEPTION & ACTION: Audition

A117 Complexity of sequence learning: a mathematical insight into cognitive science

Yuri Dabaghian¹, Andrey Tsvetkov²; ¹Department of Neurology, The University of Texas in Houston, McGovern Medical School, Houston, TX 77030, ²Department of Neurobiology and Anatomy, The University of Texas in Houston, McGovern Medical School, Houston, TX 77030

Fundamentally, every cognitive test aims at measuring a subject's ability to deal with cognitive and memory tasks of various complexity. However, it has never been clear what precisely the measure of complexity is in each particular test. At the core of the difficulty is the fact that until recently, there existed no abstract concept that could naturally be adopted for describing the kind of tasks used in cognitive and behavioral studies. However, a measure of complexity of finite sequences proposed recently by V. Arnold seems to hold great practical value for developing a fundamentally new tool for cognitive assessments. We tested Arnold measure in a hierarchy of visual, auditory and virtual reality-based navigational learning tests offered to healthy young individuals (between 20 and 40 years of age). Our results suggest that the times required by different subjects to learn a particular task, the amount of errors produced in the process of learning and other characteristics of learning effort correlate with Arnold's complexity of the underlying sequence, regardless of the task's modality. The outcome of our study suggests that this apparently abstract mathematical construct—Arnold's complexity measure—can be used for quantifying human cognitive performance in generic tasks and may lead to a concrete, practical and a general method for objective and transitive cognitive assessment of learning and memory capacity.

Topic Area: PERCEPTION & ACTION: Multisensory

A118 Differentiating Effects of Improvisational and Non-Improvisational Musical Training on Functional Connectivity

Alexander Belden¹, Tima Zeng¹, Emily Przynsinda¹, Psyche Loui^{1,2}; ¹Wesleyan University, ²Northeastern University

Jazz improvisation offers a model for creative cognition, as it involves the real-time creation of a novel, information-rich product. Previous research has shown that when jazz musicians improvise, they recruit Default Mode (DMN) regions including the medial prefrontal cortex and Executive Control (ECN) areas including the lateral prefrontal cortex. Here, we ask whether these task-fMRI findings might arise from intrinsic differences in resting state functional connectivity. We performed a combination of seed-based analysis and Independent component analysis (ICA) comparing groups of improvisationally trained musicians, classically trained musicians, and the minimally musically trained. We also compared the relative contributions of improvisational and non-improvisational musical training to connectivity patterns. Seed-based analysis consistently indicated higher connectivity in DMN and ECN regions in

musically trained individuals as compared to MMT controls. This included higher connectivity (cluster threshold $p < 0.05$, p -FDR corrected) in the classical group between the mPFC and the frontal orbital cortex, precuneal cortex, and pars triangularis of the left inferior frontal gyrus, as well as greater connections in the improvisational group between the left lateral prefrontal cortex and bilateral lingual gyrus, cuneal cortex, and intracalcarine cortex. Meanwhile, ICA revealed differential contributions of improvisational and non-improvisational musical training to intrinsic DMN connectivity. In the component most closely resembling DMN, improvisational training was associated with connectivity in the left frontal pole, left frontal operculum, and pars opercularis of the left inferior frontal gyrus, whereas general musical training was associated with connections with the left lateral occipital cortex and right thalamus.

Topic Area: PERCEPTION & ACTION: Multisensory

A119 Feed-forward mechanisms of audiovisual integration in primary visual cortex

Jessica Green¹, Allison Pierce¹, Spencer Mac Adams¹; ¹University of South Carolina

Event-related potential correlates of audiovisual integration – greater ERP amplitudes for audiovisual stimuli than for either modality alone or their arithmetic sum – have been observed over occipital cortex as early as 50-90 ms after stimulus onset. These integration effects are generally assumed to result from feedback connections to visual cortex from either auditory cortex or higher-level multimodal cortex. Here, we performed three experiments examining the activation of visual cortex by sounds presented from visible speakers, from headphones, and in the presence or absence of a visual stimulus. In all experiments, we identified a lateralized response over occipital scalp beginning 20 ms after sound onset. This rapid occipital auditory-evoked response (ROAR) flipped polarity for sounds presented from upper and lower locations, suggesting it may be generated in primary visual cortex (V1), which represents upper and lower regions of space on opposite banks of the calcarine sulcus. Subsequent source estimation localized the generator of the ROAR to V1. Importantly, the ROAR was observed regardless of whether the sound sources were visible, was independent of attention, and occurred at the same latency as the initial evoked responses in auditory cortex, suggesting it reflects a rapid, feed-forward activation of V1 by sounds. Moreover, when the sound was paired with a visual stimulus at the same location, but not at a location in the opposite hemifield, audio-visual integration effects were observed in V1. We propose that this rapid activation of visual cortex by sounds represents a feed-forward mechanism of audiovisual integration within V1.

Topic Area: PERCEPTION & ACTION: Multisensory

A120 Neural correlates of biological motion perception in sign language users

Emily Kubicek¹, Lorna C. Quandt¹; ¹Gallaudet University

Although widely studied in typically developing populations, the neural basis of biological motion perception has not yet been studied amongst a group that uses action as their primary mode of communication: sign language users. We hypothesized that the continuous perception of biological motions used in sign language may mean that native signers show an increased ability to extract relevant action information. With this EEG study we test whether Deaf signers' (N = 19) sensorimotor systems are differentially sensitive to biological motion presented in two conditions (scrambled vs. unscrambled) compared to hearing non-signers. We predicted greater central alpha event-related desynchronization (ERD) for the unscrambled condition, due to greater demands on sensorimotor cortices when understanding movement. Everyday actions (e.g., jumping jacks, jump rope) were presented using point light

displays (PLD). Time-frequency activity in the alpha and beta ranges was computed for each condition at frontal electrodes and central sites overlying the sensorimotor cortex. Paired comparisons showed significantly greater ERD at central electrode sites in response to scrambled PLDs as compared to unscrambled PLDs ($p < .05$, bootstrapped). This finding suggests that deaf signers may recruit sensorimotor systems more strongly in response to unintelligible actions than coherent action, contrary to our prediction. Frontal electrodes showed the same pattern of ERD ($p < .05$, bootstrapped), suggesting that executive functions are involved in parsing scrambled PLDs. The results from Deaf native signers were statistically compared to the EEG responses of hearing non-signers. This work provides the first investigation of sensorimotor EEG in Deaf signers during PLD observation.

Topic Area: PERCEPTION & ACTION: Multisensory

A121 Tactile agnosia after white matter disconnection due to stroke

Krista Schendel¹, Timothy J. Herron¹, Brian Curran¹, Nina Dronkers², Juliana Baldo¹; ¹VA Northern California Health Care System, ²University of California, Berkeley

While disconnection resulting from lesions or dissections of the corpus callosum have been reported, it is less understood how lesions in the white matter adjacent to the corpus callosum may impact behavior. Here we report a case study in which a focal left hemisphere stroke involving the white matter adjacent to the body of the corpus callosum resulted in the disruption of interhemispheric transfer of sensory information between the right and left hemispheres. The patient (female in her 40s with no prior neurologic history) suffered a white matter stroke primarily involving the left superior corona radiata. Tractography revealed a marked reduction in the fiber tracts extending laterally from the body of the corpus callosum into the left hemisphere. Tests of apraxia and astereognosis were administered, and the patient was asked to name letters and numbers that were “drawn” on either her left or right hand. Based on previous studies of callosal lesions, the prediction was that naming and tactile recognition of objects in the left hand would be impaired relative to that of the right hand due to impaired transfer of sensory information from the left hand (right hemisphere) to left hemisphere language regions. As predicted, the patient performed at chance for naming letters, numbers, and objects drawn/presented in her left hand (transfer condition). The combined brain imaging and behavioral data highlight the importance of white matter tract integrity in interhemispheric transfer between right hemisphere somatosensory cortex and left hemisphere language regions.

Topic Area: PERCEPTION & ACTION: Multisensory

A122 Integration of object color and shape takes place in early visual cortex

Xiaoying Wang¹, Jiasi Shen¹, Tonghe Zhuang¹, Yanchao Bi¹; ¹Beijing Normal University

How different features are bound together is a fundamental question of object representation in the human brain. Previous theories and studies ascribed the role of binding to higher-order cortices such as anterior temporal lobe (ATL) or prefrontal cortex. We conjecture that feature integration into objects could take place in corresponding perceptual cortices. To test this hypothesis, we collected fMRI data of 24 college students who performed one-back detection of blocks of pictures of correctly and incorrectly colored vegetables. The color and shape are well-matched between correct and incorrect combinations (e.g., purple eggplant and orange pumpkin versus eggplant shape with orange color and pumpkin shape with purple color). Whole-brain searchlight classification on multivariate activation patterns of correct and incorrect combinations revealed that in addition to higher-order cortex (i.e., ATL and ventral prefrontal cortex) early visual cortices (i.e., calcarine, lingual gyrus and inferior occipital gyrus) also exhibited discriminability on integration correctness. Support-

vector based regression models including only perceptual representational similarity matrices (RSM) as predictors (i.e., color and shape RSM), only integration RSM (i.e., integration correctness) as predictor and both perceptual and integration predictors were built to predict regional neural RSM and model performances were compared to measure the perceptual and integration contributions into the neural representation of these regions. The results revealed a transition from perceptual dominance in the early visual cortex into integrative dominance in the anterior higher-order cortex. Taken together, our results revealed that feature integration takes place even in early visual cortex, though in submission of a posterior/perceptual-anterior/integrative transition.

Topic Area: PERCEPTION & ACTION: Vision

A123 When Cross-Modal Information is Redundant: Auditory feedback does not impact visuo-motor sequence learning or transfer

Aleksandra Sherman¹, Daniel J. Sanchez², Carmel A. Levitan¹; ¹Occidental College, ²SRI International

The Serial Interception Sequence Learning (SISL) task was used to assess the integration and transfer of cross-modal auditory information in a traditionally visuo-motor task. In SISL, participants make keypresses to scrolling cues that embed order and timing, leading to the acquisition of sequence-specific knowledge expressed as a performance benefit over novel sequences. We investigated whether adding auditory information would improve sequence learning and subsequent transfer. Across two counterbalanced sessions on different days, participants trained on a repeating sequence embedded in several non-repeating sequences with or without auditory feedback. During auditory-visual learning, auditory feedback occurred when participants pressed the button corresponding to the correct target location during the appropriate time window. Several performance metrics were assessed: accuracy (percent correct difference between trained and unlearned sequences), speed, and temporal precision (how precisely-timed correct keypresses were relative to optimal timing). Although accuracy measures demonstrated robust sequence expression across conditions ($M=11.8\%$, $SEM=1.1\%$), auditory information did not enhance learning; participants were as accurate, as fast, and most strikingly, as temporally-precise when learning occurred with or without auditory feedback. Moreover, there were no material effects on transfer; performance was similar when the sequences were learned in one condition and tested in the other. These results may be due to the structure of the SISL task. As the scrolling visual cues already provide predictive timing information about the responses, whereas the auditory information only provides performance feedback, participants may be treating it as redundant and uninformative.

Topic Area: PERCEPTION & ACTION: Multisensory

A124 Effects of stimulus processing on event-related potentials of close others

Anca Vochin¹, Amanda Tardif¹, Ashley Chau-Morris¹, Hicham El Fouladi², J. Bruno Debrulle¹; ¹McGill University, ²University of Montreal

While engaging in social interactions, we assume that others are experiencing the same qualia, such as the “redness” of red, timbres of different sounds, as us. This assumed similarity, however, cannot be accounted for with current theories of neural correlates of consciousness as, they can be generated by different neural systems. There is thus reason to search for another account of their similarity. To this purpose, we tested whether one person’s brain could be sensitive to others’ qualia. We examined whether their late posterior positivity (LPP), an event related potential (ERP) associated with conscious processing, could depend on the stimulus presented to a close other. We thus recorded ERPs from pairs of partners as they separately but simultaneously viewed visual stimuli. To prevent any classical communication, participants were tested in adjacent rooms separated by a curtain-covered window.

Unbeknownst to the partners, half of the images were identical, while half were not. As predicted, LPP amplitudes differed between these conditions despite the participants not knowing what images their partner was seeing. This finding supports the hypothesis that an individual's stimulus processing can impact another's brain activity, which provides a potential basis for qualia similarity across individuals.

Topic Area: PERCEPTION & ACTION: Vision

A125 Magnocellular and parvocellular contributions to reading

Maddi Ibarbia¹, Pedro M. Paz-Alonso¹; ¹BCBL - Basque Center on Cognition, Brain and Language

Several models defined object recognition as a feed-forward bottom-up procedure wherein visual inputs are processed by a hierarchy of visual regions situated along the ventral visual stream. However, other theories suggested that bottom-up processing couldn't fully explain visual recognition. For instance, Moshe Bar's model proposed a mechanism for fast triggering a top-down facilitation that must be available to low-level areas before object recognition is completed. Although the magnocellular and parvocellular streams have been identified as the major visual pathways, we still do not know yet their specific contribution to visual recognition and, in particular, to reading behavior. The present study was aimed at characterizing the involvement of these visual pathways in word reading and object recognition. A total of 30 healthy young adults participated. The functional MRI task conformed to a hybrid design where participants made natural/artificial judgments to object images and words that were either (i) magno-biased: low-luminance contrast and achromatic; (ii) parvo-biased: isoluminant (red-green) and chromatically defined; or (iii) neutral: not sensitive to low-luminance-contrasts and achromatic or red-green. Behavioral results revealed similar accuracy across conditions, whereas faster response times corresponded to the neutral condition, followed by magnocellular and parvocellular conditions, respectively. Neuroimaging results revealed orbitofrontal cortex involvement for magnocellular-biased stimuli and fusiform gyrus for parvocellular-biased stimuli. Across stimuli the ventral occipitotemporal cortex was more engaged for words than objects, but its connectivity differed as a function of magnocellular versus parvocellular bias of the stimuli. These results are discussed in line with current neuroanatomical models of reading.

Topic Area: PERCEPTION & ACTION: Vision

A126 Preserved shape sensitivity in the dorsal pathway of a visual agnosia patient

Erez Freud¹, Marlene Behrmann²; ¹York University, Toronto, ON, Canada, ²Carnegie Mellon University, Pittsburgh, PA, USA

Shape processing is a cornerstone for various perceptual behaviours such as object recognition, face perception and orthographic processing. For decades, these perceptual behaviours were considered to be and investigated as the product of one visual pathway- i.e. the ventral pathway. In contrast, the dorsal visual pathway was assumed to support the visuomotor control of objects. Importantly, however, recent research has revealed novel evidence for a contribution of the dorsal pathway to shape processing. An obvious outstanding question, then, is whether dorsal shape processing mechanisms are dissociable from computations carried out by the ventral pathway. To address this issue, we utilized a parametric scrambling manipulation that has been used successfully in healthy individuals (Freud, Culham, Plaut & Behrmann, 2017; eLife) to map the large-scale organization of shape processing mechanisms in a patient with object agnosia. As expected, neural indices of shape sensitivity along the ventral pathway were remarkably altered in the patient, particularly in regions proximal and anterior to the location of the injury. In contrast, shape sensitivity along the dorsal pathway was preserved and followed a similar topographical organization to that observed in controls.

These findings were corroborated when the experiment was repeated two-years after the initial scans were acquired. Together, these findings challenge the binary segregation between the two visual pathways and suggest that the dorsal pathway derives shape representations, that might contribute to perception, independently of the ventral pathway.

Topic Area: PERCEPTION & ACTION: Vision

A127 Representational Origins of Visual Expertise: A Perceptual Training Study

Elliot Collins^{1,2}, Marlene Behrmann¹; ¹Carnegie Mellon University, ²University of Pittsburgh

The debate within the field of visual expertise attempts to explain the extent to which the same behavioral and neural mechanisms that underlie human face perception also subserve other domains of highly skilled visual perception. We argue that a representational space (RS) approach, in the context of exemplar learning, may reveal the mechanism by which expertise emerges, and subsequently, can provide a powerful means of directly comparing two domains of visual expertise. To test the former hypothesis, we completed two training studies that differed only in the class of stimuli used: faces or novel computer generated objects. Participants completed two sessions of perceptual similarity ratings for a set of 30 homogenous objects. Between these sessions, they completed 10 days of perceptual training in which they were trained to recognize four object exemplars through visual search. For novel objects, results revealed that representational distance changes generally increased, across the entire RS, and most notably for learned exemplars relative to other objects. In contrast, for participants learning faces, representational changes were local to the exemplars learned. That is representational distance increased between learned exemplars and the other exemplars most perceptually similar. Generally, RS for faces was relatively stable, in contrast to novel object space which was highly dynamic. The implications of our results are twofold: the continuum of visual expertise can be stratified by subsequent exemplar learning, and therefore elucidate the mechanism by which expertise emerges. Second, an RS approach provides a powerful means for directly comparing distinct domains of visual expertise.

Topic Area: PERCEPTION & ACTION: Vision

A128 The indispensable role of object formation in perceptual organization

Junjun Zhang¹; ¹MOE Key Lab for Neuroinformation, The Clinical Hospital of Chengdu Brain Science Institute, University of Electronic Science and Technology of China

What is the goal of perceptual organization? It has been proposed a century ago, by the founders of Gestalt psychology, that the main tenet of perceptual organization is to organize experience into objects and their background. Object formation is the goal of perceptual organization, in another word, when there is no object formation, there is no need for the rules of perceptual organization to be effective. In order to investigate the role of object formation in perceptual organization, random-dot stereograms were used to study the configural superiority effect: more efficient in visual search among stimuli with configurations than those without configurations. By swapping the stimuli between two eyes, the same shapes can be displayed in different depths, either in front of the background as objects, or on the background as holes. The difference between configural and non-configural stimuli, when forming objects and holes, were studied with behavioral and fMRI methods. Behavioral results showed that, the superiority effect of configurations were only observed with objects appeared on top of the background, not with the same-shaped holes on the background. It suggested that configural superiority only effective when there is object formation. fMRI results confirmed such suggestion by showing that, configural superiority activated the lateral occipital areas, which

is sensitive to object formation. The current study demonstrated that, configural superiority effect depends on object formation, not on the 2D image features (shape). It suggested that, when there is no object formation, there is no perceptual organization.

Topic Area: PERCEPTION & ACTION: Vision

A129 The Neural Sources of N170: Understanding Timing of Activation in Face-Selective Areas

Chuanji Gao¹, Stefania Conte¹, John Richards¹, Wanze Xie¹, Taylor Hanayik¹; ¹University of South Carolina

The N170 ERP component has been widely identified as a face-sensitive neural marker. Despite extensive investigations conducted to examine the neural sources of N170, there are two issues in prior literature: 1) few studies used individualized anatomy as head model for the cortical source analysis of the N170; 2) the relationship between the N170 and face-selective regions from functional MRI (fMRI) studies is unclear. Here we addressed these questions by presenting pictures of faces and houses to the same group of healthy adults (N = 34) and recording structural MRI, fMRI and high-density ERPs in separate sessions. Source analysis based on the participant's anatomy showed that the middle and posterior fusiform gyrus were the primary neural sources for the face-sensitive aspects of the N170. Source analysis based on regions of interest from the fMRI showed that the fMRI-defined fusiform face area was the major contributor to the N170. The current study suggests that the fusiform gyrus is a major neural contributor to the N170 ERP component and provides further insights about the spatiotemporal characteristics of face processing.

Topic Area: PERCEPTION & ACTION: Vision

A130 A latent-cause inference account of event segmentation under perceptual ambiguity

Yeon Soon Shin¹, Yael Niv^{1,2}, Sarah DuBrow^{1,3}; ¹Princeton Neuroscience Institute, Princeton University, ²Department of Psychology, Princeton University, ³Department of Psychology, University of Oregon

When experiencing a stream of events, we often segment them into meaningful clusters by inferring the underlying (latent) cause. Here, to characterize the process by which humans infer latent causes, we developed a novel perceptual categorization task and compared Bayesian models with and without temporal decay. We presented participants with "microbes" that varied along two dimensions (number and length of the microbes' spikes) and had them infer the category of a microbe on each trial. Microbes belonged to one of four categories, where each category was generated from an underlying cause with a mean number and length of spikes. Sequential transitions mostly stayed within the same category, occasionally jumping to the next unexplored category (across-new) or going back to the previous category (across-revisit). Importantly, each across-category transition was paired with a within-category transition matched for perceptual distance. Participants (n=20) were more likely to infer a new category after an across-new transition than its distance-matched within-category pair, and more likely to infer an old than a new category after across-revisit transitions. A Bayesian clustering model with temporal decay best accounted for the categorization data, suggesting that humans adaptively use temporal contiguity when inferring the latent structure. In a subsequent memory test, when probed with each category's prototypical (but novel) microbe, participants tended to choose the same category they had assigned to nearby microbes significantly above chance, indicating successful generalization. Together, these results highlight that temporal context sensitivity and generalization, processes linked to the hippocampus, may be important in inference-based event segmentation.

Topic Area: THINKING: Decision making

A131 Decisions to explore are preceded by neural interruption and response conflict

Cameron Hassall¹, Craig McDonald², Olave Krigolson¹; ¹University of Victoria, ²George Mason University

Economic choices often involve a trade-off between exploiting the known and exploring the unknown. Despite numerous studies on the topic, little is known about the time course of the neural processes underlying decisions to explore or exploit. We addressed this issue by recording EEG while participants played several gambling games. After classifying responses as either explorations or exploitations using a computational model, we examined event-related potentials locked to two events: the appearance of the choice stimuli and the arrival of feedback prior to decisions to explore/exploit. In particular, we examined the feedback-locked P300 component, thought to index a phasic release of norepinephrine (a neural interrupt signal), and the reward positivity, thought to index a phasic release of dopamine (a neural prediction error signal). We observed an exploration-dependent enhancement of the P300 only, suggesting a critical role of norepinephrine (but not dopamine) in triggering decisions to explore. Similarly, we examined the N200/P300 components evoked by the appearance of the choice stimuli. In this case, exploration was characterized by an enhancement of the N200, but not P300, a result we attribute to increased response conflict. Thus, exploratory decisions were preceded by two distinguishing events: a feedback-locked neural interrupt signal (enhanced P300) and a choice-locked increase in response conflict (enhanced N200).

Topic Area: THINKING: Decision making

A132 Development of cortical and sub-cortical components of learning: A computational analysis

Maria Eckstein¹, Sarah Master¹, Ronald Dahl¹, Linda Wilbrecht¹, Anne Collins¹; ¹University of California, Berkeley

Different brain systems mature at different rates, but little is known about the maturation of cognitive capacities that depend upon interactions across these systems. We sought to address how reinforcement learning processes and cognitive control, which rely on early-maturing subcortical regions and later-maturing frontal regions, respectively, develop during adolescence. We tested 197 youths (91 male; ages 8-17) and 53 adults (ages 25-30) in a probabilistic reversal learning task. Participants used noisy, binary feedback to learn which of two choices was most likely to lead to reward. The best option changed occasionally and unpredictably, engaging cognitive control and reinforcement learning. Children (ages 8-12) switched strategies more quickly than adolescents and adults after negative feedback, and out of all age groups, teenagers (13-18) employed the strategy closest to Bayes optimal: they were least likely to impulsively change strategies in the face of spurious absence of reward. Computational modeling employing Bayesian inference and reinforcement learning suggests that the age-related differences in behavior stem from decreasing decision noise with age, increased sensitivity to negative feedback in children compared to the other age groups, and better estimation of the underlying task contingencies by adolescents and adults. This research highlights changes in cognitive abilities associated with both subcortical regions (reward sensitivity) and frontal regions (estimation of task contingencies), suggesting a complex developmental trajectory and interplay of different systems.

Topic Area: THINKING: Decision making

A133 DRD4-521T Genotypes Differentially Modulate Reward Positivity Amplitude During Reinforcement Learning

Trevor C. J. Jackson¹, James F. Cavanagh¹; ¹University of New Mexico

The Reward Positivity (RewP) is a feedback-related ERP component that is sensitive and specific to reward surprise. As such, it is largely interpreted as a dopaminergic phenomenon. However, this association is rarely tested. Here we examined how genetic variations in dopamine sensitivity may affect the RewP, specifically pertaining to SNP DRD4-521T. This SNP can increase the amount of DRD4 receptors in the Anterior Cingulate Cortex (ACC), which in turn affects ACC functioning. Specifically, those that carry a C/C polymorphism have increased DRD4 receptors and exhibit lower ACC activation (Fan et al., 2003) as compared to their T/T polymorphism counterparts, which may in turn affect reinforcement learning, especially for those with Substance Use Disorders (Baker, et al., 2016). In the current study, participants (C/C variant, N = 25; T/T variant, N = 15) completed a probabilistic reinforcement learning task, which paired Hiragana characters with different probabilities of receiving "Correct" or "Incorrect" feedback. Those with the C/C DRD4 genotype exhibited higher RewP's than their T/T counterparts ($p = 0.015$, $d = 0.748$). This finding was specific to increased Delta-band activity following time frequency analysis (Delta: 0.5-4 Hz, $p = 0.0322$). These findings suggest that DRD4 genetic variants may affect as the appraisal of reward as reflected in the RewP.

Topic Area: THINKING: Decision making

A134 Emotion Primes Influence Decision Making

Brandy Tieman¹, Andrew Dyar¹, Caroline Martin¹, Clara Davis¹, Julian Wright¹; ¹University of the South

Increased cognitive effort is required to evaluate a scenario and to make a utilitarian decision in order to maximize benefits and minimize costs. Affective processes and cognitive control processes enable individuals to respond efficiently to moral dilemmas that induce conflict and/or are incongruent with personal and social values. We examined whether emotional primes influence one's ability to judge the appropriateness of a decision with ease, depending on the type of dilemma. Participants read and responded to personal moral dilemmas, impersonal moral dilemmas, and non-moral dilemmas. Each response was preceded by either a positive, negative, or neutral prime word. The results revealed an interaction between emotional prime type and dilemma type. Emotionally salient primes lead to decreased reaction times for judgments related to personal moral dilemmas, whereas reaction times for judgments related to impersonal moral dilemmas increased. These findings demonstrate emotion differentially affects judgment reaction time depending on the type of dilemma. We also discuss a follow-up procedure that will employ EEG/ERP methods to observe changes in brain activity related to emotional primes and moral judgments.

Topic Area: THINKING: Decision making

A135 Investigating the impulsive choice of young adults in delay discounting, probabilistic discounting, and risk preference task

Nai-Shing Yen¹, Tsung-Han Yang¹, Yu-Chi Lin¹, Fan-Ying Liu¹, Yun-Fan Fang¹, Chi Wang¹, Ruey-Ming Liao¹, Nai-Shing Yen; ¹National Chengchi University

Delay discounting task (DDT) and probabilistic discounting task (PDT) have often been used to investigate human impulsive behavior. However, the correlations between DDT and PDT were often inconsistent across different studies. Moreover, in PDT, the effect of variance of choice options while keeping the expected value (EV) equal to both options has not been examined

systematically. In this study, we aimed to investigate the relationship between DDT and PDT in young adults in Taiwan; furthermore, we designed a risk preference task (RPT) to manipulate the variances to examine how participants made a binary choice between a certain and a probabilistic reward choice under equal EV. Hence, a DDT, PDT, and RPT were deployed in our study, 28 young adults from Taiwan participated. In DDT, participants had to choose under 3 conditions, respectively between immediate vs delay 1, 2, and 3 months reward. In PDT, participants chose under 3 conditions, respectively between 100% vs 75%, 50%, and 25% reward. In RPT, participants chose under 6 conditions, respectively between 100% vs 80%, 75%, 60%, 50%, 30%, and 25% reward ($CV = 0$ vs 0.5, 0.57735, 0.81649, 1, 1.52752, 1.73205) with the EV 120 or 240. The results showed no significant correlation in parameters between DDT and PDT in participants, but the parameter of PDT was correlated with the max CV choice of what participants preferred in RPT ($p \leq 0.059$). Participants who always chose 100% rewards in VDT also had a larger discounting parameter (3.78) in PDT, reflecting the risk aversion.

Topic Area: THINKING: Decision making

A136 Dance experience predicts improvement from movement therapy in Parkinson's Disease

Anna Krottinger¹, Psyche Loui^{1,2}; ¹Wesleyan University, ²Northeastern University

Parkinson's disease (PD) is associated with a loss of internal cueing systems, which affects rhythmic motor tasks such as walking. Rhythmic stimulation has been shown to improve motor deficits in some patients; these findings have inspired dance therapies for PD. We tested the hypothesis that groove and sensorimotor experience, as quantified by music and dance experience, affect the therapeutic outcome of dance classes for PD. We assessed tapping to high- and low-groove songs, music and dance experience, and disease severity using the Unified Parkinson's Disease Rating Scale (UPDRS) in patients before and after 4 months of weekly dance therapy. We found that tapping performance was correlated with improvement in UPDRS scores from baseline to 4 months ($r = -0.45$, $p < 0.001$). Furthermore, we found associations between dance experience and tapping performance: Dance experience (numbers of years in patients with 2+ years of training) was negatively correlated with variance of the inter-tap interval for both high-groove ($r = -0.35$, $p < 0.001$) and low-groove songs ($r = -0.26$, $p < 0.001$). Mean inter-tap interval was found to be lower for high groove songs than for low groove songs ($t = 3.79$, $p = 0.001$). These data suggest that dance experience could predict rhythmic movement consistency. Results also suggest that dance experience may contribute to motor improvement from therapy in PD.

Topic Area: PERCEPTION & ACTION: Motor control

Poster Session B

Sunday, March 24, 8:00–10:00 am, Pacific Concourse

B1 Active tracking of speech in a complex auditory scene in children

Sun Meirong^{1,2}, Han Qiming^{1,2,3}, Zou Jiajie⁴, Ding Nai⁴, Luo Huan^{1,2,3}; ¹School of Psychological and Cognitive Sciences, Peking University, ²PKU-IDG/McGovern Institute for Brain Research, Peking University, ³Peking-Tsinghua Center for Life Sciences, Peking University, ⁴College of Biomedical Engineering and Instrument Sciences, Zhejiang University

Humans can selectively attend to one talker in a multi-talker environment, an important social-cognitive capacity ('cocktail party effect'). Accumulating

evidence has shown that the human brain can segregate different speech streams in auditory cortex and selectively represent the attended speech stream. However, it remains unknown how selective speech tracking mechanisms develop in children. Here, we recorded electroencephalography (EEG) activities from healthy adults (N = 13; age 20-28 years) and typically developing children (N = 13; age 9-15 years), while they selectively listened to one of two competing stories from different speakers. Neural tracking of each speech stream is separately analyzed using the temporal response function (TRF). Both adults and children can attend to the target story and correctly answer comprehension questions. Preliminary EEG results demonstrate that the neural responses, however, are less strongly modulated by attention in children than in adults. Critically, the attention effects are observed in different brain areas for children and adults. Our results demonstrate that the neural mechanism to selectively process one speech stream in a complex auditory environment is underdeveloped until about age 15.

Topic Area: ATTENTION: Auditory

B2 Childhood leukemia survivors exhibit chronic deficiencies in sensory and cognitive processes, as reflected by event-related brain potentials: A preliminary investigation

Kelin Brace¹, Wei wei Lee¹, Peter D. Cole², Elyse S. Sussman¹; ¹Albert Einstein College of Medicine, 1300 Morris Park Avenue, Bronx, NY 10461, United States, ²Rutgers Cancer Institute of New Jersey, 195 Little Albany Street, New Brunswick, NJ 08901, United States

Chemotherapy treatment for children with acute lymphoblastic leukemia (ALL) is typically curative, but the treatment has been linked to impairment in cognitive function in 40-70% of cases. The impact of treatment-induced cognitive dysfunction has immensely negative consequences affecting school performance and quality of life. However, the specific mechanisms that disrupt cognitive ability are not well understood. The goal of this preliminary study was to identify deficits in specific domains of cognitive ability (auditory sensory processing, working memory, and attention) in pediatric ALL survivors post-treatment. Event-related brain potentials (ERPs) and behavioral measures were recorded in ALL survivors and compared to healthy controls. ALL children had slower reaction times and lower hit rates on auditory tasks, and had smaller amplitude and longer latency ERP components compared to healthy control children. Overall, differences between survivors and controls were observed in all ERP and behavioral measures, showing deficiencies in sensory processing, auditory working memory, and attentional control. ERPs may be a useful non-invasive tool to assess recovery and risk of cognitive dysfunction in children who have undergone chemotherapy treatment.

Topic Area: ATTENTION: Auditory

B3 Enhancement of speech-in-noise perception in children with autism spectrum disorder using an assistive listening device

Sara Nataletti^{1,2}, Eleonora Vagnoni¹, Fabrizio Leo¹, Elena Cocchi³, Laura Scafa³, Simonetta Lumachi⁴, Luca Giuliani^{1,2}, Luca Brayda¹; ¹Istituto Italiano di Tecnologia, ²University of Genoa, ³Fondazione David Chiossone Onlus, ⁴Philos – Accademia Pedagogica

Processing of auditory information is essential for an effective social interaction and typical learning development. Children with autism spectrum disorder (ASD) exhibit abnormal behavioral performance on auditory-based tasks, especially they show significantly poorer speech recognition in noise relative to their neurotypical peers. The goal of this study was to investigate the potential benefits of an assistive listening device aimed at supporting spatial sounds segregation on fifteen ASD children. This technology is shaped as a common pair of glasses and exploits microphone arrays to spatially filter sounds. Frontal speech sources are preserved while competing noises from the sides and the back are attenuated (directional mode). In our task,

participants had to perform a listen-and-repeat task in three hearing conditions: (i) without the device (ii) with the device set in the directional mode (iii) with the device equally enhancing all sound sources (omnidirectional mode). The participants had to listen to and repeat short sentences presented concurrently with a competing cocktail party noise. The performance was measured in terms of the speech reception threshold (SRT), defined as the speech-to-noise-ratio at which 50% of the spoken words is correctly understood. We found that the mean SRT in the directional mode was significantly lower (i.e. indicative of better performance) compared to the other two hearing conditions. This finding suggests that artificially conditioning sound perception may improve speech reception in children with ASD and, indirectly, may lead to a positive impact on daily social activities that require interaction in noisy environments.

Topic Area: ATTENTION: Auditory

B4 Modulation of Phase Synchronization across Fronto-Parietal and Temporal Cortices during Auditory Attention

Fahimeh Mamashli^{1,2}, Samantha Huang^{1,2}, Sheraz Khan^{1,2}, Matti Hämäläinen^{1,2,3}, Jyrki Ahveninen^{1,2}; ¹Athinoula A. Martinos Center for Biomedical Imaging, MGH/HST, Charlestown, MA, USA, ²Department of Radiology, MGH, Harvard Medical School, Boston, MA, USA, ³Department of Neuroscience and Biomedical Engineering, Aalto University School of Science, Espoo, Finland

Many studies have documented modulations of auditory cortex (AC) when a human subject pays attention to sounds originating in one location of space while actively ignoring other sources. These modulations are presumably driven by an executive network of fronto-parietal cortex regions. However, the oscillatory dynamics of functional connections among brain areas activated during auditory attention has remained elusive. In this study we acquired magnetoencephalography (MEG) data during a dichotic auditory selective attention task. In 10-s trials, the subjects (N=15) were (a) cued to detect a harmonic target sound embedded among standard tones presented to one ear and (b) asked to ignore standard tones and occasional task-irrelevant novel sounds presented in the opposite ear. We applied a novel approach, particularly developed for functional connectivity analysis in time and frequency among subregions of broader regions of interest (ROI), to analyze functional connectivity in our cortically-constrained MEG source estimates. Phase coherences were estimated between three ROIs: AC, frontal and parietal cortices. We found that in comparison to the novel sounds, target detection increased gamma band functional connectivity between inter-hemispheric and intra-hemispheric ROIs in later time windows (>300 ms). In contrast, alpha band functional connectivity was increased in earlier time windows for novel in comparison to target sounds. Our results suggest that suppression of irrelevant auditory events vs. voluntary attention to relevant auditory targets increase functional connectivity at different oscillatory frequency bands.

Topic Area: ATTENTION: Auditory

B5 Neural markers of mind wandering during online learning sessions

Colin Conrad¹, Aaron Newman¹; ¹Dalhousie University

Attention-related constructs such as mind wandering are often used to describe user experiences that are detrimental to the efficacy of education technologies. However, these constructs are difficult to measure subjectively because the act of measuring them disrupts the very phenomenon that would try to measure. An alternative approach is to use electroencephalography (EEG). In this paper, we describe an experiment to discover EEG correlates of mind wandering using auditory evoked potentials. Sixteen participants were recruited to watch an online lecture video while task-irrelevant audio tones

were played in the background as attention probes. Participants were asked to push a button if and when they noticed their mind wandering. We found statistically significant differences in the P2 Event Related Potential evoked from auditory stimuli from the periods immediately before button presses, and those immediately afterwards. The results present a foundation for a larger project in exploring the potential of real-time EEG detection for use in the improvement of education technologies and education-related brain-computer interfaces.

Topic Area: ATTENTION: Auditory

B6 Rhythm violation releases auditory neural responses from adaptation

Melisa Menciloglu¹, Marcia Grabowecy¹, Satoru Suzuki¹; ¹Northwestern University

The sensory system utilizes temporal structures in the environment to build expectations about the timing of forthcoming events. Here, we investigated how neural responses adapted to auditory rhythm and reacted to stimuli that violated the rhythm. We recorded scalp EEG while 21 participants watched a nature video and passively listened to rhythmic tones with occasional temporal perturbations. In the short-interval block, tones were frequently presented (80%) with 1s inter-tone-intervals (ITIs)—fast-expected tones—and infrequently presented (20%) with 1.5s ITIs—slow-expected tones (expected because if no tone occurs at 1s, a tone is expected to occur at 1.5s with 100% probability). Conversely in the long-interval block, tones were frequently presented with 1.5s ITIs—slow-expected tones—and infrequently presented with 1s ITIs—fast-unexpected tones. We analyzed the sensory evoked EEG responses including the auditory event-related potentials (ERPs) and theta-alpha inter-trial phase coherence (ITPC) recorded from midline frontocentral sites. The results revealed an early rate-dependent adaptation (fast-expected < slow-expected, greater response attenuation for the faster rhythm), occurring within the initial 10 tones, as well as a long-term rate-independent adaptation based on the number of presented tones. Responses to the fast-unexpected tones yielded a near complete release from the early rate-dependent adaptation (fast-unexpected ~ slow-expected > fast-expected). These results suggest that (1) auditory sensory adaptation includes an early rate-dependent component and a long-term cumulative component, and (2) the early rate-dependent component may be subserved by the mechanisms that generate temporal expectations because it was nearly eliminated by the tones that violated rhythm-based expectations.

Topic Area: ATTENTION: Auditory

B7 The Effect of Noise on the Selective Attention

Emina Alickovic^{1,2}, Carina Graversen¹, Dorothea Wendt^{1,3}, Patrycja Książek¹, Renskje Hietkamp¹, Thomas Lunner^{1,3,4,5}; ¹Eriksholm Research Center, Oticon A/S, Denmark, ²Department of Electrical Engineering, Linköping University, Sweden, ³Department of Electrical Engineering, Technical University of Denmark, Denmark, ⁴Department of Behavioral Sciences and Learning, Linköping University, Sweden, ⁵Linnaeus Centre HEAD, The Swedish Institute for Disability Research, Linköping and Örebro Universities, Sweden

Recent research, investigating selective attention, has demonstrated that neural responses can be decoded to identify the sound source of a listener's interest in everyday concurrent talkers situations. The objective of this study was to measure the effect of different signal to noise ratios (SNRs) on selective attention and listening effort, quantified by decoding accuracy and pupil dilation (PD). In an experimental setup with two competing talkers (presented at $\pm 30^\circ$) and four-talker babble presented from the back of the listener (180°), we tested 8 hearing-impaired (HI) subjects. Subjects were instructed to attend to a speaker at either 0 dB SNR (high SNR) or at -5 dB SNR (low SNR), with

respect to the other speaker. Sixty-four channels of scalp EEG and PD were acquired during the experiment. As expected, the behavioral data showed significantly improved performance with increasing SNR, although the performance level at low SNR was still above chance level. This entails that the HI subjects could still perform the task even in the low SNR condition. PD data showed non-significant increase in overall dilation for low SNR in the time-interval 10-25 sec after stimulus onset. EEG data analysis, using auditory attention decoding (AAD) methods, showed that the SNR had a significant effect on AAD performances. Significantly higher AAD accuracy ($p < 0.03$) and correlations between reconstructed and actual speech envelopes ($p < 0.01$) were observed for the high SNR condition. It demonstrates the potential of the AAD methods to reveal the impact of SNR on selective attention in HI subjects.

Topic Area: ATTENTION: Auditory

B8 Towards defining listening demand: stream segregation performance for multi-speaker auditory scenes under various conditions

Lars Hausfeld^{1,2}, Lars Riecke^{1,2}, Martha Shieff^{1,2}, Formisano Elia^{1,2}; ¹Maastricht University, The Netherlands, ²Maastricht Brain Imaging Centre (M-BIC), The Netherlands

In everyday life, we process mixtures of sounds which involves the segregation of the auditory input and the attentive selection of the stream that is most relevant (i.e., auditory scene analysis [ASA]). For scenes with multiple irrelevant sounds, however, it is unclear how the auditory system represents this background. For the visual system, one proposed factor is perceptual demand with perceptual processing for low demand conditions and physical processing for high demand conditions. For the auditory system, however, results from psychophysical and EEG studies were inconclusive. Here, we present participants (N=10) with 540 auditory scenes consisting of 3 speakers in 5 separate sessions. We vary demand by spatial cues (ITD), target-to-masker ratio (TMR) and spectral overlap of background speakers while participants pay attention to one speaker. Subsequently, participants rate their segregation performance and perform a word recognition task (4AFC). Participants' rating results suggest that subjective streaming performance benefits from stronger auditory spatial cues (i.e., ITD), higher TMR and smaller spectral overlap of background speakers. In contrast, participants' word recognition results reveal interactions between ITD, TMR and background hinting at both acoustic-based segregation as well as working memory processes for successful task performance. In addition, the analysis of incorrect answers suggests that speech underwent perceptual processing if it consisted of a male and female speaker and only during difficult listening conditions background. These findings suggest a mismatch of perceived listening demand and ASA task performance, and possibly point at different cognitive processes underlying listening demand and performance.

Topic Area: ATTENTION: Auditory

B9 An EEG Investigation of Temporal and Spatial Reproduction

Eva Marie Robinson¹, Martin Wiener¹; ¹George Mason University

Time and space are vital dimensions for accurate navigational processing. However, whether these two dimensions are processed independently is still being debated. Therefore, this study investigated whether time and space are separate constructs or whether they are processed similarly based on their magnitudes. During 64-channel EEG collection, subjects (N=16) performed a spatial or temporal reproduction task, in separate blocks, in a virtual reality environment, in which subjects traveled a predetermined spatial or temporal interval and were then instructed to reproduce the interval traveled. In the task, the subject's travel speed varied for the estimation and reproduction phases of each trial and feedback was provided. Behaviorally, subject performance was more variable when estimating time than when estimating space, but overall, just as accurate for both dimensions. Crucially, inter-subject

performance for time was not correlated with space suggesting separable mechanisms for processing each. EEG data revealed a significantly larger contingent negative variation (CNV) for time than space at frontocentral electrodes during reproduction but not estimation phases. Additionally, a broadband increase in alpha (7.5-12.5 Hz) and beta (13-30 Hz) frequency band power was observed exclusively during the reproduction of temporal estimates at frontocentral sites. Finally, a larger increase in phase coherence was observed at frontal-mediated theta frequency (4-7 Hz) during the estimation but not reproduction phase for temporal but not spatial estimates. This frontal mediated theta suggests a stronger encoding of memory for temporal intervals. Our findings indicate that time and space are neurally separable dimensions, whose magnitudes can be measured independently.

Topic Area: ATTENTION: Spatial

B10 Attentional facilitation and inhibition in V1 during spatial long-term memory encoding

Haley A. Fritch¹, Scott D. Slotnick¹; ¹Boston College

Attending to a visual stimulus facilitates the V1 response at the attended location and inhibits the response to unattended stimuli (Slotnick, Schwarzbach, & Yantis, 2003). However, it is unclear if attentional inhibition is also present when there are no distracting stimuli. In this fMRI study, we examined attention effects in V1 while participants were exposed to one stimulus at a time during spatial long-term memory encoding. Participants maintained central fixation while abstract shapes appeared in each visual field quadrant. They were asked to remember each shape's location and later to recall these locations. A general linear model analysis was used to identify the patterns of activity associated with encoding stimuli within each quadrant. The V1 region of interest was split into four quadrants based on longitudinal and calcarine sulci. For each coronal slice, the mean magnitude of activity corresponding to each V1 quadrant (with the quadrant corresponding to the attended location near the middle slice) was analyzed to assess attention effects in attended, more posterior/central, and more anterior/peripheral representations. Attended quadrants were aligned such that attention effects could be observed across the entire visual field and a random-effect analysis was conducted. This analysis revealed: (1) facilitation at the attended location extending toward fixation, (2) inhibition in the periphery within the unattended quadrant of the attended hemifield, and (3) inhibition toward fixation within the unattended hemifield. These findings support the hypothesis that facilitation and inhibition are both important for visual-spatial attention and suggest that attention effects can occur without distracting stimuli.

Topic Area: ATTENTION: Spatial

B11 Disruption of multiple versus single nodes in the dorsal attention network with TMS leads to stronger attention impairments

Stefano Galloto^{1,2}, Tom A. de Graaf^{1,2}, Teresa Schuhmann^{1,2}, Alexander T. Sack^{1,2}; ¹Maastricht University, The Netherlands, ²Maastricht Brain Imaging Centre, The Netherlands

Top-down control of visuospatial attention is associated with activation of frontal eye field (FEF) and intraparietal sulcus (IPS), core nodes of the frontoparietal dorsal attention network (DAN). Transcranial magnetic stimulation (TMS) has been used to disrupt (i.e. inhibit) IPS or FEF activity in isolation, resulting in attention performance changes. However, since these two regions work in synergy, compensatory effects are likely to occur. It would be relevant, therefore, to test how the inhibition of both nodes affects their interaction, as compared to the effects obtained after single-region disruption. Here, we investigated how the concurrent inhibition of both the right FEF and the right IPS (by continuous theta-burst stimulation: cTBS) affects behavioral performances (measured by using the lateralized attention network test: LANT) as compared to the inhibition of one node of the right DAN in isolation

(either FEF or IPS), or none (sham TMS). In single-region right DAN TMS, orienting effects (reaction time differences between validly and invalidly cued trials) did not show hemifield differences. In contrast, orienting effects after simultaneous inhibition of both nodes of the right DAN, i.e. right FEF and IPS simultaneously, were significantly smaller ($p < 0.05$) in the right as compared to the left hemifield. No effects were found on other outcomes of the LANT. TMS has previously been shown to affect networks even when targeting single regions. However, our results suggest that multi-site TMS can induce stronger effects. This may have implications for both clinical and research applications aiming to maximize neuromodulation effects on cognitive networks.

Topic Area: ATTENTION: Spatial

B12 Inhibition of return in visual search: Disentangling overlapping processes with event-related potentials

Allison M. Pierce¹, Jessica J. Green¹; ¹University of South Carolina

Inhibition of return (IOR), the slowing of responses to a target occurring at a recently stimulated location, is typically described as reflecting a mechanism that facilitates efficient visual search. However, most studies examine IOR within cue-target paradigms, rather than visual search paradigms. In a previous study, we recorded EEG during a target-target visual search paradigm and observed both IOR and a reduced N2pc for targets appearing at previously searched locations, reflecting an attentional bias away from the previously attended location. We also observed the IOR-related attentional bias throughout the entire hemifield that was previously attended. Here, we adapted our paradigm, in which the first and second search displays both contained a target surrounded by multiple colored distractors (search target), to also include conditions in which the first display could contain either a pop-out target or a pop-out non-target surrounded by grey distractors. The pop-out non-target condition was designed to be analogous to a cue-target paradigm, in which the first display (i.e., the cue) is a salient, but irrelevant item that must be ignored. We found evidence of an attentional bias (i.e., IOR, reduction in N2pc) throughout the previously attended hemifield in both the search target and pop-out target conditions. However, in the pop-out non-target condition, IOR was only observed at the previously attended location. Our results suggest that the bias of attention away from a previously attended location and the inhibition of a location that previously contained a distractor produce distinct behavioral and electrophysiological signatures.

Topic Area: ATTENTION: Spatial

B13 The N1pc prioritizes to-be-rejected items in visual search

Sarah Donohue^{1,2}, Mandy Bartsch², Hans-Jochen Heinze^{1,2}, Mircea Ariel Schoenfeld^{1,2,3}, Jens-Max Hopf^{1,2}; ¹Otto-von-Guericke University, Magdeburg, Germany, ²Leibniz Institute for Neurobiology, Magdeburg, Germany, ³Kliniken Schmieder Heidelberg, Heidelberg, Germany

In visual search, a target must be selected among distractors, some of which may be salient. Importantly, however, such salient distractors capture attention and they must be marked as non-target, to-be-ignored items, that are rejected from further processing. The process of selection for rejection is quite paradoxical in that inherent in the ability to ignore something, one must essentially select (i.e., demarcate) what is to be ignored. Such a paradox has been described as the 'ignoring paradox,' or the 'White Bear Phenomenon,' in other contexts. How this demarcation is accomplished neurally is unknown. Here, in a series of four MEG experiments using variations of a visual search task, we show that to-be-rejected distractors are actually given attentional priority. Specifically, an early attention-related component, the N1pc, appears to demarcate items for either further selection (via the NT/N2pc) or for rejection (via the PD). The N1pc occurs earlier for distractors than for targets, and is present regardless of the predictability of the distractor. The distractor-related N1pc is also more pronounced on trials in which participants were faster to

respond, as compared to trials when they were slower. The N1pc is eliminated when participants completed a RSVP task, with the same visual search stimuli presented, suggesting that it is not an artifact of a physical confound, but rather an attention-related selection process. Together, these data demonstrate that for distractor stimuli to be ignored they must first be selected, and this selection of distractors takes priority over the selection of targets.

Topic Area: ATTENTION: Spatial

B14 Adverse childhood experiences modulate the effect of emotional arousal on visual working memory consolidation

weiwei zhang¹, Weizhen Xie^{1,2}, JC Lynne Lu Sing¹, Ana Martinez-Flores¹; ¹Department of Psychology, University of California, Riverside, ²Functional and Restorative Neurosurgery Unit, Surgical Neurology Branch, National Institute of Neurological Disorders and Stroke, National Institutes of Health

Emotion has a profound influence on information maintenance in working memory. However, it is unclear how past and present emotional experiences affect moment-by-moment encoding of fragile sensory inputs into dual working memory representations (i.e., the consolidation process). Using experimental and individual differences approaches, the present study examined the effects of chronic and acute emotional stress on visual working memory (VWM) consolidation speed and storage capacity. On each trial, participants (n=120) performed a VWM task while negative or neutral emotion experiences were induced using 6-second sound clips from the International Affective Digital Sounds (IADS) and simultaneously assessed using pupillometry. Chronic stress was assessed using self-report measure of adverse childhood experiences (ACEs). Some other affective characteristics of the participants including depressed mood and anxiety were also measured. We found that induced arousal dilated pupil sizes and speeded up the consolidation process in a concurrent VWM task, with little impact on VWM storage capacity, at the group level. The analysis on the individual differences showed that the effects of induced arousal on VWM consolidation speed followed the classic inverted U-shaped pattern, which was further shifted upward by ACEs, but not by depressed mood or anxiety. That is, individual with ACEs showed greater effects of induced arousal on VWM consolidation speed. Together, these findings suggest that past stressful life events amplifies the effects of acute stress on VWM consolidation speed.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B15 Associative learning via intentional and unintentional actions

Irem Undeger¹, René M. Visser², Andreas Olsson¹; ¹Karolinska Institutet, ²University of Amsterdam

Previous research shows that intentionally vs. unintentionally caused harms are perceived as greater in magnitude and more blameworthy. In the current study, we used an associative learning paradigm in which the stimuli presented to the participant were chosen by confederates, and were associated with either harm (intentional or accidental) or safety. We collected functional resonance imaging (fMRI) data during learning, and resting-state fMRI data before and after learning, followed by a memory test the next day. Using trial-by-trial representational similarity analysis (RSA), we assessed the development of neural activation patterns in regions involved in theory of mind (ToM) and threat learning during learning from harm and its update to safety. After the experiment, participants under-reported the amount of harmful choices made by the unintentional confederate, and were angrier towards the intentional one. We observed a refinement of activation patterns in response to the harmful choices in the anterior cingulate cortex (ACC), the insula, and the ventro-medial prefrontal cortex (vmPFC), and to intentionally harmful choices in the superior temporal sulcus (STS). Our results suggest STS, a brain region involved in mind attributions, integrate the intentionality of a harmful action whereas regions involved in threat processing have a

stronger preference for the presence of harm. The memory test revealed that participants generalized harm to stimuli in the intentional, but not the unintentional, context. Our results offer insights into how learning is shaped via associative learning during social interactions, entailing changes in both evaluations of other individuals and of memories of their actions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B16 Brain activity in processing emotional prime-target judgement task: An fMRI study

Yen-Ju Lu¹, Shih-tseng Tina Huang^{1,2}, Sing-Rong Sie¹; ¹Department of Psychology, National Chung-Cheng University, Taiwan, ²Center for Research in Cognitive Science, National Chung-Cheng University, Taiwan

The present study examined the priming effects in congruent and incongruent emotional prime-target judgements. 22 participants (12 females; mean age=21.5; SD=1.6) were recruited and scanned with a 3 Tesla GE MRI scanner during the emotional prime-target judgement task. In each run, emotional images with anger, fear, happy or neutral facial expressions were presented as prime for 2000ms and followed by a target face which participants were asked to judge if the target face was the same emotion as the prime. Data were analyzed via a 2(prime-target emotion: congruent vs. incongruent) x 4(emotion of prime: anger vs. fear vs. happy vs. neutral) x 2(condition: prime vs. target) design with all factors varied with participants. The results found significant activations of prime at bilateral lingual gyrus and bilateral cuneus (p<.05, FWE). We also found significant higher activation of congruent than incongruent trials at left superior temporal gyrus (p<.001). It was also found differences among the emotions of prime at left inferior parietal lobule, left thalamus and right caudate (p<.001). Follow-up analysis found using anger as a prime was higher than fear and neutral at right inferior parietal lobule. Furthermore, higher activation were found in processing anger-prime than processing the target faces at bilateral lingual gyrus, left superior parietal lobule, left fusiform gyrus, left inferior frontal gyrus, and left insula. Higher activation was found at superior temporal gyrus in the fear-prime congruent trials than in trials with incongruent prime-target emotion. The affective effects were found to be associated with negative emotional priming.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B17 Creativity Anxiety

Richard Daker¹, Robert Cortes¹, Ian Lyons¹, Adam Green¹; ¹Georgetown University

Creative thinking, and fostering creative thinkers, is of great and growing value in science, industry, and education – creative innovation projects to be more valuable than technical skills at which artificial intelligence will outpace human cognition. Educationally-relevant anxieties, like math anxiety, have been shown to substantially impact specific forms of achievement and engagement. Somewhat surprisingly, the possibility of creativity-specific anxiety is unexplored. Here, across multiple samples, we tested the viability of creativity anxiety as a construct. We first created and validated a new measure, the Creativity Anxiety Scale (CAS). Applying the CAS, we found that creativity-specific anxiety predicted individual differences in creative achievement and attitudes above general anxiety. Moreover, across diverse content domains, from science to arts, anxiety was greater for situations that required creativity than similar situations that did not. This research establishes and enables measurement of creativity anxiety, revealing impacts and facilitating development of interventions to foster creative achievement. As in the case of math anxiety, it also opens up new avenues of research to understand the cognitive and neural mechanisms by which affective factors impact specific forms of cognition.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B18 Differential Neural Networks of Distraction, Reappraisal and Expressive Suppression during Emotion Regulation: A fMRI Investigation

Wenjuan Li¹, Ling Li¹; ¹University of Electronics Science and Technology of China, Chengdu, China

Emotion regulation, which refers to the flexibility of responses to affective events, plays an important role in our daily social life. An appropriate regulation could benefit to our mental and physical well-being. The present study attempts to explore the neural substrates underlying the following three emotional regulation strategies: distraction, reappraisal and expressive suppression. Thirty-two young adults completed an emotion regulation task, which instructed participants to apply different strategies to regulate their emotional states when viewing negative, neutral and positive pictures during a fMRI scanning. Our findings revealed that when compared to reappraisal and suppression, distraction activated larger clusters of the inferior parietal cortex, the left superior parietal cortex, the right angular gyrus, the right middle frontal cortex, the SMA as well as partial right insula. While the dorsolateral, ventrolateral and dorsomedial prefrontal cortex (dlPFC, vlPFC, dmPFC), the orbitofrontal gyrus, the middle temporal cortex, the angular gyrus, the hippocampus, and the post cingulate gyrus were recruited in reappraisal as compared to distraction. However, only smaller clusters of the middle temporal cortex, the vlPFC and the left dmPFC were found as compared to suppression. Suppression showed increased activation of the dmPFC, the left dlPFC, the orbitofrontal gyrus, the middle and the superior temporal cortex as compared to distraction, but no significant differential activation was observed when compared to reappraisal. In general, these results suggest that reappraisal and expressive suppression recruited very similar emotion regulation networks in the prefrontal cortex, while distraction had a stronger correlation with activation of the parietal lobe.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B19 Enhanced empathic state caused by reading fiction promotes detection of and attention to task-irrelevant facial expressions

Natsuka Katayama¹, Motoyuki Sanada¹, Jun'ichi Katayama¹; ¹Kwansei Gakuin University, Japan

A high level of empathy influences task-related facial expression recognition (Choi & Watanuki, 2014), but it is unclear how empathy influences task-irrelevant facial expression recognition. In addition, although empathy has largely been treated as a trait, some studies treat empathy as a state (e.g., Lazarus, 1991). This study investigated the effect of empathic state on cognitive processing of task-irrelevant facial expressions. We set a fiction condition in which participants (N = 20) read fiction to enhance their empathic state and a nonfiction condition as a control in which they read nonfiction. The Interpersonal Reactivity Index (IRI) was used as a measure of empathic state. To examine cognitive processing of task-irrelevant facial expressions, EEG signals were recorded while participants performed a three-stimulus oddball task in which images of faces (neutral and sad, 45% each) and flowers (10%) were presented in random order. Participants pressed a key when they saw flowers. IRI surveys and oddball tasks were carried out before and after reading in each condition, which was conducted on a separate day. Results show that only after reading fiction, amplitudes of N170 and late positive potential (LPP) elicited by facial images increased. In addition, these ERP enhancements were larger for sad faces. These results indicate that both detection of and attention to task-irrelevant facial expressions (especially sad faces) were promoted by an enhanced empathic state. Therefore, a high empathic state affects facial expression recognition from a very early stage, even when people are not focusing on facial expressions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B20 From hurricanes to homecomings: A database of news broadcast videos for investigating the dynamics of emotional memory

Rosalie Samide¹, Rose Cooper¹, Maureen Ritchey¹; ¹Boston College

The emotional content of events and experiences can influence the way they are perceived, processed, and remembered. To investigate these interactions, researchers have developed experimental tasks and materials designed to elicit emotional responses in a controlled laboratory setting. Real-life emotional experiences, and our reactions to them, necessarily unfold over time, yet many of these studies have relied on static images. Therefore, little is known about the dynamic effects of emotion on perception and memory of continuous, naturalistic events. Here, we introduce a set of 126 videos of real television news broadcasts that vary in their emotional valence and intensity. In an initial norming study, participants (n = 100) continuously rated the pleasantness of each video during its presentation and judged the overall emotional intensity and valence at the end of each video. In a subsequent memory test, participants reported how vividly they could recall the video details. We found that emotion was related to subjective memory vividness: as in previous studies using static images, memories for emotional videos were reported as more subjectively vivid than memories for neutral videos. We report data on the affective qualities and memorability of each video, as well as the continuous ratings of emotional valence, which will allow researchers to study emotion-related processes while maintaining both ecological validity and experimental control.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B21 Interactions Between Media Use, Depression, and Trait Rumination

Jesus J. Lopez¹, Joseph M. Orr¹; ¹Texas A&M University

Given the prevalence of media multitasking (i.e., engaging concurrently in multiple forms of media) in today's society, it is important to examine its effect on psychosocial factors, such as depression. Previous research on media multitasking use found a relationship between media multitasking and depression (Becker et al., 2013). Depression is often associated with rumination—dwelling on negative thoughts. However, whether there is a three-way relationship between media multitasking, depression, and rumination remains an open question. Therefore, this study asked, "Does a high media multitasking individual engage in rumination more so than a low multitasker? Or, is media multitasking a replacement for trait rumination in depressed individuals?" Here, 303 participants completed the Media Use Questionnaire, which was then used to calculate an individual's Media Multitasking Index (MMI), followed by both the Beck Depression Inventory II and the Ruminative Response Scale. We predicted that the more a person with depression multitasks, the less they will engage in rumination, suggesting that the act of multitasking is a replacement for rumination. Depression was predicted by both MMI and rumination, suggesting that more media multitasking use as well as rumination are related to depression. Contrary to our hypothesis, rumination was positively predicted by media multitasking on its own, suggesting that more media multitasking is associated with higher amounts of rumination. However, a mediator analysis with MMI as the mediator variable was unsuccessful. Ongoing work should be focused on further examining the relationship between these and related variables.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B22 Neural Evidence for Cognitive Reappraisal as a Strategy to Alleviate the Effects of Math Anxiety

Rachel G. Pizzie^{1,2}, Cassidy L. McDermott^{3,2}, Tyler G. Salem², David J.M. Kraemer²; ¹Georgetown University, ²Dartmouth College, ³National Institutes of Health

Investigating the neural underpinnings of math anxiety provides an unique opportunity to study the behavioral and neural interactions between cognition and affect. Math anxiety describes feelings of tension, apprehension, and fear that interfere with math performance. High math anxiety (HMA) is correlated with a number of negative consequences, including lower math grades, less self-confidence in math, and ultimately an avoidance of quantitative classes and careers. Given these adverse consequences, it is essential to explore effective interventions to reduce math anxiety. In the present fMRI study, we investigated the efficacy of cognitive reappraisal as a strategy to alleviate the effects of math anxiety. Cognitive reappraisal, an emotion regulation strategy, has been shown to decrease negative affect and amygdala responsivity to negative emotion-eliciting stimuli. Here, we compared an instructed reappraisal strategy to participants' natural strategy for solving math problems. We found that individuals with high math anxiety showed an increase in accuracy and a decrease in negative affect on the math trials during the reappraise condition as compared to the control condition. During math reappraise trials, higher activity in a network of regions associated with arithmetic was correlated with improved math performance for HMA individuals. These results demonstrate that increased recruitment of arithmetic regions may underlie the benefits of reappraisal in this context. Overall, cognitive reappraisal is a promising strategy for improving math performance and reducing anxiety in math anxious individuals.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B23 Neural Mechanisms of Motivational Incentive Integration and Cognitive Control

Debbie Yee¹, Todd Braver¹; ¹Washington University in St. Louis

Humans regularly consider a wide variety of incentives when pursuing behavioral goals. Further, our prior work indicates different motivational incentives combine to influence cognitive task performance (Yee et al, 2016 *Frontiers*). Yet there is currently a poor understanding of the mechanisms by which motivational integration occurs in the brain. We developed an innovative fMRI task paradigm that quantifies dissociable and integrative effects of liquid motivational valence (appetitive = juice, neutral = tasteless solution, aversive = saltwater) and monetary rewards (low, medium, high) on cognitive control. Healthy young adults (N=51) performed a cued task-switching paradigm to earn varying monetary reward amount (low, medium, high), with oral liquid delivery serving as post-trial performance feedback that signaled successful attainment of monetary reward (for fast/accurate responses). Because the symbolic meaning of the liquid was constant, blocked effects of liquid valence on behavior and brain activity were taken to reflect motivational integration effects. Monetary reward effects were widespread, but most reliable in frontoparietal regions, while liquid valence effects were present primarily in value-sensitive brain regions, such as dorsal striatum, and dorsomedial frontal cortex (ACC / pre-SMA). Moreover, in this latter region, strong evidence was found for motivational integration, which moreover predicted both behavioral performance and self-reported motivation. These results are consistent with theoretical accounts suggesting the ACC encodes the expected value of cognitive control, and moreover point to the utility of studying motivational integration processes. Planned follow-up analyses will utilize multivariate decoding to examine the relationship between value-based and task-coding in frontostriatal and frontoparietal circuits.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B24 Reading faces better: Using short term training to evaluate trait empathy and micro-expression trainability

Michael Pflanze¹, Elizabeth Schroeder¹, Ferrinne Spector¹; ¹Edgewood College

Micro-expressions (MEs) are involuntary facial expressions that occur within a very short timeframe (~1/25th of a second) and may reliably indicate suppressed or subconscious emotions (Ekman, 2017). Research suggests that those with greater trait-empathy are better at recognizing micro-expressions (Svetieva & Frank, 2015). In addition, people can be trained to recognize and identify MEs (Matsumoto & Hwang, 2011; Ekman, 1972) using long-term training methods (e.g., over hours, days or weeks). The purpose of the present research was a) to replicate findings associating trait empathy with micro-expression identification, b) test the effectiveness of a novel short-term training protocol in improving ME identification and c) to understand how trait empathy is related to ME mirroring (i.e., using ME muscles when viewing MEs) and trainability. Participants completed a trait empathy scale and were fitted with facial sensors using facial EMG. Participants completed a pre-test measuring ME detection and identification followed by a 20-minute micro-expression training program. Post-test comparison revealed significant improvement in both detection ($p < .001$) and identification ($p < .001$). While rate of mirroring was independent of empathy score, all participants mirrored significantly more after completing training ($p < .05$). This study contributes to the understanding of how trait empathy utilizes networks sensitive to affect and intentionality in human faces, which may influence natural and developed skill in the interpretation of facial expressions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B25 Reinstatement of mental context facilitates retrieval of extinction memories

Augustin C. Hennings¹, Mason McClay¹, Jarrod A. Lewis-Peacock¹, Joseph E. Dunsmoor¹; ¹The University of Texas at Austin

Following fear conditioning, extinction learning introduces competition between fear and extinction memories (Bouton, M. E., 2002). The expression of extinction is contextually specific, whereas fear generalizes to novel contexts (Maren et al., 2013). Neurally, the acquisition and expression of extinction is regulated by a circuit including the ventro-medial prefrontal cortex (vmPFC), however many neuroimaging studies fail to observe vmPFC activity during extinction tests (Quirk & Mueller, 2008; Fullana et al., 2018). Recent models of human episodic memory emphasize mental context as an important factor for successful encoding and retrieval (Sederberg et al., 2008). Here, we hypothesized that reinstatement of mental context from extinction learning will facilitate the retrieval of extinction memories in a novel context. However, we did not expect to find this for patients with post-traumatic stress disorder (PTSD), a condition associated with deficits in contextual processing. One day after Pavlovian conditioning and extinction, healthy controls (N=20) and PTSD patients (N=20) were tested for fear renewal, and we used fMRI pattern classification to quantify the reinstatement of mental context from extinction learning using a "context-tagging" procedure (Gershman et al., 2013). In healthy controls, greater extinction context reinstatement was associated with better retrieval of extinction memories (i.e., fewer threat responses to CS+ items). There was no such relationship in the PTSD group. Moreover, our context reinstatement measures were significantly correlated with fMRI activity in the canonical extinction circuit, including vmPFC. These results show that context reinstatement helps resolve competition between fear and safety, but not for patients with PTSD.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B26 The Association among Fluid Intelligence, Emotional Intelligence and Emotion Regulation: Based on the Voxel-based Morphometry Analyses

Tongran Liu¹; ¹Institute of Psychology, Chinese Academy of Science

Emotion regulation is vital for individuals' daily life, and it relates to which emotions one occurs, when has them, and how experiences or regulates them, and reappraisal and expressive suppression are two essential components of emotion regulation (Gross, 1998). Fluid intelligence is human's core cognitive ability and relates to the neural function of frontal and temporal regions (Deary et al., 2010). Emotional intelligence is referred as the basic emotional abilities of perceiving and expressing emotion to better solve problems and adapt environment (Schutte et al., 1998). The current study aimed to investigate how emotional intelligence and fluid intelligence predict individual's emotion regulation behaviors through the mediation of gray matter density (GMD) of frontal and temporal areas. 24 right-handed adult volunteers participated the current study (11 females, mean age of 22.3 years old). Raven's Standard Progressive Matrix test, the Chinese version of Emotional Intelligence Scale questionnaire, and the Chinese version of Emotion Regulation Questionnaire were implemented before participants were scanned. T1-weighted structural images were analyzed using voxel-based morphometry (VBM) method. The mediation analyses showed that GMDs in right temporal lobe mediate the influence of emotional utilization of emotional intelligence on reappraisal of emotion regulation (indirect effect = 0.58, 95% CI = [0.16, 1.23], $p < 0.005$), and GMDs in right orbitofrontal cortex mediate the influence of fluid intelligence on emotion regulation (indirect effect = -0.21, 95% CI = [-0.51, -0.02], $p < 0.005$). The present results suggest that fluid intelligence and emotional intelligence could affect emotion regulation through different brain structures.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B27 The effect of mouth opening in emotional faces on subjective experience and the early posterior negativity amplitude

Sandra J.E. Langeslag¹, Liselotte Gootjes², Jan W. Van Strien²; ¹University of Missouri - St. Louis, ²Erasmus University Rotterdam

Previous studies have examined the role of the eye region in emotional expressions, but the mouth region is understudied. The main goal of this study was to examine how mouth opening in emotional faces affects subjective experience and early automatic attentional capture, as measured by the early posterior negativity (EPN) amplitude. Participants in two studies viewed angry, happy, and neutral faces with mouths open and closed while their electroencephalogram was recorded. Afterwards, participants indicated how unpleasant-pleasant (i.e., valence) and calming-arousing (i.e., arousal) each face made them feel. Angry and happy faces (and neutral faces to a lesser extent) with an open vs. closed mouth made observers feel more extreme valence and arousal. In addition, there generally was an EPN for angry and happy faces (and neutral faces to a lesser extent) with open vs. closed mouths, which suggests that emotional expressions with an open mouth capture early automatic attention more than expressions with a closed mouth. Finally, the effects of mouth opening were somewhat modulated by face gender, but not by observer gender. The current findings contribute to our knowledge of facial expressions and social interaction, but also have relevance for the growing fields of social robotics and digital animation.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B28 The relation between emotion and semantic priming: Evidence from N400 and reaction time

Dorothee J. Chwilla¹; ¹Donders Institute for Brain, Cognition, and Behaviour; Radboud University

A participant's mood has been shown to influence semantic processing at the sentence level (e.g., Chwilla, Virgillito & Vissers, 2011). Little attention has been directed at mood effects on the processing of neutral words at the word level. The aim of this study was to investigate the effects of mood on semantic priming. Visual prime-target pairs were presented that were bidirectionally

related (e.g., "boy-girl"), unidirectionally forward related (e.g., "palm-tree"), unidirectionally backward related (e.g., "tree-palm") or unrelated (e.g., "bird-soap"). Mood (happy vs. sad) was manipulated by presenting video clips. ERPs and reaction times were recorded while participants performed a lexical decision task. If mood impacts semantic processing this should be reflected by an interaction between mood and priming. The mood manipulation successfully induced a happy or sad state. For N400, a relatedness effect occurred in the absence of a relatedness by mood interaction or main effect of mood. Across moods, N400 amplitude was largest for unrelated targets, intermediate for unidirectionally forward- and backward-related targets, and smallest for bidirectionally related items. Likewise, for reaction time a relatedness effect reflected priming for bidirectionally related, unidirectionally forward and backward related compared to unrelated targets. There was no effect of mood or mood by relatedness interaction. To conclude, the N400 and reaction time results provide converging evidence that mood does not influence meaning processing of neutral words at the word level. The results are taken to suggest that the reliably reported mood effects at the sentence level, likely are mediated by more controlled mechanism, like heuristics.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B29 Volitional Recall of Affective Stimuli Reproduces Brain States that Mediate Perceived Affect

Keith Bush¹, Emily Hahn², Kayla Wilson¹, G. Andrew James¹, Clinton Kilts¹; ¹Brain Imaging Research Center, University of Arkansas for Medical Sciences, ²A.A. Martinos Center for Biomedical Imaging, Massachusetts General Hospital

Multivariate pattern analysis (MVPA) of functional magnetic resonance imaging (fMRI) data acquired during presentation of visual stimuli drawn from the International Affective Picture System (IAPS) has provided strong, physiologically-validated evidence that temporally-succinct whole-brain fMRI-derived patterns of neural activation (termed brain states) significantly encode the valence and arousal properties of IAPS stimuli and serve as central units of image induced affect processing. Moreover, the resultant models significantly predict the affect properties of out-of-sample stimuli suggesting that they can be applied to interrogate affect processing in novel contexts, such as volitional recall (VR) of affective stimuli. To test this possibility, we analyzed fMRI data acquired from (n=60) healthy subjects during VR trials that were interleaved with affect induction trials used to train the MVPA-based affective prediction models. Each of the (n=30) VR trials were comprised of an IAPS stimulus (cue) of 2 s duration succeeded by a volitional recall step (modulation) of 8 s duration in which the subject attempted to match the cue's affect properties. We then predicted the affect encoded within brain states extracted separately from the cue and modulation steps of each VR trial and conducted mixed-effect modeling to characterize the amount of affect reproduced by VR as a function of the subject's affective perception of the cue stimulus, respectively, for valence and arousal. Random effects were modeled subject-wise. We found that VR significantly reproduces both valence ($p < 0.001$, R-squared=0.211) and arousal ($p < 0.001$, R-squared=0.155) with medium to large effect size. Furthermore, we explored sources of individual differences in modulation fidelity.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

B30 A meta-analytic brain map of age-related and individual differences in neurocognitive performance

Tsung Chi Chen¹, Hsu-Wen Huang², Ovid Jyh-Lang Tzeng^{1,3,4,5,6}, Chih-Mao Huang^{1,3}; ¹Department of Biological Science and Technology, National Chiao Tung University, Taiwan, ²Department of Linguistics and Translation, City University of Hong Kong, Hong Kong, ³Cognitive Neuroscience Laboratory, Institute of Linguistics, Academia Sinica, Taiwan, ⁴College of Humanities and Social Sciences, Taipei Medical University, Taiwan, ⁵Department of

Research in cognitive neuroscience of aging has provided clear evidence that normal aging process impacts individual's cognitive function, brain activation, and behavioral performance. The compensation-related utilization of neural circuits hypothesis (CRUNCH) has been proposed to accommodate discrepant results to interpret age-related and individual differences in task-related neural activation and performance. The CRUNCH model posits that older adults would recruit more neuronal resources at lower level of task demand to maintain relatively intact performance than young adults, leaving fewer resources and declined performance for higher level of task demand. In the present study, we conducted a quantitative meta-analysis of task-related functional neuroimaging studies across a variety of cognitive domains to investigate the association between age-related neural activation and task performance. Healthy older participants were further divided into high-performing older groups (HPO; young and older participants had equivalent task performance in accuracy) and low-performing older group (LPO; older participants showed poorer accuracy than young participants) to specify the high and low levels of task demand. The meta-analytic results showed that HPO recruited greater and more distributed fronto-parietal regions compared to young group, suggesting a compensatory mechanism for optimizing task performance in older adults with lower level of task demand. In contrast, LPO exhibited decreased neural activity compared to young participants with higher level of task demand, probably indicating an inefficient mechanism of the aging brain. Our findings provide supportive evidence for the CRUNCH model and suggest an adaptive view of the human brain that functionally reorganizes and responds to normal aging process.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B31 Brain activity during a cognitive flexibility task relates to IQ and reading ability in children

Mackenzie E. Mitchell¹, Tehila Nugiel¹, Mary Abbe Roe¹, Jessica A. Church¹;
¹The University of Texas at Austin

Executive functions, or the processes supporting goal-oriented behaviors, are important predictors of academic success. Few studies have specifically examined the relationship between academic achievement and cognitive flexibility, the slow-to-mature ability to flexibly manipulate information, in the developing brain. As part of a larger study, children (N=56, mean age 12.71, ages 8-18, 28 with ADHD) performed an fMRI cognitive flexibility task: a rule-matching game with cue-only trials to separate brain activity related to preparation from task execution. To investigate how behavioral measures associated with academic achievement differentially relate to brain activity, we related behavioral measures of IQ (WASI-2; Wechsler, 2011) and reading ability (TOWRE-2; Torgesen et al., 2012) to neural activity during the preparatory and execution periods of the task. We found that age was positively associated with activity in the preparatory period; age also had no relation to activity during task execution. Interestingly, we found no effects of IQ or reading ability during the preparatory period, but motor and control activity during the execution period was positively associated with higher scores on these measures. These results held consistent within the subgroup of typically developing individuals (N=24). Preliminary results find that the ability to engage motor and control regions during task execution is related to better performance on behavioral measures of academic achievement. Further, younger children show less activity in control regions during the preparatory period but not during the execution period, consistent with previous work that supports a reactive control strategy in children (Church et al., 2017).

Topic Area: EXECUTIVE PROCESSES: Development & aging

B32 Elevated slope of the EEG power spectrum: a novel biomarker for ADHD in childhood

Madeline M. Robertson¹, Sarah Furlong¹, Bradley Voytek², Charlotte A. Boettiger¹, Margaret A. Sheridan¹; ¹University of North Carolina Chapel Hill, ²University of California San Diego

Attention-deficit hyperactivity disorder (ADHD) is a common neurodevelopmental disorder characterized by hyperactivity/impulsivity, inattentiveness and diminished executive function. A variety of ADHD biomarkers have been identified using EEG, such as increased theta/beta ratio; however, these findings are inconsistent across studies. This inconsistency may be attributable to inadequate isolation of distinct features of the EEG power spectrum. Recent work has shown that apparent band-limited and band ratio changes could be driven by overall spectral slope changes, which might index excitatory/inhibitory (EI) balance shifts (Gao et al., 2017). Thus, narrowband analyses that neglect to consider the full spectrum can conflate relative power with peak frequency shifts and/or spectral slope and/or offset changes. Therefore, we independently quantified the slope, offset, peak alpha frequency, and relative power of the resting-state EEG power spectrum in a sample of 3-7-year-old medication-naïve children with ADHD (n=50), children with ADHD treated with stimulants (n=26), and typically-developing controls (TD; n=50). Medication-naïve children with ADHD had significantly steeper (more negative) spectral slopes than TD children (p=0.01), as well as the medicated ADHD group (p<0.05), despite a 24-hour medication washout. Interestingly, slopes in the medicated ADHD group did not differ from those of the TD group (p=0.94). Furthermore, slope correlated with theta/beta ratio (r=0.50, p<0.01), suggesting that spectral slope may be a novel biomarker for ADHD. Our results are consistent with diminished EI balance in animal models of ADHD (Cheng et al., 2017), and may reflect pathology in ADHD that is normalized by stimulant medications.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B33 Integrative Functional Network Interactions Underlie the Association between Physical Activity and Cognition in Neurodegenerative Diseases

Chia-Hao Shih¹, Miriam Sklerov¹, Nina Browner¹, Eran Dayan¹; ¹University of North Carolina at Chapel Hill

Physical activity (PA) has preventive and possibly restorative effects in aging-related cognitive decline. These effects can be captured by markers of brain health such as functional connectivity (FC) in large-scale association networks. Preventive and restorative effects of PA have also been documented in relation to neurodegenerative diseases, such as Parkinson's disease (PD). However, the neural substrates that mediate the association between PA and cognitive performance in neurodegenerative diseases remain unknown. Here we set out to examine if the association between PA and cognitive performance in PD is mediated by FC in large-scale association networks. Data from 51 PD patients were analyzed. Connectome-level analysis based on a whole-brain parcellation showed that self-reported levels of PA were associated with increased FC between, but not within the default mode (DMN) and salience networks (p < .05, false discovery rate corrected). These PA-related network connections were significant predictors of global cognitive performance as assessed with the Montreal Cognitive Assessment (MoCA) scale. Multiple parallel mediation analysis then demonstrated that FC between left lateral parietal nodes in the DMN and rostral prefrontal nodes in the salience network mediated the association between PA and MoCA scores. These preliminary findings are in line with previous studies linking FC in large-scale association networks with the effects of PA on cognition in healthy aging. Our results extend these previous studies by suggesting that the association between PA and cognitive performance in neurodegenerative diseases is mediated by integrative functional interactions in large-scale association networks.

B34 Multimodal neuroimaging data are associated with common and discrete cognitive control constructsZai-Fu Yao¹, Meng-Heng Yang², Shulan Hsieh²; ¹University of Amsterdam, ²National Cheng Kung University

The aims of this study were to empirically and systematically examine which cognitive control functions are most sensitive to cross-sectional age differences and to identify neural features in different neuroimaging modalities that correlate to cognitive control function across the adult lifespan. We employed a joint independent component analysis (jICA) approach to obtain common networks among three different brain-imaging modalities (i.e., structural MRI, resting-state functional MRI, and diffusion tensor imaging) in relation to the cognitive control function. We differentiated three distinct constructs: one common (across inhibition, shifting, and updating) and two specific (shifting, updating) factors. These common/specific constructs were transformed from three original performance indexes: (1) stop-signal reaction time, (2) switch-cost, and (3) performance sensitivity collected from 156 individuals aged 20 to 78 years old. The current results show that the cross-sectional age difference is associated with a wide spread of brain degeneration that is not limited to the frontal region. We found a joint component associated with age and the common cognitive control construct. We also noted that shifting-specific and updating-specific constructs are associated with distinct components respectively. In order to generalize the current findings, other types of fusion ICA approaches, such as parallel ICA (para-ICA) and multiset canonical correlation analysis with jICA (mCCA + jICA), were also analyzed, and reported in the supplemental materials. To conclude, the current findings suggest there are some common and distinct joint multimodal components that correlate with the psychological constructs of common and specific cognitive control functions respectively.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B35 Neural and behavioral transfer of a simultaneous cognitive-physical video game intervention in an older adult populationJoshua J. Volponi¹, Alexander J. Simon¹, Alana B. Colville¹, Samirah V. Javed¹, Brigid J. Larkin², Karam K. Samplay¹, Soo M. Park¹, Jessica N. Schachtner¹, Roger Anguera¹, Christian J. Thompson², Joaquin A. Anguera¹, Adam Gazzaley¹; ¹UCSF, ²USF

Cognitive and physical interventions can have positive effects on cognitive control abilities (e.g. attention, working memory, goal management). Here we deployed a novel training video game ("Body-Brain Trainer: BBT") for older adults that combines cognitive and physical features to assess the effects of transfer to cognitive outcome measures. During training both cognitive and physical task difficulty adapted on a trial-by-trial basis (through cognitive performance metrics and real-time heart rate measurements, respectively). In this study, cognitively normal older adults (n=24; 55-85 years of age) were asked to train for 24 hours over eight weeks, with a battery of cognitive outcome measures assessed prior to and following this training period. An age and expectancy-matched group of active controls (n=25) played a set of three placebo applications comprised of both cognitive and physical aspects. Evidence of behavioral transfer included a group X session interaction suggesting differential improvements in the training group's impulsivity response time [p=0.017] and response time variability [p=0.033] compared to the control group. In the same assessment, the training group also showed a significant neural group X session effect through an increase in midline frontal theta compared to the control group [p=0.031] as well as a significant session effect [p=0.015]. These findings demonstrate the potential of transfer of improvements in cognitive control from a combined cognitive and physical intervention to an assessment in a different cognitive domain both in a behavioral and neural fashion.

B36 Relationship between event-related brain potentials during Go/NoGo task and parental characteristics or attention-deficit/hyperactivity disorder tendency: The Hokkaido studyKeiko Yamazaki¹, Sachiko Itoh¹, Atsuko Araki¹, Reiko Kishi¹; ¹Center for Environmental and Health Sciences, Hokkaido University

Event-related brain potentials (ERPs) during Go/Nogo task reflects attentional or response inhibition process, which is well-known problems in children with attention-deficit/hyperactivity disorder (ADHD). However, these ERPs might reflect characteristics of participants, because ADHD risk associates with maternal age or smoking etc. We investigated whether characteristics of participants, including ADHD tendency, associate with ERPs during Go/Nogo task, or not. The basic information of children was obtained from the Hokkaido birth cohort, the Hokkaido Study on Environment and Children's Health, which enrolled pregnant women from 2002 to 2012 in Japan. We collected ADHD-RS questionnaire written by mothers, and recorded ERPs of 13 years old children (n=94). We used visual Go/Nogo task, requiring either activation or inhibition of a button-press response to the S2 (Go or Nogo stimulus) following the S1 (warning stimulus). Go P3 (290-390 ms at parietal electrode), Nogo P3 (340-440 ms at central), and N2 (230-330 ms at frontal) to S2 were analyzed. For Go P3, amplitude increased when paternal education was more than 12 years, and latency prolonged with non-smoking father. For Nogo P3, amplitude in ADHD suspected children was larger than in not-suspected children, and latency prolonged when maternal education was more than 12 years. N2 amplitude was larger in ADHD suspected children than in not-suspected children. Although it is consistent to previous studies that Nogo P3 and N2 reflected inhibition problem of ADHD, it is possible that characteristics of participants could be adjustment factor for Go P3 and Nogo P3.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B37 Relationship between Growth Mindset, Executive Function, and Academic Achievement in Middle ChildhoodZoe D'Esposito¹, Jessica Younger¹, Bruce McCandliss³, Fumiko Hoeft⁵, Joaquin Anguera¹, Jyoti Mishra², Miriam Rosenberg-Lee⁴, Adam Gazzaley¹, Melina Uncapher¹; ¹University of California, San Francisco, ²University of California, San Diego, ³Stanford University, ⁴Rutgers University, ⁵University of Connecticut

Having a malleable view of intelligence ('growth mindset') has been shown to be positively related to persistence in challenging academic tasks and academic performance. In addition, executive functioning ('EF'), such as attention, working memory, and cognitive flexibility, have also been positively related to academic performance. We propose that growth mindset may serve as a context for developing aspects of EF via increased engagement through difficult academic tasks. To test our hypothesis, we investigated whether the degree to which students endorsed a growth (versus a fixed) mindset related to better performance on EF tasks. We also investigated the potential mediating role of EF in the positive relationship between mindset and academic achievement. As part of Project iLEAD (In-school, Longitudinal, EF and Academic Database), we assessed 4th, 6th, and 8th grade students (N=568) on EF using adaptive, tablet-based tasks. A theory of intelligence questionnaire assessed views of intelligence on a continuous scale from a highly malleable ('growth mindset') to highly fixed ('fixed mindset'). We found that, controlling for grade, mindset had a significant effect on EF task performance. We also performed a moderated mediation analysis to investigate mindset's effect on academic achievement and found a significant indirect effect of mindset on standardized test scores that varied by grade. Overall, these findings reveal novel evidence of a relationship between growth mindset, EF, and academic achievement, and provide motivation for investigating how these relationships develop over time. Specifically, the

increasingly demanding academic challenges children face over development may foster EF growth.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B38 Role of Domain-general Cognitive Skills in Reading Fluency Skill in Middle Childhood

Jessica Younger¹, Bruce McCandliss², Fumiko Hoeff³, Joaquin Anguera¹, Jyoti Mishra⁴, Adam Gazzaley¹, Melina Uncapher¹; ¹University of California at San Francisco, ²Stanford University, ³University of Connecticut, ⁴University of California, San Diego

Reading is often considered a highly specialized process, relying on neural regions involved in perceptual expertise, yet recent research has recognized it also relies on more domain general skills such as executive function (EF). Understanding the contributions of domain-general skills to specialized processes can help elucidate individual differences in trajectories of specialization. Yet, we do not have a precise understanding of the contributions of EF to reading across development. In the current study, we examined whether three major aspects of EF—visuo-spatial working memory, cognitive flexibility, and interference resolution—uniquely contribute to reading fluency beyond sound-symbol correspondence knowledge, and whether these contributions differ across elementary and middle school. As part of a larger in-school study, we used novel, adaptive, tablet-based tasks to assess executive function-related and reading-related skills in 4th, 6th, and 8th grade students (N=689; project iLEAD). We then used regression analyses to examine the relative predictive power of each of these constructs on reading fluency skill over development. As expected, we found sound-symbol knowledge to be most predictive of reading fluency. Yet, including executive function measures significantly improved the predictive model. We next predicted that, as reading skills improve between elementary and middle school, the predictors of reading fluency may change. A significant interaction between grade level and working memory showed this skill contributes to reading fluency to a greater degree in elementary school children compared to middle school children. These results suggest a developmental arc in which domain-general skills are important early in development and decrease as specialization increases.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B39 Studies on Measurement and Classification of Restricted and Repetitive Behaviors in Autism Spectrum Disorders

Zixuan Zhang¹; ¹Sparkzone Institute

Restricted and repetitive behavior (RRB) is one of the core features of autism spectrum disorder (ASD) which consists of a group of heterogeneous behaviors. This work tries to clearly describe the definition and measurement of this phenotype to provide deep insights to the psychological and pathological causes of RRBs, thereby making discussions on RRBs classification. First, tools of the measurement of RRBs mainly include direct clinical observation of children (e.g. Autism Diagnostic Observation Scale), parental development history interview (e.g. Autism Diagnostic Interview-Revised) and parental questionnaire (e.g. Repetitive Behavior Scale-Revised). Further, comparisons on different aspects (e.g. accuracy and severity) are made to reveal differences across these instruments. This work also concludes that future research on this topic should focus more on systematic analysis across instruments and aim to establish reliable biochemical biomarkers or endophenotypes behind RRBs. Second, this study elaborates on the two types, i.e., repetitive sensory motor (RSM) and insistence on sameness (IS), which correspond to lower level and higher level RRBs, respectively, of RRBs identified and mostly supported by a number of existing studies. A third factor circumstanced interest (CI) may also exist. Studies are also made to investigate on the association between the two factors, i.e., RSM

and IS, and intelligence quotient (IQ) as well as chronological age. In addition, accurate classification of RRBs can provide an alternative approach to constitute homogenous samples in studies and therefore enable the detection of genomic loci related to this behavior.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B40 The Effects of Occupational Complexity on Brain Activity and Cognitive Reserve

Katharine Casario¹, Molly Arnold¹, Nicole Mangels¹, Jessica Fleck¹; ¹Stockton University

Cognitive reserve (CR) is an individual's defense against brain disease and unhealthy brain function. To further investigate the factors that build CR, we explored how occupation affects EEG power and cognition. We collected data from participants whose ages ranged from 35 - 65. Participants completed a demographics form and interviews that questioned them about their education and work history. They also completed tests of cognitive function and had their resting state brain activity recorded with EEG. A standard multiple regression analysis was conducted to see if occupational complexity could predict global theta power. We isolated theta power because of its relevance to working memory processing. Age and education were included as covariates in the design. The analysis revealed that occupational complexity significantly predicts relative global theta power, $F(4, 116) = 4.035, p = .004, R^2 \text{ Adjusted} = .092$. A more specific analysis revealed that occupational complexity predicts left posterior theta power, $F(4, 116) = 3.872, p = .005, R^2 \text{ Adjusted} = .087$. Age, years of education and occupational complexity were significant predictors. The partial correlation between occupational complexity and left posterior theta power, while controlling for age was significant, $r(121) = .322, p < .05$. In addition, we observed a significant correlation between occupation complexity and sustained attention, $r(121) = .193, p < .05$. These results indicate that individuals with a history of more complex occupations have higher theta power over the left posterior region and stronger cognition. In addition, our findings indicate that occupation is relevant in building CR.

Topic Area: EXECUTIVE PROCESSES: Development & aging

B41 Consent appreciation and reasoning in patients with impaired executive functions and normal healthy adults

Katrina Okerstrom-Jezewski¹, Daniel Tranel¹, Steven Anderson¹; ¹The University of Iowa

Neuroscientists study patients with diseases and disorders that impair cognition, but there are no specific recommendations on how to consent participants with cognitive impairments. While general cognitive ability is related to the ability to consent, called consent capacity, it is unknown how consent capacity is related to specific cognitive impairments. Most research focuses on understanding consent materials, with a neglect for the ability to apply the information to the participant's situation (appreciation) and use of logical reasoning to come to a decision. We hypothesize that impaired executive functions are associated with poorer appreciation and reasoning in the consent process. This study examines appreciation and reasoning for a hypothetical vaccine study in patients with impaired executive functioning (EF, n=5), patients with brain damage but lacking significant cognitive impairment (BDC, n=3), and normal healthy adults (NCP, n=5). Descriptive statistics were used to characterize composite and item scores. These findings suggest that EF participants have poorer appreciation but similar reasoning when compared to other participants. Item analysis suggests variability was due to misconceptions of why the participant was being asked to participate and whether they would be put in a control group. Further research is needed to identify if these patterns generalize to other research scenarios and if these errors stem from misunderstanding or failed appreciation. This work has implications for researchers consenting participants with impaired executive

functions and identifies targets for a personalized consent process tailored to individual cognitive strengths and weaknesses.

Topic Area: EXECUTIVE PROCESSES: Other

B42 Explicating the Learning Benefits Bestowed by Transcranial Direct Current Stimulation of the Right Inferior Frontal Gyrus

Benjamin Gibson¹, Teagan Mullins¹, Jacob Spinks¹, Denicia Aragon¹, Leslie Bauchman¹, Hannah Cunningham¹, Savannah Salazar¹, Evan Klein¹, Melissa Heinrich¹, Alfred Yu², Vincent Clark^{1,3}; ¹University of New Mexico, ²Army Research Laboratory, ³The Mind Research Network

Previous work from our laboratory (Clark et al. 2012) has demonstrated that anodal transcranial direct current stimulation (tDCS) applied to the right inferior frontal gyrus (rIFG) is capable of accelerating learning of a threat identification and classification task. However, questions remain as to the cognitive mechanisms underlying this effect, and whether tDCS mediated learning is specific to threatening stimuli or, rather, a more generalizable learning processes. The goal of the current project was to isolate specific aspects of the threat detection task in order to exemplify previous findings. A novel classification task was devised, during which subjects learned to classify pictures of European streets into 2 categories that were identifiable by 2 arbitrary rules. Subjects were randomly assigned to receive 30 minutes of anodal (n = 18), cathodal (n = 18), or sham (n = 18) tDCS during training, where they received accuracy feedback after each trial. The active electrode was placed on the rIFG, and return on the contralateral arm. Following training, there were 2 test blocks without feedback. A repeated measures ANOVA showed a significant effect of group (p = 0.008) ($\omega^2 = 0.14$), with subjects who received anodal tDCS evincing 16.1% greater classification accuracy at post-test compared to sham (d = 1.12), and subjects who received cathodal tDCS a 9.9% greater accuracy compared to sham (d = 0.77). These results demonstrate that tDCS of the rIFG has a robust effect on learning, and is capable of possibly eliciting performance improvements in numerous domains.

Topic Area: EXECUTIVE PROCESSES: Other

B43 Mobile based EEG assessment of fatigue in clinical practitioners

Robert Trska¹, Thomas Ferguson¹, Alison Walzak¹, Bruce Wright¹, Olave Krigolson¹; ¹University of Victoria

Cost-effective methods of measuring fatigue in professional fields is important. This is particularly true within clinical practice, where the effect of fatigue may influence both practitioner performance and patient outcomes. Fatigue-induced errors may range in a variety of impacts, from practitioner miscommunications to patient mortality. One potentially objective tool for this assessment is the use of portable electroencephalography (EEG), which allows us to examine human event-related potentials (ERPs) in a cost-effective and reliable manner. Relatedly, prior research has suggested that the P300, an ERP component linked to working memory and attention, might be modulated by fatigue. Thus, we investigated a physiological determinant of fatigue, by way of P300 component, in an ecological setting. Participants were nurses and doctors from the Royal Jubilee hospital (Victoria, British Columbia) emergency wing, who performed a simple response odd-ball task designed to elicit the P300. We found that greater fatigue was associated with lower P300 amplitudes, when comparing pre-shift to post-shift. Thus, our work highlights the usefulness of portable EEG technology as an objective and fast measure of fatigue, with potential applications in a wide-range of professional settings.

Topic Area: EXECUTIVE PROCESSES: Other

B44 Reliability of the Cogstate™ Cognigram in assessing cognitive changes following mild traumatic brain injury

Joseph Weiler¹, Nathan Rose¹; ¹University of Notre Dame

Cognitive testing is a common tool used to aid in the diagnosis of mild traumatic brain injuries, such as concussion. Due to the heavy dependence upon subjective symptom reporting for diagnosis, there is a pressing need for standardized exams given as both baseline and post-incident assessments. However, commercial cognitive testing often lacks the necessary supporting research to validate the efficacy of these exams. To address this gap, this study investigated one commercial cognitive exam, the Cogstate™ Cognigram Solution, using participants in a women's collegiate boxing club. Boxers completed the Cognigram exam, SCATIII symptom scores, and concussion incidence reporting both before their two-week boxing tournament and after each tournament bout, ranging from one to three sessions. While data was limited due to elimination in the tournament, attrition in symptom reporting, and a small number of concussions (N = 4), moderate test-retest reliability was observed for non-concussed participants (N = 75) on the Cognigram's Psychomotor Function and Attention composite score (rs = .539, p < .01) and for non-concussed participants (N = 73) on the Cognigram's Learning and Working Memory composite score (rs = .297, p < .05). However, no interaction was found between changes in the Cognigram's Psychomotor Function and Attention score and reported concussion (p = .461), nor between changes in the Cognigram's Learning and Working Memory score and reported concussion (p = .489). While modest test-retest reliability was observed, further work with participants who have undergone concussion is necessary to validate the Cognigram's sensitivity to mild traumatic brain injury.

Topic Area: EXECUTIVE PROCESSES: Other

B45 The Influence of Agency and Self-control on the Processing of Gains and Losses

Robert West¹, Ellason Freeman¹, Anna Munoz¹, Emily Budde²; ¹DePauw University, ²University of Dayton

Feedback processing related to the outcome of our choices is important for adaptive decision making. There are two ERP components related to feedback processing (FN and P3a) that distinguish between gains and losses 200-500 ms after feedback is presented. Some evidence indicates that the FN may be sensitive to individual differences in the context of self-control including impulsivity. The aim of the present study was to examine the effect of self-control on both the FN and P3a and the possible interaction between self-control and agency. Forty-eight individuals participated in a Two Door Task representing a 2 (agency: player or computer select) x 2 (outcome: win or lose) factorial. For each trial, either the COMPUTER or YOU choose one of the doors on the screen followed by feedback indicating a win or loss. Self-control was measured with a 24 item scale. For low self-control individuals, the FN was reliable in the YOU but not the COMPUTER select trials. For high self-control individuals, the FN was reliable for both YOU and COMPUTER trials. The P3a effect was significant for YOU trials but not for COMPUTER trials, and was insensitive to self-control. These data are complementary to the preceding literature that demonstrates the different psychological processes that underpin FN. The current findings reveal that agency in a choice may interact with variation in self-control. This conclusion may provide insight into the relationship between impulsivity, risk-taking, and the shaping of adaptive decision making.

Topic Area: EXECUTIVE PROCESSES: Other

B46 The Influence of Socioeconomic Status on the Neural Correlates of Feedback Processing

Anna Munoz¹, Ellason Freeman¹, Emily Budde², Robert West¹; ¹DePauw University, ²University of Dayton

Socioeconomic status (SES) is associated with differences in brain volume and neural recruitment. For instance, the anterior cingulate cortex (ACC) is linked to decreased volume amongst those with lower family SES. Extensive work reveals that the ACC is implicated in feedback processing. In the present study, we used event-related potentials (ERPs) to test whether or not SES would affect basic feedback processing related to the ACC in a modified version of the Two-Doors Task. Forty-six individuals at a liberal arts university participated in the study. They completed a task that represented a 2 (agency: player or computer select) x 2 (outcome: win or lose) factorial. For each trial, individuals saw a cue indicating whether the current trial was a COMPUTER or YOU select trial, and then an image of two doors. For COMPUTER trials, participants waited for the computer to choose one of the doors and then received feedback indicating a win or loss. For YOU trials, the participants chose the left or right door and then received feedback. For the feedback negativity, the effect of outcome was significant for high SES individuals. In contrast, for individuals with low SES, the effect of outcome was not significant. For the P3a, the effect of outcome was significant for both high and low SES individuals. These data may provide insight as to why some people may not respond effectively to certain feedback. This could inform practices related to incentive programs in the classroom and workplace.

Topic Area: EXECUTIVE PROCESSES: Other

B47 Behavioral and neural signatures of working memory in childhood

Steven Martinez¹, May I. Conley¹, Richard Watts¹, BJ Casey¹, Monica D. Rosenberg^{1,2}; ¹Yale University, ²The University of Chicago

Working memory has been proposed to involve dynamic linking of frontoparietal networks with cortex-wide networks needed to complete goal-oriented behaviors. This study examines the emergence of behavioral and neural signatures of working memory in childhood using public access data from the initial data release of the Adolescent Brain Cognitive Development (ABCD) study, which is tracking brain development and behavior in over 11,000 U.S. children starting at age 9-10. A correlational heat map based on behavioral data from 3,006 9-10-year-olds showed that working memory ability measured with an n-back task generalized across memory task domains, independent of stimulus type and response demands, but was distinct from other cognitive abilities including response inhibition. Functional MRI analyses showed robust activation of the frontoparietal network during the n-back task that correlated with performance on a list sorting memory task completed outside the MR scanner. Future work will test for replications of the findings with the next ABCD data release and will further examine distinct and overlapping neural signatures of working memory, which may enhance understanding of the emergence of differences in working memory function.

Topic Area: EXECUTIVE PROCESSES: Working memory

B48 Electo-corticography(EOCoG) activity induced by stimulation of the Superior temporal gyrus

Noboru Mimura¹, Kota Tanaka², Eishi Asano³, Ayaka Sugiura⁴, Yasuo Nakai⁵, Hiro Motoi⁶; ¹Wayne University, ²Yokohama City University

The superior temporal gyrus (STG) on the left hemisphere has been suggested to be a part of the receptive language systems in human. Here, we determined what brain regions are functionally connected to the superior

temporal gyrus, using electrical stimulation via subdural electrodes directly placed on the brain surface. We studied 11 patients with drug-resistant focal epilepsy, who underwent two-stage epilepsy surgery. During extraoperative electrocorticography (EOCoG) recording at the bedside, 40 single-pulse electrical stimuli were delivered to a neighboring electrode pairs involving the STG. Stimulation-induced responses were recorded in other regions. The mean amplitude of beta activity was animated on a standard brain template.

Topic Area: EXECUTIVE PROCESSES: Working memory

B49 Exploring brain-behavior relationships in the N-back task

Bidhan Lamichhane¹, Andrew Westbrook¹, Todd Braver¹; ¹Washington University in Saint Louis, Saint Louis, MO, USA.

Two critical questions in the cognitive neuroscience of working memory (WM) relate to how WM load increases are reflected in brain activity, and moreover, in which brain regions and networks do these load-related activity patterns best predict behavior. Here, we used functional magnetic resonance imaging (fMRI) of the N-back task, involving a wide range of load levels (N=1:6) to test both questions. As expected, participants' behavioral performance (RT, accuracy) reliably varied with load. Primary analyses focused on a focal left dorsolateral prefrontal cortex (DLPFC) region, defined from prior findings and meta-analyses, along with other relevant brain networks (e.g., frontoparietal, default mode network [DMN]). Within-individuals, RT measures were a better predictor of the inverted U-shaped load function than accuracy. However, between-individuals, brain-behavior relationships were found most strongly with target accuracy (and to a lesser extent, d'), and related to the linear slope of DLPFC load-related activity. Additionally, multiple regression analyses found the strongest predictions of behavior, even with robust cross-validation approaches, came from a combination of DLPFC activity, along with its global functional connectivity, and DMN activity. Counter-intuitively, these predictive effects were observed most strongly at high load levels (N=4-6). Activity in the same DLPFC region was also one of the strongest predictors of N-back performance and WM function in a large out-of-sample dataset from the Human Connectome Project. Together, these results confirm the critical role of DLPFC in WM function, but also indicate that brain-behavior individual difference relationships might be most sensitively detected at high load levels.

Topic Area: EXECUTIVE PROCESSES: Working memory

B50 Object-location association binding is transiently impaired during post-traumatic amnesia

Emma-Jane Mallas¹, Gregory Scott¹, Rituja Kamble¹, David J. Sharp¹, Nikos Gorgoraptis¹; ¹Imperial College London

Patients with moderate-severe traumatic brain injury (TBI) will typically experience post-traumatic amnesia, a transient period of impaired orientation, anterograde memory and working memory (WM). WM impairment in PTA is associated with reduced functional-connectivity within the medial-temporal lobe (De Simoni et al., 2016), regions of known importance for the integration of object identity and spatial information. Here, we examined whether PTA patients (n=15) demonstrated impaired object-location binding in WM compared to TBI (n=9) and healthy controls (n=15) and reassessed their performance on resolution of PTA. Participants memorised the location of one or two fractal shapes and were asked to identify and relocate the target item to its remembered location. In two-item trials where the target was correctly identified, we examined how its remembered location was biased by the location of the non-target item using i) a measure of the proportion of 'swap-errors' as in Pertzov et al (2012) and ii) a novel approach to study the distribution of responses in a normalised space. PTA patients demonstrated impaired recognition memory compared with controls (p<0.001) but not TBI (p=0.09). Localisation was impaired within correct two-item trials: PTA made significantly more swap-errors than TBI (p<0.0001) and controls (p<0.0001),

with placement biased by the non-target significantly more than TBI ($p=0.02$) and controls ($p=0.01$). Following recovery, this impairment resolved compared to TBI ($p=0.60$). The influence of the non-target object in correctly identified trials suggests that patients in PTA are able to encode information about an object's individual features (identity and location) but fail in binding these together.

Topic Area: EXECUTIVE PROCESSES: Working memory

B51 Different Methods of Communication in Two Groups of Children with Autism Spectrum Disorder during a Dyadic Social Interaction

Philip Lai¹; ¹University of Nebraska Kearney

The characteristics of a successful communicative exchange require different elements to work together. One must have the ability to negotiate meaning, exchange ideas, integrate new information, and clarify any misunderstandings. In this study, we are interested in how children use and integrate verbal and multiple channels of nonverbal behaviors in the context of a social interaction. Participants in this study included 30 toddlers with Autism Spectrum Disorders (ASD) ($M=31$ months) and their mothers. Half of the toddlers were minimally verbal, while the other half were verbal. A 15-minute mother-child play session was completed. Parents were instructed to "Play with your child as you normally would at home" using a set of toys. Coding of nonverbal behaviors for the children included: gestures, eye contact, positive and negative affect through auditory vocalizations. For parents, verbal behaviors included the total time speaking and for nonverbal behaviors included: gestures, eye contact, and physical contact. A MANOVA showed differences in how the two groups of children with ASD were communicating with their mothers. The verbal group relied more on eye contact and gestures, while the minimally verbal group relied on negative affect to convey information. For the mothers, physical contact was observed more in parents with minimally verbal children with ASD. Taken together, we are seeing a qualitatively different pattern of communication in these two groups of children with ASD. Not only are the minimally verbal children not speaking at this age, they are not utilizing gestures and eye contact, highlighting their deficits in communication.

Topic Area: LANGUAGE: Development & aging

B52 Early cortical processes underlying the development of whole-word perception.

Tomoki Uno^{1,2}, Ayumi Seki¹; ¹Hokkaido University, ²Research Fellow of the Japan Society for the Promotion of Science

Rapid letter identification and detection of the whole word are remarkable skills which are acquired through reading development. It has been suggested that the letter identification reflected by print-specific N1 enhancement of event-related potentials (ERPs), which emerged even in early grades of elementary school (Maurer et al., 2005; 2011). However, it remains unclear how children develop the whole-word perception and its underlying cortical processes. Thus, we investigated the development of reading skills using eye-tracking measurements and ERPs. 29 Japanese-speaking children (aged 6-12) participated in our experiments. In the eye-tracking task, they required to read the word list aloud as quickly as possible. The numbers of fixation per words were used as a marker of whole-word reading. In ERP task, we rapidly presented three-letter Hiragana words, nonwords and unfamiliar foreign-letter strings, and required the children to detect particular color stimuli. As results, N1 peak amplitudes for words and nonwords were larger than unfamiliar letter strings regardless of grades, and these effects became smaller with increasing the age. More importantly, P1 for words, but not for nonwords, was enhanced along with the decrease of fixations for words, indexed by negative correlation between P1 amplitude for words and the number of fixations. This

enhancement for words was not correlated with age, in contrast to N1 print tuning effects. Our results suggest that children acquired whole-word perception depending on emergence of the early cortical processes specialized for words, while letter identification is refined according to general maturation at least in typically developing children.

Topic Area: LANGUAGE: Development & aging

B53 Emotional Language in Healthy Aging

Li-Chuan Ku¹, Vicky Tzuyin Lai¹; ¹University of Arizona

Does age influence the comprehension of emotional language? There is some evidence indicating that healthy older adults have greater attention to and better memory for positive pictures and faces than negative ones, termed as the positivity effect (Mather & Carstensen, 2005). Based on the strength and vulnerability integration (SAVI) model (Charles, 2010), such positivity effect can be modulated by the intensity of emotion (arousal). However, the time course of the arousal modulation is unclear. The present study used event-related potential (ERP) to test this in language. Younger (18-30 years of age) and older (60-75 years of age) adults were recruited. Their mental well-being and cognitive functions were assessed by Beck Depression Index-II, Mini-Mental State Examination, and the Digit Symbol Substitution task. Stimuli consisted of positive high-arousing (winner), positive low-arousing (grandpa), negative high-arousing (pain), negative low-arousing (trash), and neutral words (teeth). We found that younger adults displayed a typical negativity bias, as reflected by the enhanced late posterior positivities (LPPs; 600-800 ms) for negative words relative to positive words. Such negativity bias was modulated by word intensity/arousal, as reflected by enhanced LPPs for negative low-arousing words than for negative high-arousing words. In healthy older adults, the LPP amplitudes were attenuated, especially in negative low-arousing words. Contrary to our expectation, older adults were not more emotionally responsive to positive words. These findings support the SAVI model in general, and further suggest a more top-down, controlled process for the regulation of negative emotions in healthy older adults.

Topic Area: LANGUAGE: Development & aging

B54 Neural mechanisms underlying audio-visual integration in Chinese young children

Zhichao Xia¹, Ting Yang¹, Xin Cui¹, Hua Shu¹, Xiangping Liu¹; ¹Beijing Normal University

Audio-visual integration of letter and speech sound is critical for reading acquisition and the left superior temporal sulcus (STS) has been identified playing an important role. However, the conclusion is restricted to alphabetic languages. No relevant study until now has been done in Chinese. Therefore, in this study, we investigated neural correlates of audio-visual integration in 30 typically developing children (mean age = 126 months) with two fundamental components in Chinese: pinyin and radicals (specific single-element characters). Conditions of audio-only, visual-only, audio-visual congruent, and audio-visual incongruent were created with both pinyin and characters. Here we focused on the integration effect (audio-visual congruent > audio-only + visual-only) and the congruency effect (audio-visual congruent > incongruent). In whole brain analysis of pinyin, while left and right fusiform/hippocampus displayed integration effect, no areas showed congruency effect. In characters, on the other hand, while cuneus/lingual gyrus displayed integration effect, left and right STS showed congruency effect but in the opposite direction (i.e., congruent < incongruent). These clusters were further defined as regions-of-interest and we found that only the character congruency effect in right STS was correlated with word reading efficiency ($r = 0.430$, $p = 0.018$), and sentence reading comprehension ($r = 0.409$, $p = 0.025$). To summarize, this study for the first time demonstrated the involvement of the left STS in audio-visual integration in Chinese young children. The results also indicate

important roles of other areas play such as the right STS, which might be associated with the specific linguistic feature of Chinese.

Topic Area: LANGUAGE: Development & aging

B55 Younger and Older Adults Adapt Differently to Animacy Violations in Fictional Narratives: Electrophysiological Evidence

Kathryn Bousquet¹, Megan Boudewyn¹, Debra Long¹, Fernanda Ferreira¹, John Henderson¹, Tamara Swaab¹; ¹University of California, Davis

Aging is characterized by cognitive decline in several domains, but the effect of aging on language processing is relatively unclear. In the present ERP study, we used animacy violations in fictional narratives to determine whether anticipatory processing and adaptation vary as a function of healthy aging while discourse develops. Younger and older adults listened to four-sentence passages in which the main characters were animate beings (e.g. fellow) or inanimate objects (e.g. peanut). Critical words in the fourth sentence required either animate or inanimate entities (e.g. elated/salted). We found a significant animacy effect that interacted with story position. Planned comparisons revealed that younger adults exhibited an N400 effect at the second and fourth sentences, with more negative waveforms for inanimate characters. Older adults only showed this N400 effect at the fourth sentence. The results suggest that participants anticipated upcoming animacy violations: younger adults by the second sentence, older adults by the fourth. Additionally, both groups displayed similar N400 effects at the critical words, although the latency of the effect was delayed in older adults. Waveforms were more negative for critical words that required an inanimate entity; the effect was larger for stories with animate characters than for stories with inanimate characters. This suggests that both groups relied more on discourse context than world knowledge. Collectively, the results indicate that both groups arrived at similar discourse representations, but reveal a substantial processing delay in the older adults.

Topic Area: LANGUAGE: Development & aging

B56 Neural Coding for Word Frequency in Fusiform and Occipital Cortex

Oscar Woolnough¹, Cristian Donos¹, Patrick Rollo¹, Nitin Tandon^{1,2}; ¹UTHealth, Houston, TX, ²Memorial Hermann, Houston, TX

Word length and frequency are two influential factors that govern how quickly and efficiently we read. However, the neural correlates of how these factors influence reading are not currently well characterized but will help us understand the basis for congenital and acquired dyslexia. Correlates of word frequency have previously been studied in high-order language regions but recent evidence has suggested these effects may originate from the visual system. We measured neural activity from intracranial electrodes in 25 epilepsy patients while they silently read real and Jabberwocky word sentences in rapid serial visual presentation. Gamma-band responses to individual words were extracted and used to index local processing. We found electrodes showing activation to reading in occipital cortex bilaterally and along left fusiform cortex. In left mid-fusiform cortex we found a region that showed high sensitivity to both word length ($P < 0.05$) and frequency ($P < 0.001$). The responses in any electrode were not influenced by any of bigram frequency, orthographic neighbourhood or word class. This frequency selectivity was also evident unilaterally in left occipital cortex. In this early visual region we saw a medial-to-lateral topology, shifting sensitivity from word length to word frequency. These results suggest word frequency is able to be encoded early in the visual pathway, before reaching higher level language regions, though potentially with top-down influence from them. Early visual regions, traditionally thought only to operate at a sub-lexical level, may be performing whole word level processing - much earlier than expected in the visual pathway.

Topic Area: LANGUAGE: Lexicon

B57 Online build-up of neocortical memory traces for spoken words: specific facilitatory effects of novel semantic associations.

Alina Leminen^{1,2}, Eino Partanen^{1,2}, Andreas Højlund Nielsen², Mikkel Wallentin², Yury Shtyrov^{2,3}; ¹University of Helsinki, Finland, ²Aarhus University, Denmark, ³Saint Petersburg University, Russia

Recent research has shown that the brain is capable of a rapid build-up of novel cortical memory traces for words during mere perceptual exposure to new lexical items. This has been shown as an online increase in electrophysiological response to new word forms even when they have no specific meaning attached and are not attended to or rehearsed by the learners. However, the operation of this fast cortical language-learning mechanism in online acquisition of word meaning has not been thoroughly investigated yet. Here, we presented our participants with novel word forms in a word-learning task taking place during a short magnetoencephalography (MEG) recording session. Novel words were either learned perceptually through auditory exposure only or were assigned a clear semantic reference using a word-picture association task, in which novel words were presented in conjunction with novel objects. Real familiar words were used as controls. Our findings show that, already after approximately five presentations of each stimulus, novel stimuli learnt through semantic association demonstrated stronger activation over the left perisylvian cortices than perceptually acquired word forms that lacked semantic reference. Perceptual items demonstrated a linear learning-related amplitude increase throughout the 10-minute recording session. This result suggests a more efficient process of online novel word memory trace build-up in the presence of semantic reference. Our results confirm rapid formation of memory traces for novel words over a course of a short exposure and suggest facilitatory effects of acquisition of novel semantics on the neocortical memory trace formation.

Topic Area: LANGUAGE: Lexicon

B58 Picture-naming in American Sign Language: an ERP study of the effects of iconicity and alignment

Meghan McGarry^{1,2}, Megan Mott¹, Katherine J. Midgley¹, Phillip J. Holcomb¹, Karen Emmorey¹; ¹San Diego State University, ²University of California, San Diego

Event-Related Potentials (ERPs) and a picture-naming task were used to investigate the effects of iconicity on sign production in American Sign Language (ASL). Twenty-three deaf ASL signers named pictures with iconic or noniconic signs, and 23 hearing nonsigners served as a control group and named the pictures in English. For the iconic signs we compared an aligned picture condition in which a visually salient feature of the picture aligned with the iconic feature of the sign (e.g., the sign BIRD depicts a bird's beak and aligns with a picture of a bird with a prominent beak) and a non-aligned picture condition (e.g., a picture of a bird where the beak is not visible). Results showed that the N400 amplitude for iconic signs was more negative than for non-iconic signs, suggesting that the retrieval of iconic signs may activate additional perceptual or sensory-motor features. The ERPs to iconic signs in the picture-aligned condition showed reduced N400 negativity compared to those in the non-aligned condition with a right anterior scalp distribution. This result may constitute a priming effect that occurs when visible features of a picture and a sign overlap. Iconicity and alignment effects were not observed in the hearing nonsigners. Overall, the results indicate that retrieval of iconic signs involves more elaborate processing than retrieving noniconic signs and that the structural alignment between visual features of a to-be-named picture and an iconic sign facilitates lexical retrieval.

Topic Area: LANGUAGE: Lexicon

B59 The lexical categorization model: A computational model of left ventral occipito-temporal cortex activation in visual word recognition

Benjamin Gagl¹, Fabio Richlan², Philipp Ludersdorfer³, Jona Sassenhagen¹, Susanne Eisenhauer¹, Christian J. Fiebach¹; ¹Department of Psychology, Goethe University Frankfurt, Theodor-W.-Adorno-Platz 6, 60323 Frankfurt/Main, Germany, ²Centre for Cognitive Neuroscience, University of Salzburg, Hellbrunnerstrasse 34, 5020 Salzburg, Austria, ³Wellcome Trust Centre for Neuroimaging, Institute of Neurology, University College London, 12 Queen Square, WC1N 3BG London, UK

To characterize the role of the left ventral occipito-temporal cortex (lvOT) during visual word recognition in a quantitatively explicit and testable manner, we propose the lexical categorization model (LCM) according to which lvOT categorizes perceived letter strings into words or non-words. LCM simulations successfully replicate nine benchmark results from human functional brain imaging. Empirically, using functional magnetic resonance imaging, we demonstrate that quantitative LCM simulations predict lvOT brain activation. Using electroencephalography (EEG), we show that LCM accounts for word-related activations in an expected time window. Interestingly, we could also find that the model predicts lvOT activation when stimuli were selected such that LCM would predict an inverted activation pattern relative to established standard effect directions. Also, we found that word-likeness, which is assumed as input to LCM, is represented posterior to lvOT and (based on EEG data) temporally before the lexical categorization. In contrast, a dichotomous word/non-word contrast, which is the assumed output of the LCM, could be localized to upstream frontal brain regions. Thus, we propose a ventral-visual-stream processing framework for visual word recognition involving word-likeness extraction followed by lexical categorization, before accessing word meaning.

Topic Area: LANGUAGE: Lexicon

B60 Words in speech decompose to their roots even when the root is interrupted: a study on Emirati Arabic

Samantha Wray¹, Alec Marantz^{1,2}; ¹New York University Abu Dhabi, ²New York University

Language areas of the brain are sensitive to how unexpected a speech sound is given the previous sounds (quantified as surprisal); this sensitivity is evidence for predictive processing based on the stored forms of morphemes. For words which are morphologically complex, there are two possibilities for prediction of a phoneme: surprisal could be computed at a phoneme based on the probability distribution over the cohort of whole words consistent with the previous phonemes, before a word's root is extracted, or surprisal could be based on the probability distribution of decomposed word roots consistent with the input, modulated by its morphological context. We tested these competing hypotheses in spoken Emirati Arabic, a dialect that is not standardly written and which is characterized by words with roots distributed throughout the word in a non-linear fashion. 18 participants had their neural responses measured with MEG while they listened to words which maximally differed in surprisal based on their whole word and root based surprisal values. These words included prefixed forms for which a consonant is heard before the root and infixed forms for which a consonant 'interrupts' the root. We found a spatiotemporal cluster of activity in inferior frontal cortex ($p=0.006$ resulting from cluster-based permutation test correcting for multiple comparisons across sources and timepoints) associated with an interaction between linear and root surprisal at 165-250ms, before any significant response correlated with whole word surprisal alone. Our data are consistent with the role of online decomposition in auditory word recognition.

Topic Area: LANGUAGE: Lexicon

B61 Delayed N1 suppression effect for self-generated speeches in patients with aphasia

Chia-Ju Chou¹, Edward W. Wlotko²; ¹Institute of Neuroscience, National Yang-Ming University, Taiwan, ²Moss Rehabilitation Research Institute, Elkins Park, PA USA

The Hierarchical State Feedback Control (HSFC) model suggests that the deficits in repetition and speech production of conduction aphasia point to a deficit at auditory-motor transformation. This hypothesis has proven difficult to directly test from behavioral experiment protocols. Suppression of the N1 auditory event-related potential (ERP) to self-generated speeches is thought to be due to the forward prediction of the sensory consequences of speech. This study aims to investigate the real-time action of the internal model system in aphasia by measuring N1 components. Impairment in the translation of motor-to-sensory predictions should result in reduced or altered N1 suppression effect. We recorded scalp electroencephalography in six chronic stroke patients with language performance typical of conduction aphasia and dramatically poor performance in nonword repetition, irrespective of their diagnosed aphasia subtype. The results show reduced N1 amplitude during speaking compared with passive listening to the playback of self-generated speech in these patients. The latency of N1 suppression effect across 11 electrodes at frontal sites is negatively correlated with the discrepancy between the observed and predicted nonword repetition accuracy ($r = -0.80$, $p = 0.05$). The present findings suggest that an impairment in nonword repetition is related to the efficiency of integrating forward prediction and sensory feedback. Delayed N1 suppression effect might result from compensatory involvement of replacement mechanisms to achieve better monitoring of external sounds while talking.

Topic Area: LANGUAGE: Other

B62 Neural components of reading revealed by distributed and symbolic computational models

Ryan Staples¹, William W. Graves¹; ¹Rutgers University - Newark

Explicit computational models could fill a critical need by constraining the interpretation of fMRI data. The domain of reading has two well-characterized computational models, both taking orthographic input and producing phonological output. The biologically-inspired connectionist model learns statistical, distributed relationships between inputs and outputs. In contrast, the dual-route cascaded model (DRC) is symbolic, connecting orthography to phonology with preprogrammed rules. Both models are supported by behavioral data, but have never been directly compared in the brain. Using representational similarity analysis, we compare the neural representation of orthography-phonology transforms generated by a connectionist model using graphemic and novel, graded orthographic inputs. We further provide the first comparison of connectionist and DRC models of reading in the brain. The correlation between all models (orthographic-graphemic, $r=0.765$; graphemic-DRC, $r=0.537$; orthographic-DRC, $r=0.497$) was high. All model dissimilarity structures were correlated to neural representations in a left-lateralized network spanning frontal, temporal, and occipital cortices, as well as a limited right-lateralized network. No differences were found in the neural representations of the two connectionist models, or when comparing the graphemic model with the DRC model. The connectionist model with graded orthographic inputs showed greater correspondence than the DRC model with activity in a subset of the areas described above. Our results show that a connectionist model fits the neural representation of words better than the DRC model when the inputs are orthographic. Overall, we have provided a computational approach to revealing the neural systems associated with specific cognitive components of reading.

Topic Area: LANGUAGE: Other

B63 Phonological STM Versus STM for Meaningful Material: A Case Study Approach in ADHD

Genni Newsham¹, Hannah Travis¹, Sarah Vadnais¹, Audreyana Jagger-Rickels¹, Emily Caminiti¹, Jennifer Schlak¹, Maria Stacy¹, Zsófie Imre¹, Michelle Y. Kibby¹; ¹Southern Illinois University

Phonological and semantically meaningful material may be learned and stored in short-term memory (STM) via dissociable routes. Nevertheless, limited research has compared the two systems using ERP. Furthermore, no research was found including ERP, cognitive and MRI data in a single study. Hence, this was the purpose of our project using a case study approach. Participants included two controls and one adolescent with ADHD, ages 14-16. 128-lead EGI nets were used with Geosource software. For both conditions 4, one-syllable items were presented orally, followed by a 3-second retention interval, then a recognition probe. In the semantic condition all words in a trial were from the same category. In the phonetic condition, all items were pseudowords. As hypothesized, separate but overlapping peaks were found for the two systems. In controls, phonetic items' peak activation occurred in right prefrontal during learning, and in right parahippocampal and lingual areas during retrieval. Word encoding yielded peak activation in right parahippocampal, along with right fusiform and lingual areas suggesting potential visualization. Retrieval yielded similar peaks. The teenager with ADHD displayed deficits in phonetic STM and story learning but not word list learning. Commensurate with this, he displayed multiple peaks during phonetic learning, suggesting the need for more global processing to complete the task. Peak activation during phonetic retrieval and word learning differed as well, although word recognition peaks were similar to controls. On MRI analysis ADHD differed from controls in right occipital and prefrontal volumes, potentially contributing to the differing activity.

Topic Area: LANGUAGE: Other

B64 Relating Individual Differences in Beta Oscillations Recorded at Rest to Second Language Aptitude and Basal Ganglia Signal Routing

Chantel Prat¹, Margarita Zeitlin¹, Malayka Mottarella¹, Brianna Yamasaki², Tara Madhyastha¹; ¹University of Washington, Seattle, ²Vanderbilt University

In 2016, we first reported that intrinsic, network-level brain functioning recorded with EEG predicted second language (L2) learning. These results converged with two lines of research showing that: (1) individual differences in task-free measures of brain functioning relate to fluid reasoning, and (2) task-free MRI measures predict L2 learning. Here we bridge these fields by investigating the neurocognitive nature of rsEEG beta power (13-30 Hz), which has been increasingly linked to language processes. First, 5-minutes of eyes-closed rsEEG were recorded from Emotiv headsets. Data from 60 monolingual-English-speaking participants were correlated with performance on a standardized language aptitude test (MLAT). Results showed that right-posterior-low-beta power, which has previously been correlated with rate of L2 learning, correlated positively with the grammatical sensitivity portion of the MLAT ($r = .28$); whereas left-temporal-beta power, which has previously been negatively correlated with speech quantity and quality, negatively correlated with the associative memory portion of the MLAT ($r = -.32$). Second, rsfMRI data from 55 participants were analyzed using seed regions in the striatum, based on the known involvement of thalamo-striato-cortical loops in beta oscillations. Consistent with a prominent model of striato-cortical functioning, the Conditional Routing Model, results showed that rsEEG beta power recorded over fronto-temporal locations correlated negatively with connectivity between the striatum and its posterior input regions (e.g., precuneus) and positively with connectivity between the striatum and its output regions, including the left insula and Broca's area. These results provide missing links about the nature of individual differences in rsEEG beta power.

Topic Area: LANGUAGE: Other

B65 The Moderating Effect of White Matter Tract Integrity on Phonemic Decoding After Transcranial Magnetic Stimulation

C Nikki Arrington^{1,2}, Sean Rogers¹, Emilio Acosta¹, Robin Morris^{1,2}; ¹Georgia State University, ²GSU/GT Center for Advanced Brain Imaging

Phonemic decoding (PD) is a complex skill that is facilitated by a left-lateralized reading neural network and is necessary for proficient reading. Research suggests a link between PD and white matter (WM) integrity in tracts connecting reading-related brain regions. Research also suggests that transcranial magnetic stimulation (TMS) to the supramarginal gyrus (SMG), a node of the brain's reading network, can modulate PD. The current study examined the moderating effect of WM integrity on change in PD following TMS to the SMG. Seventeen participants (male=7; mean age=24.5) received continuous and/or intermittent theta burst stimulation to the left SMG. Pre- and post-stimulation PD was assessed using median reaction time (RT) on a forced-choice pseudoword discrimination task. Atlas-based probabilistic tractography was used to extract fractional anisotropy (FA) values for tracts associated with the reading network. Post-stimulation RT was correlated with FA in anterior portions of the corpus callosum ($r = -0.38$, $p < 0.05$) and temporal portions of the superior longitudinal fasciculus ($r = -0.44$, $p < 0.05$). The interaction between pre-TMS RT and FA of the corpus callosum accounted for a significant portion of the variance in post-TMS RT, $R^2 = 0.64$, $F(3,9) = 5.33$, $p < 0.05$, $t = -2.72$, $p < 0.05$. Examination of the interaction plot showed an enhancing effect such that those with higher FA and shorter pre-TMS RT showed the largest change in RT after stimulation. WM integrity may play a role in moderating the brain's response to TMS and targeted reading outcomes.

Topic Area: LANGUAGE: Other

B66 An Intracranial EEG Study of Taxonomic and Thematic Relations

Melissa Thye¹, Jason Geller¹, Diana Pizarro¹, Jerzy P. Szaflarski¹, Daniel Mirman¹; ¹University of Alabama at Birmingham

The hub-and-spoke model of semantic cognition posits that the anterior temporal lobe (ATL) serves as a critical hub, integrating multimodal information from surrounding spokes to arrive at semantic representations. The dual-hub account suggests that although ATL is important for processing taxonomic relations [defined by shared features (e.g., dog - bear)], an additional hub in the temporo-parietal cortex (TPC) may be specialized for processing thematic relations [based on event-related co-occurrence (e.g., dog - leash)]. Previous studies of semantic cognition have been restricted to neuroimaging methods with limited spatial or temporal resolution. In the current study, we overcome this limitation by recording from 84 electrode channels from 5 participants with refractory epilepsy undergoing intracranial EEGs from an array of multi-contact depth electrodes. Participants completed a semantic relatedness judgement task where critical word pairs varied in semantic type (taxonomic vs. thematic) and relatedness strength (high vs. low). Data were epoched, bandpass filtered to extract the high gamma range (70-110 Hz), transformed to generate the analytic signal, smoothed, and baseline corrected. Peak high gamma power (HGP) was greater for taxonomic compared to thematic relations in ATL. The opposite pattern was observed in TPC with greater peak HGP for thematic relations. Peak HGP was relatively consistent across the regions for the relatedness strength manipulation with greater peak HGP in response to the highly related trials. Our data support a dual-hub account of semantic cognition, with ATL as a critical hub for processing taxonomic relations, and TPC as a secondary hub for processing thematic relations.

Topic Area: LANGUAGE: Semantic

B67 Semantic training affects online formation of memory traces for novel morphology

Viktória Roxána Balla¹, Yury Shtyrov^{1,2,3,4}, Miika Leminen^{1,3}, Alina Leminen^{1,3}; ¹University of Helsinki, ²Higher School of Economics, ³Aarhus University, ⁴Saint Petersburg State University

Learning to recognize morphemic boundaries is crucial for fluent language use. The question of morphological learning is especially relevant in languages with a rich morphology, such as Finnish. Neurocognitive studies propose separate systems for decomposition and storage, which are flexibly used during the processing of polymorphemic inflections and derivations. Nevertheless, neural mechanisms underlying the acquisition of novel morphology remain unexplored. To address this question, we trained 19 native Finnish-speaking participants with new derivational suffixes through a word-picture association task. Following the short training session we used magnetoencephalography (MEG) to record the participants' brain responses to trained and untrained suffixes combined with real and pseudoword stems. We compared event-related fields recorded during the first and last 4 minutes of the passive listening task to assess the rapid online learning of novel suffixes. We found a response increase in the left frontal and temporal sensors for the trained suffixes compared with the untrained at the 55-85 ms, 100-140 ms and 180-260 ms time-windows following the suffix onset. This response increase suggests that a short semantic training of novel affixes can facilitate morphological decomposition and speed up suffix memory trace formation. At the same time, the left temporal sensors showed enhanced effects for untrained suffixes at 180-260 ms towards the end of exposure, suggesting the online formation of memory traces even without previous semantic training. Overall, our findings suggest immediate formation of memory representations for novel affixes, with a facilitative effect of semantic training on morphological parsing.

Topic Area: LANGUAGE: Semantic

B68 The incremental effect of conceptual specificity in minimal sentence composition: MEG evidence

Songhee Kim¹, Liina Pykkänen¹; ¹New York University

MEG research has shown that at 200-250ms after stimulus onset, activity in the left anterior temporal lobe (LATL) increases in the presence of semantic composition. This effect is sensitive to the conceptual specificity of the input items, suggesting that the composition of complex meaning is modulated by conceptual specificity. As these results have only been demonstrated for noun phrases, we tested the generality of the pattern by expanding the investigation to cover the full sentence, varying specificity in the subject, verb and object positions of simple three-word sentences. 27 participants were visually presented with sentences one word at a time. All positions had two levels of specificity, i.e., general and specific, and at the subject and verb positions, "no word" condition was also added to measure the effect of composition, e.g., 'employees/waiters/#### clean/sweep/#### floors/decks'. Our results did not find a main effect of specificity in the LATL but in the left mid-superior temporal cortex (ImSTC), a region implicated for thematic role processing. Some interaction effects of verb and object specificity, and subject and object specificity, were found in the LATL, as well as subject and object specificity in the ImSTC, a pattern that resembles findings in the noun domain. Finally, the effect of subject composition (i.e., subject + verb vs., no subject + verb) was significant in the LATL and ImSTC but not in the left angular gyrus (LAG), suggesting that the LAG is not a combinatory region. Overall, our results support that the LATL is a cross-categorical combinatory region.

Topic Area: LANGUAGE: Semantic

B69 The semantic timescales of speech prediction unfold along an auditory dorsal processing hierarchy

Lea-Maria Schmitt¹, Sarah Tune¹, Julia Erb¹, Anna Rysop², Gesa Hartwigsen², Jonas Obleser¹; ¹University of Lübeck, Lübeck, Germany, ²Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany

When poor acoustics challenge speech comprehension, angular gyrus increasingly draws on semantic context to predict upcoming speech. As research so far focused on predictions informed by short timescales of context (i.e., sentences), we here ask how the brain builds up predictions when confronted with a multitude of timescales underlying natural speech. In a functional magnetic resonance imaging (fMRI) study, healthy participants (N=31, 19-73 years) passively listened to a one-hour, naturally narrated story embedded in a competing stream (SNR 0 dB) of resynthesized natural sounds. We used similarity of word vectors to model semantic predictability at five timescales corresponding to a logarithmic increase in context length and compared the results with a more fine-grained linguistic model scaled by typical segments of written language (i.e., words, sentences, paragraphs, chapters). In an initial analysis of 12 participants, we found the timescales of semantic prediction organized along an auditory dorsal processing hierarchy: informative short timescales elicited increased activity in lower-order cortical regions like the posterior portion of superior temporal gyrus, whereas higher-order cortical regions like angular gyrus favoured informative long timescales. Furthermore, the brain areas most sensitive to the longest timescales widely overlapped with the dorsal default mode network. Critically, the linguistic model outperformed the logarithmic model which speaks to a neural gradient coding for units of semantic abstraction rather than for semantic load per se. Next, we will investigate how brain areas representing different contextual timescales interact along the processing hierarchy to predict what someone is about to say.

Topic Area: LANGUAGE: Semantic

B70 The spatiotemporal dynamics of flexible meaning: Neuromodulation of noun meaning by the preceding verb

Bingjiang Lyu¹, Alex Clarke¹, Hun Choi¹, William Marslen-Wilson¹, Lorraine Tyler¹; ¹Centre for Speech, Language, and the Brain, Department of Psychology, University of Cambridge

As utterances are heard, each word is integrated into an ongoing incremental interpretation, placing immediate constraints on following words. Here we investigate the spatial location and temporal dynamics of the neural mechanisms underpinning these processes, focusing on verb semantic constraints and their effect on the semantic interpretation of its direct object (DO) noun. Participants' brain activity (EEG/MEG) was recorded while they listened to sentences like "The old man ate the apple". Using Topic Modelling based on large corpora, we generated models which captured (a) verb semantic constraints (b) DO noun (e.g., 'apple') semantics and (c) the effect of verb semantics on the noun (verb-weighted noun semantics) as probability distributions over 200 semantic topics, and tested them against brain activity using Representational Similarity Analysis. Verb semantic constraints showed effects in LpMTG and LSMG from verb onset. Directed connectivity analysis revealed that information flowed continuously from LpMTG to LSMG with a 15 msec delay, whereas information flow from SMG only occurred after verb recognition point. There was no model fit for noun semantics alone, but significant verb-weighted noun semantic effects in LpMTG and LIFG around noun recognition point. While there is rapid and constant feedforward information flow from LpMTG to LIFG from noun onset, feedback from LIFG is relatively slower but long-lasting. These novel results reveal the distinct patterns of dynamic connectivity involved in the broader neural network involved in real-time semantic interpretation, with LpMTG & LSMG involved in semantic access and LpMTG & LIFG in semantic integration.

Topic Area: LANGUAGE: Semantic

B71 Top-down influence of semantic similarity on low-level encoding of continuous speech

Michael Broderick¹, Andrew J. Anderson², Edmund C. Lalor^{1,2}; ¹Trinity College Dublin, ²University of Rochester

Speech perception involves the integration of sensory input with expectations based on the context of that speech. Much debate surrounds the issue of whether or not high-level information feeds back to affect early auditory encoding in the lower levels of the speech processing hierarchy, or whether perception can be best explained as a purely feedforward process. Although there has been compelling evidence on both sides of this debate, experiments involving naturalistic speech stimuli to address these questions have been lacking. Here, we use a recently introduced method for quantifying the semantic content of speech and relate it to a commonly used method for indexing low-level acoustic encoding of speech. The relationship between these measures is taken to be an indication of how semantic context leading up to a word influences how its low-level acoustic features are processed. We record EEG from participants listening to continuous natural speech and find that the early cortical tracking of a word's speech envelope can be predicted as a function of that word's semantic similarity to its sentential context. Using a 'forward modelling' approach, we find that prediction accuracy of the EEG signal also shows the same effect. Furthermore, this approach shows distinct spatiotemporal patterns of correlation depending on the type of speech input representation (acoustic or phonological) used for the model, implicating a top-down propagation of information through the processing hierarchy. These results suggest a mechanism that links top-down prior information with the early cortical entrainment of words in natural, continuous speech.

Topic Area: LANGUAGE: Semantic

B72 Age differences in hippocampal glutamate modulation during object-location encoding: evidence from proton functional magnetic resonance spectroscopy (¹H-fMRS).

Chaitali Anand¹, Dalal Khatib¹, Cheryl Dahle², Jeffrey Stanley¹, Naftali Raz²; ¹Department of Psychiatry and Behavioral Neuroscience, Wayne State University, Detroit MI, USA, ²Institute of Gerontology, Wayne State University, Detroit MI, USA

Hippocampal glutamate mediates learning and memory and glutamatergic dysfunction may signal age-related cognitive decline. We hypothesized that differences in glutamate modulation during memory encoding underlie age-differences in associative learning and memory. Spectroscopy data were acquired from unilateral hippocampi (randomized across subjects) of thirteen young (age 24±2.3; M=6; F=7) and six old (65±3.5; M=2; F=4) healthy adults during an associative learning and memory task, which involved encoding and cue retrieval of 12 object-location pairs. Twelve encoding-retrieval cycles were interspersed with epochs of counting backwards to foil rehearsal. Associative learning data were modeled using Gompertz function. Outcome variables included learning proficiency over time (slope, asymptote, inflection-point) and glutamate levels acquired during a neutral condition, and across the encoding and retrieval epochs. Old participants attained a lower asymptote [$t(17)=1.93$, $p=.011$], and tended to show a later inflection-point of learning [$t(17) = 1.85$, $p=.08$], compared to the young. Patterns of glutamate changes over encoding differed between groups: age-group × epoch: $F(5,74)=3.96$, $p=.003$. In young adults, a linear increase followed by a linear decrease was observed. Older participants evidenced a steady linear decrease after the initial three trials. In the older but not young adults, higher neutral-condition glutamate was associated with earlier inflection point of the learning curve. Results show altered hippocampal glutamate modulation during memory encoding concomitant with the poorer learning proficiency in old compared to the young. The results suggest a functional role of glutamate in age-related

memory decline, without the confounding effects of hemodynamics that limit the validity of fMRI inference.

Topic Area: LONG-TERM MEMORY: Development & aging

B73 Children process multiplication problems for meaning regardless of format: An event-related potential study of spoken number words and digits

Amandine E. Grenier¹, Danielle S. Dickson¹, Nicole Y.Y. Wicha^{1,2}; ¹The University of Texas at San Antonio, ²UT Health San Antonio

Multiplication problems can be represented in different ways, including as Arabic digits or number words. Given that children rely on rote memorization and verbal rehearsal to learn these facts, it has been suggested that the format in which a problem is presented—digits versus words—should influence access to these facts in memory. The current study investigated the effect of operand format on multiplication fact verification in children, and compared the results to adult data. Children (3rd-5th grade) verified the correctness of single-digit multiplications with multiplicands presented as either spoken words ("two"... "four") or digits (2...4). Event related potentials were time-locked to the onset of Arabic digit solutions that were either correct (=8) or incorrect (=12). In a 2(operand format) × 2(correctness) factor design, results showed a robust N400 correctness effect—reflecting access to semantic memory—with more facilitation (smaller amplitude) for correct than incorrect solutions. Critically, there was no difference in the N400 effect based on format. This finding suggests that children access multiplication facts from semantic memory similarly for words and digits. In contrast, data from adults on the same task revealed a qualitatively different congruency effect—namely a modulation on the P300 that reflects the salience of the correct solutions as target items to adults. Although the P300 was not influenced by operand format, adults showed an additional frontal effect of format that was absent in children. Together these data suggest that sensitivity to number format in arithmetic arises during later stages of cognitive development, perhaps as arithmetic facts become highly rehearsed.

Topic Area: LONG-TERM MEMORY: Development & aging

B74 Developmental trajectories and brain correlates of Directed Forgetting in Velo-cardio-facial syndrome

Céline Souchay¹, Maria Paluda^{2,3}, Maude Schneider³, Martin Debbané³, Christopher Moulin¹, Stephan Eliez³; ¹Laboratoire de Psychologie et Neurocognition, University of Grenoble, Grenoble, France, ²Friedrich Miescher Institute for Biomedical Research, Basel, Switzerland, ³Developmental Imaging and Psychopathology Laboratory, Office Médico-Pédagogique, Department of Psychiatry, University of Geneva, Geneva, Switzerland, ³Developmental Imaging and Psychopathology Laboratory, Office Médico-Pédagogique, Department of Psychiatry, University of Geneva, Geneva, Switzerland

Velo-cardio-facial syndrome (VCFS), is a rare genetic disorder caused by a microdeletion on chromosome 22q11.2. The phenotype encompasses heart anomalies, cleft palate and cognitive difficulties. Alongside brain differences in VCFS such as reduced brain volume in the hippocampus, different cognitive developmental trajectories can be observed. The aim of this study was to explore the developmental trajectories of cognitive inhibition in memory using longitudinal data acquired in a large cohort of individuals with VCFS and the brain correlates to those developmental changes. 51 participants with VCFS (mean age: 13.75± 4.26, mean IQ score: 70.50 ± 10.75) and 43 typically developing individuals matched for age (M = 13.50 ± 4.91) and gender were recruited. To explore inhibition in memory, the Directed Forgetting paradigm was used. 30 words were presented, half were 'To be remembered items'(TBR) and the other half 'To be forgotten items' (TBF). At the recognition stage, when participants discriminated the word as old, they had to say if it

was a TBR- or a TBF-item, to measure source memory. Participants were tested during two consecutive visits, with a mean interval of 3 years. T1-weighted images were acquired using a 1.5T Philips or a 3T Siemens scanner at both visits. Both groups recognized more TBR than TBF items (Directed forgetting effect), however, participants with VCFS recognized fewer TBR items and did not show an increase in TBR items with age. Furthermore, increase source memory errors in participants with VCFS with age was associated to a decline in hippocampal volume.

Topic Area: LONG-TERM MEMORY: Development & aging

B75 Increased reconfiguration of frontal connectivity during episodic memory retrieval in older adults

Lifu Deng¹, Benjamin Geib¹, Zachary A. Monge¹, Matthew Stanley¹, Olga Lucia Gamboa Arana¹, Erik Wing², Roberto Cabeza¹; ¹Duke University, ²University of Toronto

Brain network analyses have revealed that multi-region collaboration supports successful memory retrieval. However, it remains unclear how these large-scale interactions contribute to memory success differentially in older adults (OAs) and younger adults (YAs). In our task, YAs and OAs were fMRI scanned while studying labelled pictures of scenes. Later, they were presented the labels alone and asked to recall the associated scenes and rate the level of vividness of their memories. The retrieval trials were classified into 'vivid' and 'dim' trials, and for each participant whole-brain beta-series networks were constructed. Within nodes of interest, we examined functional network reconfiguration, which is defined as 1 minus the correlation between the vivid and dim networks, where higher values indicate greater memory-related reconfiguration. Compared to the YAs, we found that the OAs exhibited attenuated memory-related reconfiguration within medial temporal lobe (MTL) regions. Conversely, OAs showed enhanced memory-related reconfiguration within frontal regions. The disparity of MTL/frontal reconfiguration in the two age groups was further characterized by a negative relationship uniquely existing between MTL and frontal reconfiguration across subjects, but absent amongst other pairs of functional regions. Lastly, stronger connectivity between frontal regions and the rest of brain was associated with vivid retrieval in OAs. In conclusion, our results characterized a link between age-specific reconfiguration in frontal connectivity and memory quality, which further suggests a potential mechanistic explanation of age-related frontal compensation in memory retrieval facilitated by brain network.

Topic Area: LONG-TERM MEMORY: Development & aging

B76 Lower episodic memory abilities are associated with less age-related impairment in daily life

Carina Fan^{1,2}, Laryssa Levesque¹, Laura Oliva¹, Terry Yu¹, Kristoffer Romero¹, Brian Levine^{1,2}; ¹Rotman Research Institute, Baycrest, ²University of Toronto

Individuals differ in how they remember the past—some tend to recall the gist of an event, whereas others richly re-experience specific details. At the extremes, those with highly superior autobiographical memory (HSAM) recall copious details from past experiences, whereas those with severely deficient autobiographical memory (SDAM) are unable to recall any. The Survey of Autobiographical Memory (SAM) is a self-report measure developed to assess trait mnemonics along the normal spectrum of memory abilities between these two extremes. While memory decline is a hallmark of cognitive aging, trait-level individual differences in memory abilities have not been considered in cognitive aging research. Given the functional decline that accompanies memory deficits, one might expect that individuals endorsing high trait-level episodic memory would be less impaired—but we hypothesized that older adults with lower episodic memory abilities would report better daily function than those with congenitally strong episodic memory. We reason that the latter individuals must newly adjust to age-related memory decline, whereas those

with lower episodic memory abilities enter aging prepared with compensatory strategies. We tested 949 older adults in an online battery that included the SAM and self-reports of daily function. As predicted, trait mnemonics moderated the relationship between age and cognitive function in daily life: lower episodic memory abilities were associated with less age-related functional impairment. Importantly, when we examined the relationship between age and function without accounting for individual differences in autobiographical memory, no clear associations emerged—emphasizing the importance of considering individual differences when studying cognitive aging trajectories.

Topic Area: LONG-TERM MEMORY: Development & aging

B77 Neural correlates of elaborative encoding strategy use in younger and older adults

Samantha Williams¹, Robyn Husa¹, Madison Cochran¹, Madison Bertolin¹, Danielle Bond¹, Danielle Kelly², Phoebe Novack², Deanna Barch², Brenda Kirchoff¹; ¹Saint Louis University, ²Washington University in St. Louis

Older adults often display declines in episodic memory performance. Prior research suggests that reductions in older adults' self-initiated use of elaborative encoding strategies contribute to age-associated declines in episodic memory. Self-initiated elaborative encoding strategies are intentional and rely on complex, effortful cognitive processing. Prior lesion and neuroimaging research has demonstrated that prefrontal cortex plays an important role in supporting self-initiated elaborative encoding strategies. The goal of the current study was to investigate whether the same prefrontal brain regions support self-initiated elaborative encoding strategy use in both younger and older adults. The relationships between age, functional brain activation during unconstrained intentional encoding, overall use of self-initiated elaborative encoding strategies, and memory performance were examined. Overall self-initiated elaborative encoding strategy use was calculated for each participant by determining the proportion of trials for which they used any elaborative strategy (visual imagery, sentence generation, and/or personal relevance) during intentional encoding. Older adults had worse performance on a recognition memory test than younger adults and used elaborative encoding strategies less frequently. Preliminary fMRI data analyses revealed that brain activity during intentional encoding was positively correlated with overall use of elaborative encoding strategies in both younger and older adults in prefrontal cortex. Age did not significantly moderate the positive relationships between brain activity during intentional encoding and overall use of elaborative encoding strategies in prefrontal regions. These results suggest that the same prefrontal brain regions may support overall elaborative encoding strategy use in younger and older adults.

Topic Area: LONG-TERM MEMORY: Development & aging

B78 Neural mechanisms of age-related decline in episodic memory precision

Saana Korkki¹, Franziska Richter², Jon Simons¹; ¹University of Cambridge, UK, ²University of Leiden, Netherlands

Episodic memory declines with older age, but the neurocognitive mechanisms of this decline remain debated. Recent work has highlighted reduced precision of retrieved memories as one factor contributing to age-related memory loss, however the neural underpinnings of this deficit are yet to be characterised. In the current functional magnetic resonance imaging study, healthy young and older participants encoded stimuli displays that consisted of one object overlaid on a scene background. The location and colour of the objects at encoding were randomly selected from circular feature spaces (0-360 degrees), and at retrieval, participants reconstructed either the location or the colour of each object using a continuous response dial. Computational modelling of retrieval errors allowed for detailed assessment of memory

fidelity. Behaviourally, we observed age-related decreases in retrieval precision across the two feature conditions. At the neural level, retrieval-related activity in a network that involved regions such as the angular gyrus and the hippocampus tracked memory precision in both age groups. However, at encoding, we observed a diminished relationship between activity in visual regions and subsequent memory precision in the older group. Furthermore, encoding activity in the lateral prefrontal cortex was a significant predictor of memory precision in the younger group only. Together, the results implicate functional differences at encoding as contributing to the age-related deficit in episodic memory precision.

Topic Area: LONG-TERM MEMORY: Development & aging

B79 Self-Reference Enhances Memory for Multi-Element Events Judged Likely to Happen in Young and Older Adults

Mingzhu Hou^{1,3}, Matthew D Grilli^{1,2}, Elizabeth L Glisky^{1,2}; ¹Department of Psychology, University of Arizona, USA, ²McKnight Brain Institute, University of Arizona, USA, ³Center for Vital Longevity and the School of Behavioral and Brain Sciences, University of Texas at Dallas, USA

Older adults show relational memory impairments that have been partially attributed to reduced memory functioning mediated by the hippocampus. We investigated whether the strategy of self-reference can benefit memory for multi-element events, a kind of relational memory that is relatively less studied but highly needed in daily life. Young and older adults imagined different person-object-location events with reference to themselves and two famous others (i.e., George Clooney and Oprah Winfrey), rated the likelihood that each event would happen, and then took incidental memory tests on different pairs of elements within the event. We found that self-reference enhanced memory for pairwise associations as well as complete three-element events in both age groups. Such self-reference effects were observed exclusively for events rated as likely to happen. There was also an overall memory advantage for the higher-likelihood events, which was greater for older adults than young adults. Further, the observed self-reference effects were not correlated with overall memory functioning in either age group. Retrieval of within-event associations showed a significant level of dependency, a measure previously found to be related to the hippocampus, which did not differ as a function of reference condition or likelihood category. These findings highlight the importance of self-reference as well as prior knowledge in improving relational memory, and suggest that the advantage of self as a referent is not attributable to increased dependence of elements associated with complex events.

Topic Area: LONG-TERM MEMORY: Development & aging

B80 T1rho in Hippocampal-Cortical Systems Predicts Spatial Navigation and Associative Learning Performance in Older Adults

Matt Sodoma¹, Rachel Cole¹, James Kent¹, Vincent Magnotta¹, Michelle Voss¹; ¹University of Iowa

As the aging population grows, detecting changes in brain pathologies that increase risk of memory decline is paramount. Acidosis is a marker and facilitator of pathologies that lead to memory impairment and Alzheimer's disease (AD), including amyloid and tau pathologies, oxidative stress, and metabolic dysfunction. T1p is a non-invasive MRI measure of tissue pH, such that elevated T1p may be sensitive to these neurodegenerative processes. Hippocampal T1p can distinguish clinically relevant cognitive impairment, however, no studies have tested its sensitivity to subtler episodic memory functions thought to indicate risk for memory decline. Studies show the posterior-medial and anterior-temporal cortico-hippocampal systems (PMAT) have unique behavioral correlates. Spatial navigation correlates with the posterior system while object perceptual processing correlates with the anterior system. Thus, T1p relations to memory may vary across the hippocampal longitudinal axis. To examine this, we measured T1p in healthy

older adults (N=41) and behavioral performance on spatial navigation and associative learning. T1p was measured in the anterior hippocampus (head), posterior hippocampus (body & tail), perirhinal, and parahippocampal cortex. Elevated posterior hippocampal T1p and right medial temporal lobe predicted poorer spatial navigation learning. At delayed testing, elevated hippocampal T1p predicted poorer spatial navigation performance regardless of PMAT system and laterality. Additionally, as expected, elevated T1p in the left perirhinal cortex predicted poor performance on associative learning, yet the right perirhinal showed the opposite trend. Overall, results suggest medial temporal T1p may give insights into subtle memory decline undetected by other imaging methods and standardized clinical behavioral tests.

Topic Area: LONG-TERM MEMORY: Development & aging

B81 Transcranial direct current stimulation enhances episodic memory in healthy older adults by modulating retrieval-specific activation and resting functional connectivity

Juan Li¹, Lijuan Huo¹, Rui Li¹; ¹Institute of Psychology, Chinese Academy of Sciences, Beijing, China

Episodic memory is one of the most vulnerable cognitive functions to aging. The prefrontal cortex, especially the dorsal lateral prefrontal cortex (DLPFC), is the core region responsible for episodic memory. The aim of this study was to investigate whether Transcranial direct current stimulation (tDCS) targeting in dorsolateral prefrontal cortex (DLPFC) could improve memory performance of normal older adults and explore the underlying neural mechanisms by magnetic resonance imaging (MRI) method. In the current study, forty-nine healthy elderly above 60 years old were randomly allocated to the experimental group (n=24, 66.58 ± 6.11ys old) or the control group (n=25, 65.48 ± 3.39ys old), receiving either active (2 mA for 30 min per day) or sham stimulation in ten days, respectively. Brain activity was measured before and after stimulation, while subjects completed the memory task undergoing functional MRI. The results show that (1) At the behavioral level, item recognition increased significantly in the experimental group compared to the control group. The improvement remained three months later. (2) At neural level, the experimental group demonstrated increased activity during memory retrieval in medial prefrontal cortex and anterior cingulate cortex, decreased resting functional connectivity between the prefrontal cortex and the posterior brain, as well as volume increase in the bilateral prefrontal cortex after tDCS. More importantly, these brain changes were correlated with memory gains. The study indicated that atDCS may improve episodic memory in older adults by inducing neural alterations.

Topic Area: LONG-TERM MEMORY: Development & aging

B82 Competitive remembering shapes memory along diagnostic feature dimensions

Maxwell L. Drascher¹, Brice A. Kuhl¹; ¹University of Oregon

When memories share overlapping features, this results in interference and, ultimately, forgetting. With practice, however, competition between overlapping memories subsides (Anderson et al., 1994; Norman et al., 2007). These learning-related reductions in competition are thought to reflect differentiation of neural representations (Chanales et al., 2017; Favila et al., 2016; Hulbert and Norman, 2015). However, it remains poorly understood how overlapping memories actually change as neural representations become differentiated or, more generally, as competition subsides. Here, using a continuous, multidimensional feature space, we tested for learning-related changes in feature memory induced by competition. Subjects first studied and practiced remembering a set of artificially-generated face stimuli in an extended learning session. Critically, the set of learned faces included pairs of highly similar faces that only differed on a single face dimension (the diagnostic face dimension). After the learning session, participants repeatedly

'reconstructed' each of the faces, from memory, by manipulating randomly-generated face images along two dimensions. The two dimensions included the diagnostic dimension that discriminated the paired faces and a non-diagnostic dimension that did not discriminate the paired faces. Critically, we found that participants' reconstructions were significantly less variable (or sharper) along the diagnostic dimension than the non-diagnostic dimension. These results are consistent with a 'sharpening' account of interference-resolution, with sharpening preferentially occurring along feature dimensions that are relevant for discriminating between competing memories.

Topic Area: LONG-TERM MEMORY: Episodic

B83 Distinct Connectivity Patterns of Anterior and Posterior Hippocampus

Lea E. Frank¹, Caitlin R. Bowman¹, Dagmar Zeithamova¹; ¹University of Oregon

Memories may be hierarchically organized along the long hippocampal axis, such that representations shift from specific and detailed in the posterior hippocampus to increasingly more abstract in the anterior hippocampus. Similar distinctions are thought to exist within neocortex, with ventromedial prefrontal and lateral temporal cortices supporting memory generalization, and lateral prefrontal and lateral parietal regions supporting memory specificity. Here we tested whether functional connectivity follows these dissociations. We predicted greater anterior hippocampal connectivity with hypothesized generalization regions and greater posterior hippocampal connectivity with hypothesized memory specificity regions. Furthermore, we tested whether differences in connectivity are stable under varying levels of task engagement. Following category training, participants underwent fMRI, including a rest scan, two scans of passive viewing of category exemplars, and four runs of a category generalization task. Analyses revealed that anterior hippocampus was preferentially connected to ventromedial prefrontal cortex, and posterior hippocampus was preferentially connected to the angular gyrus and inferior frontal gyrus, consistent with their differential involvement in memory specificity and generalization. These differences remained stable across the three phases (rest, passive viewing, category generalization), suggesting the organization of background connectivity is relatively unaffected by task engagement. Whole-brain analyses further revealed there was little overlap in regions connected to anterior and posterior hippocampus. These results contribute to our understanding of functional organization along the long axis of the hippocampus, highlighting interactions with distinct cortical regions that contribute to differentiating details or finding commonalities respectively.

Topic Area: LONG-TERM MEMORY: Episodic

B84 Effects of cortisol reactivity and REM theta activity on emotional memory consolidation

Sara Y. Kim¹, Elizabeth A. Kensinger², Jessica D. Payne¹; ¹University of Notre Dame, ²Boston College

Sleep and stress independently have been shown to benefit emotional memory consolidation. In particular, theta oscillations (4-7 Hz) during rapid eye movement (REM) sleep have been linked to coherence in an emotional memory network and enhanced emotional memory. Here, we tested the hypothesis that pre-encoding stress exposure and theta power during REM sleep would interact to predict memory for emotional information. Participants underwent a psychosocial stressor (the Trier Social Stress Task; $n = 32$) or a comparable control task ($n = 32$) prior to encoding. Task-evoked cortisol reactivity was assessed by salivary cortisol rise from pre- to post-stressor. Participants in the stress condition were categorized as high or low cortisol responders via median split. During encoding, participants studied 150 negative, neutral, and positive images. All participants slept overnight in the lab with polysomnographic recording. The next day, they were given a surprise

recognition memory task. As predicted, high responders exhibited greater cortisol reactivity relative to both low responders ($t(15.80) = 6.14$, $p < 0.001$) and controls ($t(17.36) = 5.67$, $p < 0.001$). For high responders, REM theta significantly predicted memory for emotional information, specifically for positive items ($b = 0.15$, $R^2 = 0.34$, $p < 0.05$). Notably, for low responders and controls, there was no relationship between theta and memory of any valence. These findings provide initial evidence that events occurring at encoding, and accompanying changes in neuromodulators such as cortisol, and theta activity during REM sleep may interact to promote selective consolidation of emotional information during sleep.

Topic Area: LONG-TERM MEMORY: Episodic

B85 Fixating on a memory: The role of encoding and retrieval eye movements in detailed remembering

Azara Lalla¹, Caterina Agostino¹, Signy Sheldon¹; ¹McGill University

Research has documented that spontaneous eye movements made when encoding complex information reflects the recruitment of visuo-perceptual processes. More recent work has suggested that eye movements made when retrieving a memory can also reveal how these processes are used to mentally construct a representation of an event. These lines of work open up questions about the link between engaging visuo-perceptual processes when encoding versus retrieving complex information and the impact this engagement has on subsequent memory performance. To address these questions, we designed a study in which we tracked eye movements of young adult participants as they encoded and described complex visual images. After a delay, participants retrieved their descriptions of these images while we monitored eye-movements across a blank screen. We scored the retrieved descriptions in two ways. First, we tallied the number of details in these descriptions that were reinstated from the encoding description. Second, we tallied the number of details that were newly generated during retrieval (i.e., not present in the encoding description). Our key finding was that eye movements (fixation count) during retrieval but not during encoding predicted the total number of details (reinstated and newly generated) that were remembered. In addition, while both fixation count at encoding and retrieval predicted the ability to remember reinstated details, only retrieval fixation count predicted the ability to remember newly generated details. These data suggest that activating visuo-perceptual processes at retrieval can aid memory, possibly by mentally reconstructing a visualized representation of an encoded event.

Topic Area: LONG-TERM MEMORY: Episodic

B86 How mnemonic integration and structured knowledge contribute to goal-directed virtual navigation

Corey Fernandez¹, Jiefeng Jiang², Anthony D. Wagner^{2,3}; ¹Neurosciences Program, Stanford University, ²Department of Psychology, Stanford University, ³Wu Tsai Neurosciences Institute, Stanford University

Conjunctive memory representations enable recall of past episodes and the abstraction of relationships across experiences. The building of structured knowledge through mnemonic integration may enable goal-directed behavior, such as navigation. Here, we examined how the structure of experience and mnemonic integration link and transform memory representations, driving their evolution over learning. Specifically, we assayed the encoding and updating of memory representations across a three-day period during which subjects learned to navigate to goals in a virtual environment. Participants first learned to navigate between cued goal locations on three distinct paths in a virtual environment (within-context task). On day 2, the separately learned paths were connected, and subjects had to navigate across paths to reach cued goals (across-context task). We assessed learning by examining whether participants navigated to goal locations efficiently (i.e., via the shortest route) and found that participants quickly learned the within-context relationships.

Initial performance on the cross-context task was variable across participants, but despite differences in the rate of learning, all participants demonstrated knowledge of cross-context spatial relationships at a final test on day 3. Participants completed an fMRI scan each day, where they viewed images of landmarks and goals found within the virtual environment. The fMRI analyses leveraged pattern similarity to quantify the ways in which experienced trajectories through virtual space transform the similarity between environmental features. Initial neural findings revealed altered similarity evident of the emergence of structured knowledge, providing insight into the mechanisms that integrate and transform memory representations to guide goal-directed behavior.

Topic Area: LONG-TERM MEMORY: Episodic

B87 How neural representations during encoding predict recall success and failure for dynamic episodes

Griffin E. Koch^{1,2,3}, John P. Paulus^{1,2}, Marc N. Coutanche^{1,2,3}; ¹University of Pittsburgh, ²Learning Research and Development Center, University of Pittsburgh, ³Center for the Neural Basis of Cognition, Pittsburgh, PA

Despite experiencing the same information and opportunities to encode certain events into memory, humans differ in the particular aspects and details of episodes that we encode. Previous research has investigated neural similarity between people for information that is subsequently recalled, but few studies have investigated neural similarity (and dissimilarity) during encoding that might lead to differences in later recall success. In this study, we investigate how brain activity during encoding differs for information that is, and is not, ultimately recalled. Participants viewed brief video clips of animals, while undergoing a functional magnetic resonance imaging (fMRI) scan, and then answered a series of behavioral questions that measured memory performance. We employ univariate and multivariate techniques to compare neural representations for individual video scenes and ask how these vary by measures of individual differences, such as tendencies to remember different forms of information, and memory performance. Regions such as the parahippocampal gyrus, hippocampus, posterior medial cortex, as well as the dorsal Default Mode Network showed greater neural similarity for remembered, than not remembered, information. Additionally, activation within the dorsal Default Mode Network and anterior cingulate cortex was associated with subsequent memory performance.

Topic Area: LONG-TERM MEMORY: Episodic

B88 Individual variability in reward-related memory enhancements relate to white matter microstructure

Vera Dehmelt¹, Ashvanti Valji¹, Matthias Gruber¹; ¹Cardiff University Brain Research Imaging Centre (CUBRIC), School of Psychology, Cardiff University, UK.

In a given day, we only remember a fraction of what we experience. Critically, the salience of an event will influence the probability of remembering. It has been demonstrated that extrinsic reward anticipation facilitates hippocampus-dependent memory. However, the extent to which reward affects memory varies highly between individuals. Here, we employed deterministic tractography on diffusion-weighted imaging to investigate how anatomical connections within memory-related networks relate to preferential memory for rewarded information. We targeted the fornix, a white matter structure that supports memory functions and exploratory behaviour via its connections between the hippocampus and striatal regions, and the uncinate fasciculus (UF), which might contribute to reward-related memory effects via its connections with hippocampus and prefrontal cortex. Across two reward-motivated encoding paradigms, differences in fornix/UF microstructure are correlated with inter-individual variability in reward-related memory enhancements. While Experiment 1 focused on how individual differences in

fornix/UF microstructure correlate with incidental reward-related memory enhancements for different types of memory (i.e., temporal memory, recollection, familiarity), Experiment 2 focused on how fornix/UF microstructure correlate with reward effects on intentional memorization in immediate and 1-day delayed memory tests. Preliminary findings suggest enhanced recognition memory for high- compared to low-reward items (Experiment 1-2), while showing a more pronounced reward-related memory enhancement in the delayed memory test (Experiment 2). Importantly, reward-related memory effects varied highly between individuals in both experiments allowing targeted investigations on how reward-related memory enhancements relate to white matter microstructure within the fornix and uncinate fasciculus.

Topic Area: LONG-TERM MEMORY: Episodic

B89 Navigational demand modulates representational gradients along the human hippocampal longitudinal axis

Nichole R. Bouffard^{1,2,5}, Iva K. Brunec^{1,2,5}, Buddhika Bellana⁴, Ali Golestani¹, Jason D. Ozubko³, Jessica Robin², Morgan D. Barense^{1,2,6}, Morris Moscovitch^{1,2,6}; ¹University of Toronto, ²Rotman Research Institute, Baycrest, ³SUNY Geneseo, ⁴Johns Hopkins University, ⁵These authors contributed equally, ⁶Signifies joint senior authorship

When navigating, it is important to hold multiple scales of space in mind (e.g., general route vs. specific turns). Evidence for neural mechanisms that maintain these representations comes from rodent neurophysiology, where the hippocampus scales along a gradient of granularity, with larger place fields in the ventral hippocampus and smaller place fields in the dorsal hippocampus (Kjelstrup et al., 2008). Recently, Brunec, Bellana et al. (2018) demonstrated a similar gradient in the human hippocampus, along the anteroposterior axis (homologous to ventral-dorsal axis in rodents). It is still unclear, however, how this gradient supports the maintenance of representations over time (e.g. from route starting point to end goal). In the present study, nineteen participants were scanned while they navigated four different types of Google Street View routes that varied in difficulty. Using a novel temporal autocorrelation (AC) method (a measure of how much signal history a particular voxel carries forward in time) combined with a data-driven approach, we replicated the findings from Brunec, Bellana et al. (2018), demonstrating that voxels with high AC clustered in the anterior hippocampus and those with low AC clustered in the posterior hippocampus. Interestingly, we found that the magnitude of the gradient was modulated by route type and measures of self-reported difficulty. Temporal autocorrelation in the anterior hippocampus increased more during difficult route types and on individual routes that were rated as more difficult. These results suggest that as navigational demand increases, neural representations in the anterior hippocampus are extended across longer timescales.

Topic Area: LONG-TERM MEMORY: Episodic

B90 Switching between attention and memory in the hippocampus and medial prefrontal cortex

Eren Günseli¹, Mariam Aly¹; ¹Columbia University

Past experiences influence the way we behave in uncertain environments: We rely on memory to set attentional goals that serve adaptive behavior. We tested the hypothesis that the hippocampus and medial prefrontal cortex (mPFC), due to their roles in long-term memory and goal representations respectively, coordinate memory-guided attention by switching between memory retrieval and selective attention. Participants searched a set of images (rooms with paintings) to detect paintings of a similar style ('art' trials) or rooms with the same spatial layout ('room' trials). In 'explicitly-instructed' blocks, participants were told to attend to either the art or the rooms on each trial. In 'memory-guided' blocks they chose their attentional goal (art or room)

based on memory for images in the previous trial. In the memory-guided condition, we observed enhanced univariate activity in the hippocampus and mPFC, perhaps reflecting increased demands on memory retrieval. Conversely, multivariate representations of attentional goals were weaker when memory retrieval was required, consistent with a trade-off between externally-oriented attention and internally-focused memory retrieval. In line with this, the strength of attentional goal representations in mPFC predicted externally-oriented attention behavior more strongly when memory retrieval was not required. Finally, prior to image onset, mPFC represented attentional goals chosen on the basis of memory, but not those that were explicitly instructed. Together, these results suggest that the hippocampus and mPFC play key roles in memory-guided attention, switching between externally-oriented and internally-oriented processing as a function of task demands.

Topic Area: LONG-TERM MEMORY: Episodic

B91 Temporal context and memory consolidation mediate the boundary between retrieval induced forgetting and facilitation

Xiaonan L. Liu¹, Charan Ranganath¹; ¹University of California, Davis

Retrieval practice dramatically improves retention of targeted information, but there are conflicting findings about effects on memory for non-tested information. Some studies show increased forgetting of non-tested information that is related to the target (retrieval induced forgetting, RIFO) but others show enhanced retention (retrieval induced facilitation, RIFA). The present study tested the prediction that the boundary between RIFA and RIFO is determined by the extent to which retrieved and non-retrieved items are semantically and temporally related, and whether one is asked to recall immediately or after a delay. Participants learned associations between words and scene contexts, and each scene was paired with different words. We manipulated temporal distance between overlapping scene-word pairs and semantic relatedness between the two words. Next, participants repeatedly recalled one of words that had been paired with each scene, and we examined how retrieval affected retention of the non-retrieved words at either short (10 mins) or long (24 hours) delays after practice. At the short delay, we observed RIFA for temporally-close items but RIFO for temporally-distant items, regardless of semantic relatedness. At the long delay, however, we observed RIFA for both temporally-close items and temporally-distant items that semantically related, and RIFO for temporally-distant, unrelated items. These results suggest that retrieval generally enhances retention of contextually-linked information that were experienced in similar temporal contexts, and that there is a surprising delay-dependent switch between RIFO and RIFA for semantically-related information. The latter effect is consistent with proposals suggesting that memory consolidation strengthens associations between memories with shared elements.

Topic Area: LONG-TERM MEMORY: Episodic

B92 The human hippocampus is necessary for remembering durations within a sequence of events but not durations of individual events

Daniela Palombo^{1,2,3}, Allison Reid¹, Sathesan Thavabalasingam⁴, Renee Hunsberger¹, Andy Lee^{4,5}, Mieke Verfaellie^{1,2}; ¹VA Boston Healthcare System, ²Boston University School of Medicine, ³University of British Columbia, ⁴University of Toronto (Scarborough), ⁵Rotman Research Institute

Recent interest in the role of the hippocampus in temporal aspects of cognition has been fueled, in part, by the observation of “time” cells in the rodent hippocampus—that is, cells that have differential firing patterns depending on how long ago an event occurred. Such cells are thought to provide an internal representation of elapsed time. Yet, the hippocampus is not needed for processing temporal duration information per se, at least on the order of seconds, as evidenced by intact duration judgments in rodents and humans

with hippocampal damage. Rather, it has been proposed that the hippocampus may be essential for coding higher-order aspects of temporal mnemonic processing, such as those needed to temporally organize a sequence of events that form an episode. Does the hippocampus use duration information in the service of establishing temporal relationships among events? Further, is its role in memory for duration unique to sequences? If so, hippocampal damage should impair the ability to remember sequential duration information, whereas it should leave intact judgments about duration devoid of a sequential demand. Here, we tested this hypothesis in amnesic patients with hippocampal damage. We found, as expected, that amnesics were impaired in making judgments about durations within a sequence but not in judging single durations. Control experiments demonstrated that this impairment was not due to higher cognitive load associated with duration judgments about sequences. In convergence with rodent and human fMRI work, these findings shed light on how time coding in the hippocampus may contribute to temporal cognition.

Topic Area: LONG-TERM MEMORY: Episodic

B93 The Influence of Memory Performance on Neural Representations supporting Associative Retrieval

Courtney R. Gray¹, Jordan D. Chamberlain¹, Kayla E. McGraw², Harini Babu¹, Amy A. Overman², Nancy A. Dennis¹; ¹The Pennsylvania State University, ²Elon University

Successful associative memory requires not only memory for individual pieces of information, but, critically, memory for the relationship between those pieces. Associative memory errors arise both from forgetting of information (misses) as well as the misidentification of information combined in a different manner at retrieval than that which was originally presented (false alarms). While misses and false alarms are associated with different subjective memory responses (‘new’ and ‘old’, respectively), they share the commonality of arising from flawed cognitive processing. Of interest is whether neural representations in memory-critical regions, like the hippocampus, are more similar across such subjective memory errors compared to the objective presentation history of the information and successful memory responses. To investigate this, we tested 25 younger adults on an associative memory task examining memory for face-scene pairings. A representational similarity analysis revealed that neural patterns within the hippocampus were less distinct for memory errors (misses and false alarms) than those associated with accurate memory responses (hits and correct rejections). Interestingly, patterns of activation in both early and late visual cortex did not differ across memory behavior. These results suggest that memory errors arise from greater similarity in neural representations within the hippocampus, whereas accurate memories are associated with more unique processing, irrespective of the objective history of the associative pairing. Furthermore, when all individual items within an associative memory test are ‘old’, processing within the visual cortex may do little to differentiate between their associative history.

Topic Area: LONG-TERM MEMORY: Episodic

B94 A Comparison of Conditioning Methodologies on Formation of Methamphetamine Associated Memories Using Conditioned Place Preference

Michael Hanna¹, Megan Jeske¹, Taylor Underwood¹; ¹Vanguard University of Southern California

Many research labs that study memory consolidation and reconsolidation use the conditioned place preference (CPP) paradigm to associate specific cues with drug administration. Drug associated memories go through consolidation, a process of stabilizing a memory trace after the initial acquisition. When a memory is later triggered, or reactivated, it goes through reconsolidation, in which the memory trace becomes temporarily unstable and liable

to disruption before becoming stable once again. Previous studies from our lab have shown that the NMDA receptor is necessary for the reconsolidation process as administration of the NMDA receptor antagonist memantine disrupts drug seeking behavior. To study whether similar methamphetamine (MeAM) associated memories go through reconsolidation independently we paired two separate compartments of distinct CPP chambers with MeAM. Two different methods were examined to test the most effective process in establishing preferences for the MeAM paired compartments. The first method involved a 15 day conditioning period, administering MeAM and saline alternatively before placing rats in a single compartment. The second method involved a 12 day conditioning period, administering MeAM before placing rats in one compartment and then immediately transferring them to a second MeAM paired compartment. Our results show that both conditioning methodologies resulted in rats demonstrating a strong preference for the MeAM paired compartments. Additionally, we found that using both methods, administration of memantine after exposure to one MeAM paired compartment disrupted drug-seeking behavior for that particular compartment but did not disrupt drug-seeking behavior for the second MeAM-associated compartment.

Topic Area: LONG-TERM MEMORY: Other

B95 Characterizing aphantasia through memory drawings of real-world images

Wilma A. Bainbridge¹, Zöe Pounder², Alison Eardley², Chris I. Baker¹; ¹National Institute of Mental Health, USA, ²University of Westminster, UK

Aphantasia describes the phenomenon of impaired visual mental imagery in the presence of intact vision and semantic memory. Little is understood about aphantasia as it causes few impairments in daily life and often develops congenitally without brain trauma, so aphantasics are largely unaware their phenomenological experiences differ from the standard population. Recent work suggests surprisingly intact abilities at several visual working memory tests (Jacobs et al., 2018), making the nature of the impairment in aphantasia unclear. In the current study, we use a drawing memory task to explore the differences between visual memory representations for aphantasics and controls, and compare performance to standard visual imagery questionnaires. Previous work has shown such drawing tasks can reveal detailed object and spatial information within memory (Bainbridge et al., 2018). Aphantasics (N=31) and controls (N=31) participated in an online experiment where they studied 3 real-world scene images, drew them from memory, copied the same images while viewing them, and then performed a recognition task on those images. We find striking differences in the types of object details recalled by aphantasics and controls, in spite of high detail in the copied scene drawings done by both groups. These differences are also highlighted by differences in the order in which aphantasics drew memory details. Overall, memory drawings reveal a more objective characterization of aphantasia and provide insight into the nature of this deficit.

Topic Area: LONG-TERM MEMORY: Other

B96 Hexadirectional modulation of human entorhinal theta oscillations during human navigation and spatial memory

Shachar Maidenbaum¹, Jonathan Miller¹, Joshua Jacobs¹; ¹Columbia University

The entorhinal cortex contains a network of grid cells that play a fundamental part in the brain's spatial system, supporting tasks such as path integration and spatial memory. In rodents, grid cells are thought to rely on network theta oscillations, but such signals are not evident in all species, challenging our understanding of the physiological basis of the grid network. We analyzed intracranial recordings from neurosurgical patients during virtual navigation to identify oscillatory characteristics of the human entorhinal grid network. The power of entorhinal theta oscillations showed six-fold modulation according to

the virtual heading during navigation, which is a hypothesized signature of grid representations. Furthermore, modulation strength correlated with spatial memory performance. We then pre-registered these results and replicated them in an independent dataset. These results demonstrate the connection between theta oscillations and the human entorhinal grid network and show that features of grid-like neuronal representations can be identified from population electrophysiological recordings. Thus, this signal offers a new window into exploring Spatial Memory in humans. Finally, I will demonstrate how this new signal is modulated by parameters such as the availability of visual cues and differences between encoding and retrieval.

Topic Area: LONG-TERM MEMORY: Episodic

B97 Does the fMRI scanning environment weaken criterion shift stability?

Evan Layher¹, Courtney Durdle¹, Sara Leslie¹, Michael B. Miller¹; ¹University of California, Santa Barbara

We assessed criterion shift stability across recognition memory and visual perception domains both at a computer and during fMRI scanning. In part 1 of Study 1, participants (N = 30) initially studied scene images that either contained a person or not. At test, participants made recognition (scene studied or not) and perceptual (person present or absent) judgments. We manipulated criterion by awarding 5 cents for correct responses while only penalizing one of two error types. Participants either lost 10 cents for false alarms (conservative condition) or misses (liberal condition). In part 2, participants performed a longer version of the task (4 times as many test trials with longer study sessions) during fMRI scanning. Even though criterion shift performance is remarkably stable across domain types in part 2 ($r = 0.86$, $p < 0.01$), there is less stability within domains between parts 1 and 2 for both recognition ($r = 0.32$, $p = 0.08$) and perceptual ($r = 0.24$, $p = 0.21$) judgments. To test whether the scanner environment weakened criterion shift stability, we conducted Study 2 (N = 30) using the same paradigm without fMRI scanning. Again, criterion shift stability remained weaker between parts 1 and 2 for both recognition ($r = 0.39$, $p = 0.03$) and perceptual ($r = 0.15$, $p = 0.43$) judgments compared to the stability across domain types in part 2 ($r = 0.49$, $p < 0.01$). Contrary to our prediction, the scanner environment did not greatly impact criterion shifting stability.

Topic Area: LONG-TERM MEMORY: Other

B98 The Impact of Video Game Mechanics on hippocampal GABA and glutamate: a MRS study

Vilesha Waller¹, Deanna Molina¹, Kelsey Prena², David Raymond¹, Hu Cheng^{1,3}, Sharlene Newman^{1,3}; ¹Department of Psychological and Brain Sciences, Indiana University, ²Media School, Indiana University, ³Program in Neuroscience, Indiana University

The hippocampus is responsible for various functions including memory, reward, and spatial navigation. Video game play taps each of these mechanisms and is thought to interact with both the reward pathway and memory processing. Our prior behavioral study suggested that reward-present video games have a greater positive effect on a subsequent declarative memory task; the study showed increased delayed recall for the reward-present game compared to the reward-absent game (Prena et al., 2018). The improved memory performance for the reward-present game was attributed to improved hippocampal mediated memory encoding. GABA is the primary inhibitory neurotransmitter and glutamate is the primary excitatory neurotransmitter. Both are involved in many pathways of the hippocampus (Gasbarri & Pompili, 2014; Riedel et al., 2003) and are linked to memory formation. Because reward-present and reward-absent video games appear to differentially impact memory and because both glutamate and GABA are related to memory formation, it was hypothesized that these two types of video

games may differentially interact with neurochemistry. The goal of the current study was to test this hypothesis by using MRS to observe hippocampal GABA and glutamate concentration differences in participants who played a reward present game, Sonic, and another group who played a reward-absent game, Proteus. Compared to the reward-absent group, participants who played the reward-present video game showed increased GABA and decreased glutamate. This preliminary study supports the hypothesis that these different games may have differing effects on neurochemistry which may account for the differing effects on memory.

Topic Area: LONG-TERM MEMORY: Other

B99 The Impact of Video Game Mechanics on Learning and Memory: an fMRI study

Deanna Molina¹, Kelsey Prena², David Raymond¹, Sharlene Newman^{1,3}; ¹Department of Psychological and Brain Sciences, Indiana University, ²Media School, Indiana University, ³Program in Neuroscience, Indiana University

The hippocampus is responsible for various functions including memory, reward, and spatial navigation processing; each of these neuronal mechanisms are commonly utilized during video game play. Although anticipated reward has previously been correlated with declarative memory formation the impact of video game play on memory formation has not received much attention. Our prior behavioral study has suggested that reward-present video games had a greater positive effect on a subsequent declarative memory task, delayed recall, than a reward-absent game (Prena et al., 2018). The improved memory performance for the reward-present game was attributed to improved hippocampal mediated memory encoding. The goal of the current study was to test the hypothesis generated by the previous behavioral study by using fMRI to observe brain activation in the hippocampus during the memory encoding phase of a delayed recall task. A between-subjects design was employed with one group playing a reward present game, Sonic, and another group playing a reward absent game, Proteus. Compared to the reward-absent group, participants who played the reward-present video game exhibited greater bilateral hippocampal activation during memory encoding. These findings support the hypothesis presented in the behavioral study and demonstrate that reward present video games impact hippocampal processing and thereby may enhance memory encoding.

Topic Area: LONG-TERM MEMORY: Other

B100 Classification As Bad Epoch Rejection (CABER): An advanced technique for “tossing” low-quality trials from EEG datasets

Phui Cheng Lim¹, Karl Kuntzleman¹, Matthew R Johnson¹; ¹University of Nebraska-Lincoln

Electroencephalography (EEG) datasets always contain some number of low-quality trials, which ideally should be identified and removed before further analysis. Techniques exist for removing overt problems such as blinks or other ocular/muscular artifacts; however, more subtle artifacts, or trials with poor data due to e.g. participant inattention, might be missed by traditional techniques (including visual inspection). Thus, we developed the Classification As Bad Epoch Rejection (CABER) technique to filter out (“toss”) such trials. CABER uses multivariate pattern analysis (MVPA; implemented here via the DeLINEATE deep-learning toolbox, <http://delineate.it>) and requires a factorial design with at least two factors; e.g., in a visual paradigm, location (left/right) x number of items (one/two). First, per-trial classification on one dimension (e.g., location) is used to identify and reject poorly-classified trials. Then, the remaining trials are analyzed normally over the other, orthogonal dimension (e.g., number of items). Classification performance for the second dimension on the filtered dataset should improve relative to the original dataset, even though the dataset was pruned based on an unrelated dimension. We tested CABER on two sample datasets, using two different cognitive paradigms and

two different EEG systems. In both datasets, classification performance improved significantly after CABERing, regardless of whether or not traditional artifact rejection was applied beforehand. Our results suggest that the CABER technique can be used to improve data quality across a range of datasets, which could facilitate the detection of subtle effects that might be missed with less sophisticated analyses.

Topic Area: METHODS: Electrophysiology

B101 Electrophysiological Frequency Band-Ratio Measures Conflate Changes in Periodic and Aperiodic Features

Julio Dominguez¹, Thomas Donoghue¹, Bradley Voytek¹; ¹UC San Diego

Electrophysiological signals are characterized by an aperiodic component, which displays 1/f-like characteristics, and periodic oscillations which rise above the aperiodic signal. A common and longstanding approach to measure oscillatory power is to compute the power ratio between two frequency bands. Band-ratio applications include investigations of cognitive processes, biomarkers for conditions such as attention-deficit hyperactivity disorder, and others. Recent work demonstrates that two electrophysiological features - the periodic and aperiodic components - can vary independently and likely reflect different physiological processes. Here, we investigate periodic and aperiodic dynamics to determine whether band-ratios specifically reflect oscillatory components, or aperiodic changes. Power spectra were simulated with incremental changes in oscillatory center frequency, amplitude, and bandwidth and over varying aperiodic signals. We find that although band-ratio measures reflect oscillatory amplitude change, as expected, center frequency and bandwidth also influence band-ratio measures. Additionally, differences in band-ratio measures can reflect aperiodic changes, with measured differences when oscillations are completely stable or nonexistent. In electroencephalography datasets we validate that band-ratio measures reflect differences that can reflect non-oscillatory changes. We show that periodic and aperiodic features, can drive the same observed changes in band-ratio measures. As such the band-ratio measure is a non-specific measure, and can be misinterpreted if taken to necessarily reflect relative oscillatory power between bands. Finally, we show how an alternative approach which parameterizes neural power spectra across both periodic and aperiodic components is able to provide specific measurements as to which components of the data actually change.

Topic Area: METHODS: Electrophysiology

B102 Paired Trial Classification: A Novel Deep Learning Technique for MVPA

Jacob Williams¹, Ashok Samal¹, Prahalada Rao¹, Matthew Johnson¹; ¹University of Nebraska - Lincoln

Many recent developments in machine learning have come from the field of “deep learning,” or the use of advanced neural network architectures and techniques. While these methods have produced state of the art results and dominated research focus in many fields, they have not gained as much ground over standard multivariate pattern analysis (MVPA) techniques in classifying EEG data, whose high dimensionality, noisiness, and relatively low number of trials present special challenges for deep learning MVPA models. To address some of these problems, we present a new method of paired trial classification that, instead of predicting the class of a single trial, attempts to determine whether two trials are drawn from the same class or different classes. This allows a drastic increase in the size of the training dataset, as the number of possible trial pairs is much greater than the original number of trials. However, paired trial classification still allows us to predict the actual class of a sample by comparing the test sample to a corpus of known samples, and basing the class judgment on the proportions of same/different decisions. In a sample EEG dataset, this technique showed high accuracy on

same/different judgments, validating its usefulness as a pure similarity metric. Furthermore, when it was extended to categorical classification, we found performance comparable to the best contemporary methods. Through its use as a similarity metric, the technique also opens up avenues for new types of analyses and thus presents a promising direction for future work.

Topic Area: METHODS: Electrophysiology

B103 Reliability of resting-state EEG spectral power - advantage of normalization is not guaranteed

Matthew King-Hang Ma¹, Tan Lee¹, Manson Cheuk-Man Fong², Nga Yan Hui², William Shiyuan Wang²; ¹The Chinese University of Hong Kong, ²The Hong Kong Polytechnic University

As a noninvasive and handy technique, EEG is widely used to study brain functions. However, while spectral analysis in terms of band power is extensively applied, the reliability of extracted features was seldom confirmed. The current study investigates the reliability of EEG spectral features in a resting-state setting. Resting state EEG is task-free and easy to collect, making it feasible for long-term monitoring of neurodegenerative diseases in clinical situations, for which reliability is a crucial prerequisite. Linear mixed-effect model (LMM) was employed to analyze eyes-open and eyes-closed resting-state data (three minutes each), collected in 16 elderly subjects (gender-balanced) across two sessions separated by a month on average. Absolute and relative band powers were extracted, with the relative band power being computed by normalizing the absolute power with respect to the total band power (1-45 Hz). Their reliability over the two sessions was evaluated by intraclass correlation (ICC). The major advantage of LMM is that subject-specific components such as baseline activities can be extracted. Results showed that despite being a normalized feature, the relative power did not exhibit its advantages consistently across all spectral bands. For example, absolute power in alpha band attained higher reliability than relative power over the whole scalp, but the pattern was reversed in beta band. While huge enhancements were found by using relative power in eyes-open beta band, the normalization greatly decreased the reliability in eyes-open theta band. Such inconsistency raised the need of careful consideration in feature selection based on research aim.

Topic Area: METHODS: Electrophysiology

B104 Separating Aperiodic Stochastic Neural Dynamics from Neural Oscillations via Spectral Power Variation

Richard Gao¹, Lauren Liao¹, Bradley Voytek¹; ¹University of California, San Diego

Oscillatory brain activity observed in neural field potentials has been widely used to index behavior, cognition, and disease. There is emerging evidence, however, that oscillations can exist in different modes – sustained versus bursting – that have different physiological origins and different behavioral relevance. Additionally, there exist non-oscillatory components in the field potential that can obscure or be mistaken for oscillations, especially in the average power spectral density (PSD). One such component is the aperiodic signal that gives rise to the 1/f power law background in the field potential PSD, which has been proposed to reflect synaptic potentials induced by Poisson population spiking. It remains an ongoing challenge to consistently define, operationalize, and isolate oscillatory and non-oscillatory neural dynamics. In this work, we begin with a null model of the field potential as a superposition of the stochastic aperiodic (1/f) component and oscillatory components. We use two measures – spectral coefficient of variation (SCV) and deviation from stochastic power distribution – to separate these components in simulation. Under the null stochastic model, spectral power at all frequencies follow

exponential distributions. Using the proposed measures, we demonstrate the existence and separation of these components in a range of experimental data, including intracranial and intracortical data from humans, macaques, and rodents, against a theoretical null. We find conserved frequency regions at 30-50Hz that follow theoretical stochastic power distributions, and sustained and bursting oscillations in other frequencies over and above the stochastic signal in a task-related manner.

Topic Area: METHODS: Electrophysiology

B105 DeLINEATE: A deep learning toolbox for neuroimaging data analysis

Karl Kuntzelman¹, Jacob M. Williams¹, Ashok Samal¹, Prahalada K. Rao¹, Matthew R. Johnson¹; ¹University of Nebraska-Lincoln

Brain decoding, the use of machine learning techniques to identify cognitive states from neuroimaging data, has rapidly grown in popularity since the advent of multivariate pattern analysis (MVPA). The relatively simple linear algorithms that underlie most MVPA, however, are computationally inadequate for large and complex datasets, and in at least some domains (e.g., image classification) easily outperformed by deep neural networks (DNNs). Consequently there has been a recent surge of interest in approaches to brain decoding that capitalize on these “deep learning” techniques. Still, adoption of DNNs for MVPA has been slowed by the greater complexity of DNN architectures, the programming expertise required to use current DNN tools, and the lack of built-in support for specific methodological requirements of the neuroimaging community. To address these issues, we have created an open-source Python toolbox called Deep Learning In Neuroimaging: Exploration, Analysis, Tools, and Education (DeLINEATE). Notable features include support for several cross-validation and rescaling schemes; a text-based job description file format that requires no Python coding knowledge from users; and backend support for PyMVPA, enabling comparisons to traditional MVPA techniques. Across multiple datasets analyzed with DNNs, we demonstrate advantages in computational speed and/or classification performance relative to traditional MVPA techniques. DNNs can also implement novel forms of MVPA and tackle research questions that were unavailable to older methods. The current release is available on the project website (<http://delineate.it>) and all project code is hosted on Bitbucket (<https://bitbucket.org/delineate/delineate/src/master/>). Development is ongoing and we invite feature requests from the community.

Topic Area: METHODS: Neuroimaging

B106 Electro-corticography (ECoG) activity induced by stimulation of the Inferior

Kota Tanaka¹, Ayaka Sugiura¹, Noboru Mimura¹, Yasuo Nakai¹, Hirota Motoi¹, Eishi Asano^{1,2}; ¹Department of Pediatrics, Children’s Hospital of Michigan, Wayne State University, Detroit, MI, 48201, USA, ²Department of Neurology, Children’s Hospital of Michigan, Wayne State University, Detroit, MI, 48201, USA

The inferior-frontal gyrus (IFG) on the left hemisphere has been suggested to be a part of the expressive language systems in human, and also known as the Broca’s area. The IFG consists of the following three sub-regions: (i) pars opercularis, (ii) pars triangularis, and (iii) pars orbitalis. Here, we determined what IFG subregions are functionally connected to the superior temporal gyrus (STG), using electrical stimulation via subdural electrodes directly placed on the brain surface. We studied 11 patients with drug-resistant focal epilepsy, who underwent two-stage epilepsy surgery. During extraoperative electrocorticography (ECoG) recording at the bedside, 40 single-pulse electrical stimuli were delivered to a neighboring electrode pairs involving the STG. Stimulation-induced responses were recorded in other regions. The mean amplitude of beta activity was animated on a standard brain template.

Beta activity induced by stimulation of the pars opercularis and pars triangularis of the left IFG involved the STG within 40 milliseconds. Conversely, beta activity induced by stimulation of the pars orbitalis failed to involve the STG in this patient cohort. The present study demonstrated that the pars opercularis and triangularis of the left IFG are functionally connected to the STG of the same hemisphere. The pathways between STG and pars opercularis and triangularis, compared to that between STG and parsorbitalis may have more robust foundation allowing neural communication between the left frontal and temporal lobes.

Topic Area: METHODS: Neuroimaging

B107 Multi-Scale Plasticity in an Embodied Simulation of the Human Brain

Jessica Dafflon¹, Federico Turkheimer¹, Robert Leech^{1,2}, Peter Hellyer;
¹King's College London, UK, ²Imperial College London, UK

A wide range of different computational models has been used to study how spontaneous activity emerges from the structure of the brain. However, most of these models consider the brain at rest and do not explore the brain-environment interaction [1]. Recently, our work showed that homeostatic mechanisms, both at the micro- as well as macroscopic level, are crucial to the regulation of dynamic neural activity and may act as a mechanism to support emergent exploratory behaviour in the brain [2]. In this project, we developed a computational model that incorporated the Wong-Wang model within and embodied a virtual 'agent'. In this model, the agent navigated the environment and its interactions with the environment lead to changes in neuronal activity. We then explored the importance of homeostatic mechanisms at different levels in the exploration of the environment. We observed that while non-plastic models tend to be blocked on the same location, multi-levels of plasticity lead to a more efficient exploration of the environment. Therefore, suggesting that homeostatic plasticity ensures that the system is dynamic and that the agent does not stay trapped in any specific state for too long. This project is an important step to understand the interplay between environment, neural activity and the importance of different balancing homeostatic mechanisms. 1. Hansen, E.C., et al., Functional connectivity dynamics: modeling the switching behavior of the resting state. *Neuroimage*, 2015. 105: p. 525-35. 2. Hellyer, P.J., et al., Balanced activation in a simple embodied neural simulation. *arXiv preprint arXiv:1606.03592*, 2016.

Topic Area: METHODS: Neuroimaging

B108 Network Analysis Comparing Structural and Functional Neuroimaging Data

Han Yang Tay¹, Saray Shai¹, Psyche Loui^{1,2}; ¹Wesleyan University, ²Northeastern University

The human brain is a complex structural and functional network, but the relationship between network structure and function is unclear. Using a network science approach, we directly compare properties of structural and functional networks obtained from diffusion tensor imaging (DTI) and resting state functional MRI (rsfMRI) data. We define nodes in the network as region of interests (ROIs) obtained from the Craddock atlas. In the structural network, an edge is quantified using probabilistic tractography from DTI. In the functional network, an edge is quantified as bivariate correlation between two ROIs from rsfMRI. While the structural network shows local patterns of connectivity between anatomically adjacent brain regions, the functional network shows presence of many cross-hemispheric links between ROIs and their contralateral homologues. We also observe Rich Clubs and Diverse Clubs along the cortical midline brain structures in the structural network, and along the cortical surface in the functional network. Rich Clubs comprise nodes with disproportionately high number of edges that are highly interconnected with each other, while Diverse Clubs comprise nodes which

are diversely connected to different network communities. Furthermore, while the structural Rich Club is consistent across subjects, the functional Rich Club shows considerable variability between subjects. These differences between structural and functional networks may shed light on the relationship between structure and function in the brain.

Topic Area: METHODS: Neuroimaging

B109 Separating Task and Individual Differences: A Bilinear Model of Functional Connectivity

Matthew Galdo¹, Xiangrui Li¹, Zhong-Lin Lu¹, Mark Steyvers², Brandon Turner¹; ¹Ohio State University, ²University of California, Irvine

Functional connectivity is a ubiquitous measure in neuroimaging thought to give insights on how regions in the brain coordinate their activity. The coordination of these regions is theorized to vary as a function of cognitive demand (task) and individual. Here we adapt bilinear models, previously used to separate the style and content of images, to explore the interaction between individual and task within functional connectivity data. We fit different parameterizations of the bilinear model to a comprehensive dataset containing the functional connectivity of 174 participants for 9 different tasks. We then cross-validated each parameterization's fit using a subset of 19 participants who repeated the tasks on a later date. Our model performs best when we allow it to have high dimensional individual differences. When we allow the model to appreciate task differences, the model can succinctly measure relative task similarity and dissimilarity. Most notably, the model predicts that the resting state task is orthogonal to all other tasks in our data set. In sum, we find the bilinear model useful in separating task and individual differences and a promising tool for a variety of cognitive and clinical questions in neuroimaging.

Topic Area: METHODS: Neuroimaging

B110 Sub-specialization of "visual" cortex for multiple higher-cognitive functions in congenital blindness

Shipra Kanjlia¹, Rita Lioitile¹, Nora Harhen¹, Marina Bedny¹; ¹Johns Hopkins University

Studies of blindness provide a window into how experience shapes cortical function. In people who are blind from birth, "visual" cortices are active during auditory and tactile tasks (Kujala et al., 1995, *Neuro. Letters*; Sadato et al., 1996, *Nature*). A key outstanding question is whether "visual" cortices specialize for multiple different cognitive functions, or instead show non-specific responses. We examined visual cortex activity during multiple higher-cognitive tasks within the same set of congenitally blind and sighted participants. We manipulated (1) difficulty of math equations in an auditory math task, (2) grammatical complexity in a sentence comprehension task, (3) cognitive conflict in an auditory Stroop task and (4) response-inhibition in an auditory go/no-go task. Sub-regions of the "visual" cortex showed distinct sensitivity to language, math and different types of executive control. Different sub-regions of the "visual" cortex were sensitive to math and language (Lane et al., 2015, *JoN*; Kanjlia et al., 2016, *PNAS*). Another sub-region within the "visual" cortex was sensitive to response-inhibition but not to language, math or conflict in the Stroop task. Finally, we observed a fourth functional profile: domain general responses to difficulty in all four tasks. These patterns mirror selectivity preferences in fronto-parietal and fronto-temporal cortices of sighted and blind individuals (e.g. Menon et al., 2000, *Neuroimage*; Ben-Shachar et al., 2004, *Neuroimage*; Ridderinkhof et al., 2004, *Brain & Cognition*). These findings demonstrate that the "visual" cortex specializes for multiple distinct higher-cognitive functions in congenital blindness.

Topic Area: OTHER

B111 Action-Perception Coupling and Near Transfer of Motor Sequences in the Dorsal Premotor Region in Response to Piano Practice

Örjan de Manzano¹, Karin Ström¹, Karen Kuckelkorn¹, Fredrik Ullén¹; ¹Karolinska Institutet

Action-perception coupling can be established through training. For example, non-musicians who learn to play a melody on the piano, show activity in premotor regions when listening to that melody, but not when listening to untrained melodies. The increased activity could represent a general preparatory signal, or it could reflect actual motor representations of the trained melody. To test these hypotheses, we taught 12 non-musicians to play two melodies with different sequential structure on the piano. On the following day, training was repeated, and participants were scanned with fMRI while listening to the trained melodies as well as two untrained melodies. A matched control sample without training was also scanned. Multivariate pattern analysis involving machine learning was used to train a classifier to distinguish between melodic patterns based on beta-estimates representing brain activity during presentation of the melodies. The dorsal premotor region (PMD) was defined as region-of-interest. One participant was excluded after neurological screening. In the experimental sample, accuracy was significantly above chance level for both classification between trained melodies and between untrained melodies. Further, the trained melodies could be distinguished from the untrained melodies. None of the melodies could be classified with above-chance accuracy in the control sample. This demonstrates action-perception coupling and automatic retrieval of motor sequence patterns in the PMD in response to auditory stimuli, as well as near transfer from trained to untrained sequences. There is no support for the PMD being a shared neural substrate for perception of auditory and motor sequences.

Topic Area: PERCEPTION & ACTION: Audition

B112 Behavioral correlates of Zwicker tone percepts in rodents

Achim Schilling¹, Konstantin Tziridis¹, Holger Schulze¹, Patrick Krauss¹; ¹Experimental Otolaryngology, Neuroscience Group, University Hospital Erlangen, University of Erlangen-Nuremberg

Subjective tinnitus is an auditory phantom percept in the absence of any physically present sound source which often causes severe psychological stress. Unfortunately, the underlying cognitive mechanisms are still not fully understood. An interesting model for acute tinnitus is the Zwicker tone percept, as recent models suggest that underlying neural mechanisms are similar. The Zwicker tone is an auditory phantom percept which e.g. may be induced by the presentation of noise stimuli with a spectral notch, leading to the transient perception of a pure tone in the range of the notched frequency band for several seconds after the end of the stimulation. To analyze the neurophysiological mechanisms leading to the perception of a Zwicker tone, the usage of an animal model would be desirable. However, still no behavioral paradigms are available to objectively prove the presence of a Zwicker tone percept in animal models. Here we use the effect of a modified gap pre-pulse inhibition of the acoustic startle reflex (GPIAS; introduced by Turner in 2006) testing the possibility of inducing a Zwicker tone percept in our animal model (Mongolian gerbil). We present a 60 dB SPL notched noise stimulus with a silent gap 100 ms before a loud startle stimulus. We demonstrate that a Zwicker tone percept within this gap leads to an increased pre-pulse inhibition as the phantom percept itself may serve as pre-stimulus which modulates the startle reflex amplitude. The here described paradigm demonstrates that Mongolian gerbils are able to perceive the Zwicker tone.

Topic Area: PERCEPTION & ACTION: Audition

B113 Bringing groups of people into greater temporal and psychological synchrony using a multi-person adaptive metronome

Lauren Fink¹, Prescott Alexander¹, Petr Janata¹; ¹University of California, Davis

Synchronization of movement enhances cooperation and trust between people. Typically, synchronization depends upon each individual's ability to perceive the timing of a pacing signal and/or others' actions and produce movements accordingly. Here, we test whether a novel, multi-person adaptive metronome can improve synchronization among groups of people. The Groove Enhancement Machine (GEM) is implemented on Arduino Uno circuit boards, allowing for negligible temporal latency between player input and adaptive sonic output. Across four tapping experiments, participants were tasked with synchronizing their finger tapping to the metronome. Rounds of tapping lasted ~30 secs; metronome adaptivity was randomized, with conditions: 0 (no adaptation), .3, (adapting by 30% of the group asynchrony relative to the previous metronome click), .7, and 1. Auditory feedback (whether participants could hear the sound produced by their own and others' taps) was manipulated between experiments. Across all experiments, player synchronization with the metronome followed a U-shaped function, where synchrony was significantly better with 30% adaptivity and significantly worse during 100% adaptivity, compared to the baseline condition. Subjective ratings, such as feeling 'in the groove' or 'synchronized with group members' also varied as a function of adaptivity conditions. Between experiments, when participants could hear the sound produced by their own taps, tapping accuracy and subjective ratings improved. In summary, we show that it is possible to bring people into greater temporal alignment than they are capable of on their own and to influence their individual and group-oriented feelings of synchrony. All GEM hardware and software is open-source.

Topic Area: PERCEPTION & ACTION: Audition

B114 Neural correlates of auditory perception

Patrick Krauss¹, Achim Schilling¹, Holger Schulze¹; ¹University Hospital Erlangen

In search of the neural correlates of auditory perception in rodents we compare three different classes of neural activity patterns recorded via a multichannel recording system: (1) stimulus driven activity, reflecting both, sensory processing and perception; (2) spontaneous activity in naïve animals, i.e. neither sensory processing nor perception; (3) activity reflecting a stable (phantom) percept without sensory processing. Therefore, we use our animal model for chronic subjective tinnitus as a tool to induce a phantom percept without sensory input. The frequency of the perceived subjective tinnitus is estimated using a well established behavioral paradigm, i.e. the gap pre-pulse inhibition of the acoustic startle reflex. We find that acoustic percepts are characterized by attractor-like spatiotemporal patterns of neuronal activity within auditory cortex. These neuronal attractors are specific for the perceptual quality of each distinguishable percept, i.e. different frequencies of acoustic stimulation or silence, respectively. In case of subjective tinnitus, the neural attractor that can be measured during silence is shifted into that location where the corresponding stimulus driven activity leading to a similar perceptual quality as the tinnitus is represented.

Topic Area: PERCEPTION & ACTION: Audition

B115 Prefrontal cortex aids adaptation to accented speech

Esti Blanco-Elorrieta^{1,2}, Laura Gwilliams^{1,2}, Alec Marantz^{1,2}, Liina Pykkänen^{1,2}; ¹New York University, ²NYU Abu Dhabi Institute

Speech is a complex and ambiguous acoustic signal that significantly varies across speakers; yet, the human experience is typically one of effortless comprehension. In the case of accents, a ubiquitous source of this variability, listeners are able to adapt to non-canonical pronunciations rapidly. The goal of this study is to build upon previous behavioural literature to uncover the neurobiological bases of this perceptual attunement process. 24 native English participants were exposed to spoken words of a “canonical” American talker and an “accented” talker. Accents contained systematic phonological substitutions (e.g. [s]↔[sh]). Participants performed a simple word-picture matching task while magneto-encephalography (MEG) was recorded. We found that activity in the auditory cortex, superior and middle temporal gyrus varied depending on accentness, and this was not influenced by exposure. Critically, prefrontal regions did show an interaction between the presence of an accent and amount of exposure: while activity decreased for canonical speech as the experiment went on, the amount that accented speech engaged prefrontal regions remained constant. Grainger causality analyses revealed that these responses emerged in prefrontal and travelled to auditory regions, suggesting the recruitment of top-down processing to decode the accented signal, and plausibly an adaptation mechanism based on error detection. In sum, our results provide the first characterization of how the perceptual system adapts to systematic yet idiosyncratic variations of speech, and posits the prefrontal cortex as the locus of the necessary signals to recalculate phonetic classification and subsequent identification of lexical items.

Topic Area: PERCEPTION & ACTION: Audition

B116 Speech production rate modulates syllable perception

Johanna Rimmele², Florencia Assaneo¹, David Poeppel^{1,2}; ¹New York University, ²Max Planck Institute for Empirical Aesthetics, Frankfurt/Main

Recent studies suggest that auditory perception relies on temporal predictions from the motor system to increase its performance (see Rimmele et al. 2018). However, there exists little behavioral evidence for this conjecture in the speech domain. In order to test this prediction, we designed a behavioral protocol capable of testing the influence of rhythmic speech production on speech perception. In line with previous results (Assaneo et al. forthcoming), we hypothesize that individual differences in the degree of audio-motor coupling could modulate the strength of behavioral effects. Thus, we first measured and subsequently classified participants into two groups according to the strength of their spontaneous audio-motor synchronization (high or low). Next, during the main experiment participants were instructed to produce rhythmic sequences of syllables. Immediately following speech production offset, a syllable was presented, embedded in noise, and participants performed a syllable discrimination task. Using a decoding approach, we assessed whether task performance was modulated by the phase of the syllable presentation with regard to the motor rhythm. The motor rhythm was derived from the oscillation generated by the produced speech envelope. We show that only for individuals with high audio-motor coupling performance is modulated by the speech production rhythm; i.e., participants' perceptual performance is predicted by stimulus occurrence with respect to motor production phase.

Topic Area: PERCEPTION & ACTION: Audition

B117 The Developmental Course of Multisensory Speech Integration in Autism

Michael Crosse¹, Aida Davila¹, John Foxe^{1,2}, Sophie Molholm^{1,2}; ¹Albert Einstein College of Medicine, ²University of Rochester

Numerous behavioral studies suggest that children with autism spectrum disorder (ASD) are impaired in their ability to integrate audiovisual (AV) speech, which may contribute to some of the social and communicative deficits that are prevalent in this population. Understanding the neural basis of

this deficit is critical to improving intervention strategies, but there are few studies that have investigated this directly. Traditionally, electrophysiological investigations of AV speech processing in children with ASD have focused on syllabic stimuli, which may only partially engage the underlying cortical network involved in speech perception and multisensory integration. Recent EEG studies using system identification methods have demonstrated how neural correlates of multisensory integration can be obtained in response to natural AV speech (Crosse et al., 2016). Moreover, the same technique can be used to isolated neural indices of speech processing along the auditory cortical hierarchy at a phonetic (Di Liberto et al., 2015) and semantic (Broderick et al., 2018) level. Here, we consolidate these methodological frameworks to track the developmental course of AV speech processing in ASD in a hierarchical manner. Movies of a speaker reciting children's stories were presented to children with and without a diagnosis of ASD while recording high-density EEG. Stimuli alternated between A, V and AV speech and were accompanied by acoustic noise at -3, -6, -9, -12, -15 dB SNR and a no-noise condition. Speech stimuli were transformed into spectrotemporal, phonetic and semantic representations and mapped to the EEG responses to derive neural indices of multisensory integration in each participant.

Topic Area: PERCEPTION & ACTION: Multisensory

B118 Atypical sensory responsiveness as an endophenotype in individuals with autism spectrum disorder (ASD)

Yang-Teng Fan^{1,2}, Ling Chu³, Hui-Fang Chen¹, Yawei Cheng³, Ching-Ching Wong⁴, Chih-Mao Huang^{1,2}, Ovid J. L. Tzeng^{1,2,5,6}; ¹National Chiao Tung University, ²Academia Sinica, ³National Yang-Ming University, ⁴Child Developmental Assessment & Intervention Center, ⁵Taipei Medical University, ⁶National Taiwan Normal University

Unusual responses to sensory stimuli are prominent in ASD, and they have recently been added to the diagnostic criteria for the disorder. Notably, ASD is known to be heritable; however, very few studies, particularly in neurobiological research, have investigated whether atypical sensory responsiveness is manifested in relatives of ASD. To address these issues, this study adopted the endophenotype-based approach to investigate the group differences (ASD vs. typically developing controls (TDC) and parents of ASD (P-ASD) vs. parents of TDC (P-TDC)) in performance and neural activity on multiple sensory tasks for disentangling the nature of sensory alterations in ASD. We recruited 15 ASD and 11 typically developing controls (TDC), and 17 their parents (11 P-ASD and 6 P-TDC). Outcome measures ranged from questionnaire-based evaluations, to lab-based sensory assessments, and to neural-based sensory measures. Behaviorally, ASD and P-ASD had hyper-responsivity to the sensory stimuli than TDC and P-TDC, respectively. Moreover, significant agreements were obtained between ASD and P-ASD on tactile and auditory responsiveness. Neurophysiologically, ASD compared with TDC showed heightened activity in the primary sensory cortices during the sensory fMRI tasks, and P-ASD relative to P-TDC also showed stronger activity in these areas. Conjunction analysis further demonstrated that there are significant neural similarities in sensory responsiveness between parents and their children in the ASD dyads, but not in TDC dyads. These findings present preliminary evidence that sensory responsiveness can be viewed as an endophenotypic marker for ASD and provide a better understanding of the genetic contribution of atypical sensory processing in ASD.

Topic Area: PERCEPTION & ACTION: Multisensory

B119 Does your hand fit your body? The developmental trajectory of the body model.

Lara Coelho¹, Claudia LR Gonzalez¹; ¹University of Lethbridge

The representation of the body's spatial characteristics is referred to as the body model. Previous research has shown that the body model of our hands

is distorted (Longo & Haggard, 2010). This distortion is characterized by an overestimation of hand width and an underestimation of finger length. This result has been replicated on numerous occasions (Saulton et al., 2016; Coelho et al., 2018; etc), but only adult participants have been tested. The purpose of the present study therefore, was to document the developmental trajectory of the body model of the hand. To do this we recruited three groups of participants: children (aged 8-16), young adults (aged 18-26), and older adults (aged 50-68). All participants completed a hand mapping task, where they placed their hands palm-up against a covered table top and pointed to the location where they believed ten landmarks were on their hands. The locations were recorded with an Optotrak® camera and XY coordinates were derived for every landmark. Results showed that children overestimated the width of their hands and the length of their fingers, significantly more than the other two groups. In addition, a significant correlation showing that as we age the body model decreases in size was found. Since children are in a period of rapid growth, perhaps body representation cannot match the changes in physical size. This could explain why children during periods of growth have been found to have motor-coordination issues. Further research including younger children and older seniors is underway.

Topic Area: PERCEPTION & ACTION: Multisensory

B120 Drawing Sounds: Translational features across domains

Sara Hill¹, Ferrinne Spector²; ¹Edgewood College

The purpose of this study is to further understand how sensory information is translated across sensory domains. Specifically, whether basic properties of an auditory stimulus consistently associate to features in a visual image created in response to the sound. This is one of the first two studies of audio-visual perception using a newly developed sound stimulus set consisting of 64 sound stimuli, each created to manipulate a single property of sound (pitch, volume, ascension, tempo, continuity), with each sound property represented across four musical instruments to capture differences in timbre. Participants listened to 30 sounds drawn randomly from the auditory stimulus set and drew their visual interpretation of each sound using crayons on white paper. Using systematic inter-rater coding, we examined each visual representation for the presence of numerous visual elements, including color lightness, angularity, continuity and reduplication of shape and lines. Overall, we found that sound features are consistently associated with related visual features, with some auditory features leading to more consistent audio-visual translation. For example, a fast tempo is frequently represented using reduplicated clusters of lines (proportion = .92), high pitch is strongly related to the color lightness (proportion = .83), and legato sounds were frequently represented with continuous lines (proportion = .82). These results highlight the value of using a standard sound set for comparison across experimental and descriptive studies and provide insight into the consistent translation of information across the visual and auditory domains.

Topic Area: PERCEPTION & ACTION: Multisensory

B121 Dynamical neural similarity tracks shifts of stimulus features and memory fluctuations

Yi Zhu¹, Qun Ye¹, Yi Hu¹; ¹East China Normal University

Neural similarity of a group of audience has been found to be indicative of stimulus engagement by measuring inter-subject correlations (ISC) with fMRI or EEG signals. However, there has been little evidence to directly characterize the three-dimensional relationships between shifts of stimulus features, fluctuation of neural responses and the resulting behavioural performances. We measured brain activity with electroencephalograph (EEG) from 35 participants while they viewed ten 76-second nature documentary excerpts, each of which involved two storylines (A & B) and was segmented into four parts (A1, A2, B1, B2). Excerpts were played half in a consecutive

order and half in an interleaved order. After watching each of the excerpts, subjects completed a recognition memory task to judge whether frames were extracted from the excerpts. Neural similarity is assessed by the correlation between a participant's neural response and peers' to the same stimuli. Consistent with the stimulus shift between segments in both play orders, we observed a dynamical neural responses (ISC) corresponding to the segment shift: (i) ISC decreased gradually while viewing the same storyline and (ii) ISC increased while shifting from one storyline to another. Furthermore, such dynamical neural similarity subserved the recognition memory: the higher the ISC in video viewing was, the better its subsequent memory judged. Thus, our findings provide direct evidence of ISC in tracking stimulus processing, and implicate a mediated mechanism of ISC between stimulus encoding and subsequent memory retrieval.

Topic Area: PERCEPTION & ACTION: Multisensory

B122 Silent lip reading generates speech signals in auditory areas: Evidence from intracranially implanted electrodes in humans

Karthikeyan Ganesan¹, Eunseon Ahn¹, John Plass¹, William Stacey¹, David Brang¹; ¹University of Michigan- Ann Arbor

Audiovisual integration plays a vital role in speech perception, especially during face-to-face communication. Crossmodal activation of auditory processes by visual stimuli is an important aspect of natural speech perception. It has also been previously shown that lip reading activates areas including the superior temporal gyrus (STG). Though visual stimuli have been shown to influence neural representations in auditory cortex, it has not been conclusively shown whether auditory and visual stimuli activate the same population of neurons in the STG. Here, we examine the spatial distribution of silent lip reading signals in the STG in a large cohort of patients. We recorded electrocorticographic (ECoG) activity from macroscopic depth electrodes implanted within the STG of 13 patients with epilepsy. On each trial, patients were presented with one of three types of stimuli: (1) single phonemes, (2) videos showing the lip movements articulating each phoneme (visemes), or (3) videos showing audio-visual speech movements. Group-level analyses using mixed-effects modelling were performed to show that visual lip reading generates neural responses broadly along the STG, spatially overlapping with the distribution of phoneme responses. Furthermore, we also investigated whether the identity of these phonemes and visemes could be discriminated from neural responses in auditory areas. Several electrodes across patients reliably discriminated between specific instances of the phonemes or visemes. However, preliminary analyses indicate that auditory and visual speech information is encoded at distinct areas of the STG. These results demonstrate that observing silent visual speech crossmodally activates speech-processing areas in a content-specific manner in the STG.

Topic Area: PERCEPTION & ACTION: Multisensory

B123 Similar Motor Learning Performance with a Single Modality Preference in Individuals with High and Low Autistic Traits

Maria G. Daly¹, Alexandra L. Mastrangelo¹, Noah C. Yeagley¹, Jennifer L. Stevenson¹; ¹Ursinus College

Individuals on the autism spectrum may have difficulties with motor learning; however, they have intact implicit learning abilities. Additionally, there is inconsistent literature regarding the ability of individuals on the autism spectrum to integrate sensory stimuli. The current study investigated the effects of using a single or double sensory stimuli paradigm to assess motor learning among individuals with high or low autistic traits while also investigating the effects of instructional condition (implicit or explicit). Participants were divided into high (n = 26) and low (n = 24) autistic trait groups using a median split (Med = 109) on the Autism-Spectrum Quotient. Participants completed the Serial Reaction Time Task (SRTT) to assess motor

learning, once with only a visual cue and once with both visual and auditory cues while their eye movements were monitored. Half of the participants were informed there was pattern to the motor sequence (explicit instructional condition) and the other half of participants were given no information about a pattern to the sequence (implicit instructional condition). Overall, the autistic traits groups did not differ in accuracy or fixation patterns. However, all participants exhibited better performance when completing the task with only a visual cue compared to visual and auditory cues. These results support previous research showing intact implicit learning in autistic individuals and provide evidence to support the notion that multiple sensory modalities may be a hindrance to pattern learning in some circumstances.

Topic Area: PERCEPTION & ACTION: Multisensory

B124 Comparing object identity and viewpoint gradients in the dorsal and ventral streams

Carol A. Jew¹, Rajeev D. S. Raizada¹; ¹University of Rochester

The dorsal and ventral visual streams have traditionally been considered separate and distinct processing pathways. The ventral stream is usually thought of as the “what” pathway, but recent findings suggest that the dorsal stream also processes some visual shape information. This limited information alone, however, does not appear sufficient for accurate object perception or recognition. We set out to explore the gradients of both object identity and object viewpoint information along both the ventral and dorsal streams. Using a neuroimaging paradigm, we presented different objects at various viewpoints to participants. We functionally localized visually-selective voxels and then used Gaussian Naive Bayes classifiers and canonical correlation analysis as measures of the amount of identity and viewpoint information respectively. We found a negative correlation between the amount of identity information and the amount of viewpoint information across voxels. Compared to the ventral stream, there was less identity information in the dorsal stream. However, a majority of voxels in the dorsal stream still contained more identity information than expected by chance performance. In both streams, the amount of identity information correlated positively with voxels’ y-coordinates moving anteriorly while the amount of viewpoint information correlated negatively with the same coordinates. These gradients suggest that both object identity and viewpoint information are present in both streams, just to differing extents. These findings add to the mounting evidence that the dorsal and ventral streams should no longer be viewed as strictly separate pathways.

Topic Area: PERCEPTION & ACTION: Vision

B125 Could different attended features modulate the degree in which we embody the same stimuli? Investigating the specificity of sensorimotor encoding of body-related stimuli.

Sonia Abad Hernando¹, Beatriz Calvo-Merino¹, Alejandro Galvez-Pol^{1,2}, Bettina Forster¹; ¹Cognitive Neuroscience Research Unit, City, University of London, ²Institute of Neurology, University College London

How do we represent observed actions in working memory? Could we differentiate between perceptual or functional roles of embodiment? Recent studies already suggest we hold information in working memory (WM) differently when it contains body information. It has been shown that visual encoding of body stimuli engages electrophysiological activity not only in visual cortices, but also in body-related areas. It was found that persistent activity increased in somatosensory cortex (SCx) only when maintaining body images in WM, whereas visual/posterior regions’ activity increased significantly when maintaining non-body images (Galvez-Pol et al, 2018). The aim of this study is to clarify whether this activity is triggered by body stimuli per se or modulated by the degree in which we embody that stimuli. For this purpose, participants performed a visual WM task (Vogel and Machizawa 2004) in which items to-be-remembered were coloured hand images

(depicting 6 different hand positions and in 6 different colours). Each memory array consisted of 1 or 2 hands per hemifield. In 50% of the trials, we elicited simultaneously VEPs and SEPs by applying task-irrelevant single tactile taps simultaneously delivered to both hands. This allowed us to do a later subtraction to isolate and examine the state of the SCx free of visually evoked activity, exposing its underlying processing during memory encoding and maintenance. We found that SCx areas involved in holding body information in memory are sensitive to the degree of embodiment elicited by different attended features while using the same body stimuli.

Topic Area: PERCEPTION & ACTION: Vision

B126 How to separate extraction of numerical and non-numerical magnitude information in the visual stream with a frequency-tagging approach?

Amandine Van Rinsveld¹, Mathieu Guillaume¹, Christine Schiltz², Wim Gevers¹, Alain Content¹; ¹Université Libre de Bruxelles, ²University of Luxembourg

The ability to handle approximate large quantities has been identified as a building block of mathematical skills but the mechanism allowing to extract numerical magnitudes (i.e., numerosity) from visual environments is still debated. Many authors agree that humans have an Approximate Number System that specifically processes numerosity. However, a set of objects is not only characterized by its numerosity but also by non-numerical visual information related to its continuous dimensions (e.g., total area, dot size). Accordingly, the alternative theory argues that the numerosity is extracted through a weighting of continuous dimensions. Until now the opposite view could not be tested properly due to the intrinsic correlations between numerosity and continuous dimensions. We aimed at isolating the specific cerebral responses to numerosity and to continuous dimensions by using Steady-State Visual Evoked Potentials (SSVEP). Participants (N=21) were presented dot collections that varied randomly along all dimensions but one, which entailed a systematic change at the rate of 1.25 Hz. This periodic dimension was either the numerosity or one of the continuous dimensions (size, area, convex hull or density). Electrophysiological recording showed a neural synchronization on the numerosity but also on the total area of the collections. In contrast, no synchronization was observed for the other continuous dimensions. In conclusion, we provide evidence that not only numerosity but also some continuous properties can be extracted rapidly along the visual stream. Our study bypasses the recurrent problem of intrinsic correlations between numerosity and continuous dimensions, providing novel insights to existing theories of numerosity extraction.

Topic Area: PERCEPTION & ACTION: Vision

B127 Impact of Emotional Salience on Evidence Accumulation and Moment of Recognition

Mickella Hardy¹, Daniel Levitas¹, Thomas James¹; ¹Indiana University, Bloomington

Perceptual decision making is grounded in accumulation models that posit an aggregation of information until a decision “threshold” is reached – the point at which adequate information has been acquired to produce a response. Stimuli that contain some form of emotional or affective salience may enhance or impair performance, depending on whether the stimuli are task relevant or not; however, the role of emotional salience has received little attention however in the realm of visual evidence accumulation. Thus, the purpose of this research was to assess how emotional salience influenced visual accumulation and subsequent decision making. We hypothesized that emotional affect would induce a distractor effect that would impair task performance and result in a shallower BOLD timeseries accumulation slope. Participants completed a gradual reveal categorization task during an fMRI

session, where they were to respond when they could recognize a gradually revealed image as either a foot or hand. Half of the images contained some form of mutilation, thereby providing the task irrelevant aversive saliency. Participants categorized 100 images each, where time of recognition (ToR) was approximately 4.2 seconds longer for aversive stimuli compared to neutral stimuli. We found that inferior occipital regions most closely resembled prototypical accumulation profiles. More importantly, these occipital regions demonstrated the most sensitivity to differences in affect. The results suggest that occipital regions play an important role in modulating accumulation of evidence based on affective salience.

Topic Area: PERCEPTION & ACTION: Vision

B128 Intermediate visual features convey affective content

Amanda Del Giacco¹, Valentinou Zachariou¹, Merage Ghane¹, Xiaomin Yue¹, Leslie Ungerleider¹; ¹National Institutes of Health

It is generally assumed that information processing within the ventral visual pathway occurs hierarchically. This model assumes that higher-order object information is evaluated on the basis of whole-object properties. However, recent studies demonstrated that differences in the amount of curvilinear and rectilinear visual features of objects are sufficient for high-order categorization. Here we explored whether these intermediate visual features also convey information associated with threat. We used the International Affective Picture System as a guide to create two sets of stimuli. One consisted of animal images with high arousal and low valence (high-threatening set) and the other of animal images with high valence and low arousal (low-threatening set). Then, we generated synthesized versions of the animal images in each set, which maintained the intermediate visual features of the original versions but made them unrecognizable. Participants (n=20) performed a one-back working memory task in an MRI scanner with alternating blocks of high- and low-threat textured and intact animal images. Results showed that bilateral amygdala was significantly more active in response to both sets of threatening compared to non-threatening images. In contrast, fMRI activity in control brain regions, not involved in affective processing, did not differ for the two sets of images. Importantly, the neural difference in response to high- and low-threat images correlated positively with behavioral ratings of threat. Lastly, these threat ratings significantly predicted the magnitude of activation in the amygdala; participants who rated the threatening stimuli as more threatening had greater amygdala activation in response to these stimuli.

Topic Area: PERCEPTION & ACTION: Vision

B129 Modulating Visual Perception with Trans-cranial Alternating Current Stimulation

Jorge Delgado¹, Guillaume Reisen¹, Anthony Norcia¹; ¹Stanford University

Transcranial alternating current stimulation (tACS) has been shown to modulate auditory perceptual thresholds in a phase dependent fashion (Neuling et al. 2012 Neuroimage) and experiments in ferret and rat visual cortex have shown that tACS stimulation sums in a constructive or destructive fashion with cell membrane potential (Ali et al. JNeurosci, 2013, Reato et al. JNeurosci, 2010). Here we used a binocular rivalry paradigm to determine whether similar frequency- and phase- specific tACS over the visual cortex can modulate visual percepts in humans. 24 participants observed rivaling Gabor patches that were flashed at 3Hz in each eye, with the temporal phase between eyes set to be 180° of phase apart. The phase of tACS with respect to the visual stimulus was varied over four values 0°, 90°, 180°, or 270° in relation to the right eye's stimulus. A baseline no-tACS block preceded the stimulation blocks and two more followed, immediately and ten minutes after. Individual blocks lasted 4 minutes. During stimulation, 90° tACS phase presented to the right eye slowed the right eye relative to the left eye, which received 270° phase tACS. Conversely, 90° phase tACS presented to the left

eye slowed the left eye relative to the right eye, which received 270° phase tACS. Durations were equal at 0 and 180° tACS phases. Immediately after tACS, durations were slightly slowed in both eyes, and durations returned to baseline after 10 minutes. Our results are consistent with online tACS constructively and destructively interacting with the underlying visual response.

Topic Area: PERCEPTION & ACTION: Vision

B130 Numerous comparisons of numerical comparison tasks: A meta-analysis of the heterogeneity of the Weber Fraction.

Mathieu Guillaume¹, Amandine Van Rinsveld¹; ¹Université Libre de Bruxelles

Since more than fifteen years, researchers have been expressing their interest in evaluating the Approximate Number System (ANS) and its potential influence on cognitive skills involving number processing, such as arithmetic. Although many studies reported significant and predictive relations between ANS and arithmetic abilities, there has recently been an increasing amount of published data that failed to replicate such relationship. Inconsistencies lead many researchers to question the validity of the assessment of the ANS itself. In the current meta-analysis of over 68 experimental studies published between 2004 and 2018, we show that the mean value of the Weber fraction (w), the minimal amount of change in magnitude to detect a difference, is very heterogeneous across the literature. Within young adults, w might range from less than .10 to more than .60, which is critical for its validity for research and diagnostic purposes. We illustrate here the concern that different methods controlling for non-numerical dimensions lead to substantially variable performance. Nevertheless, studies that referred to the exact same method (e.g., Panamath) showed high consistency among them, which is reassuring. Eventually, we observed that all reported correlation coefficients between the value of w and general accuracy were very high. Such result calls into question the relevance of computing and reporting at all the Weber fraction. We are thus in disfavour of the systematic use of the Weber fraction, to discourage any temptation to compare given data to some values of w reported from different tasks and generation algorithms.

Topic Area: PERCEPTION & ACTION: Vision

B131 The Role of Memory in Interval Timing

Franklenin Sierra¹, David Poeppel^{1,2}, Alessandro Tavano¹; ¹Max Planck Institute for Empirical Aesthetics, ²NYU

The ability of an organism to quantify an interval of time and compare different durations is crucial for surviving as well as for everyday life social behavior, for example in the context of decision-making interval timing is essential for driving a car or performing sports. The mechanisms supporting this ability and their link with memory remain unclear. In this study, we test whether the point of subjective equality (PSE) in judging whether two stimuli are of the same length changes as a function of inter-stimulus intervals (ISI), a proxy for memory decay. We designed a visual two-interval forced choice experiment, in which subjects (N=11) evaluated the subjective equality of a standard duration (120 ms) to a comparison duration (20, 60, 100, 140, 180, and 200 ms). We used four different ISI durations (400, 800, 1600, and 2000 ms). We conjectured that the shorter the ISI, the shorter the PSE. However, behavioral results show that the best performance occurs for the condition with 1600 ms ISI. These data indicate two phenomena: first, at short ISIs, temporal precision decreases, indicating a temporal constraint for integration. Second, with long delays, memory decay impacts duration estimation performance. Our findings suggest a trade-off between memory and integration processes in time estimation, with best performance around 1 second.

Topic Area: PERCEPTION & ACTION: Vision

B132 Aesthetics in Motion: The Beauty of Action Paintings in Parkinson's Disease.

Stacey Humphries¹, Jacqui Rick¹, Daniel Weintraub¹, Anjan Chatterjee¹;
¹University of Pennsylvania

Viewing art engages sensory and motor systems in the brain. Particularly dynamic paintings evoke a sense of movement, which may engage the motor system in response to visible artistic gestures, or to actions depicted in paintings. We tested the hypothesis that motor engagement contributes to aesthetic experience, by assessing responses to art in patients with motor impairment from Parkinson's disease (PD) who typically have damage to fronto-striatal motor networks and are impaired in producing actions and perceiving others' actions (Poliakoff, 2013), and in perceiving visual motion (Castel-Branco et al., 2009). We predicted that responses to motion in paintings, and the relationship between this motion and preference, would be different for PD patients relative to controls. 37 patients with PD and 26 age-matched controls rated a set of 10 high motion (Pollock) and 10 low motion (Mondrian) abstract paintings for variables such as motion, beauty, liking, and interest. A linear mixed-effects model revealed a significant group difference for motion ratings: controls rated both sets of paintings higher for motion. An interaction between artist and group was also found for beauty ratings, with controls finding the Mondrians more beautiful and PD patients finding the Pollocks more beautiful. Correlations among the ratings differed between groups, with a positive association between motion and liking in the PD patients ($r = .3$), which was absent in controls. Overall, motor system impairments can affect aesthetic experiences of abstract art. PD patients' perception of motion in art is blunted, while their preference for this art is heightened.

Topic Area: THINKING: Decision making

B133 Don't Pop the Balloon! The Impact of Impulsivity on Risky Decision Making and Reward Processing

Taryn Berman¹, Brianna Turner¹, Clay Holroyd¹, Olav E. Krigolson¹;
¹University of Victoria

Our personalities influence every decision we make. Specifically, impulsivity levels can have an effect on high risk driving, substance use, gambling, and eating behaviours (Adams & Moore, 2007; Dahlen et al., 2005; Doumas et al., 2017; Golchert et al., 2017; Johansson et al., 2009). Here, we sought to examine the impact of impulsivity on high risk decision making. Participants completed a computerized risk task, wherein a balloon was inflated, with subsequent pumps accumulating points, as well as increasing the risk of the balloon bursting. A balloon burst results in the loss of all acquired points associated with said balloon. This task was performed while electroencephalographic data was recorded. Analysis of the event-related potential data revealed that impulsivity levels were positively correlated with larger P300 component amplitudes in response to balloon bursts. This difference is attributed to an augmented reward sensitivity present in impulsive individuals. When the probability of the balloon bursting was low or moderate, higher impulsivity levels were associated with faster reaction times when inflating the balloon. This suggests that highly impulsive individuals are spending less time premeditating and deliberating their decision. Together, these results indicate that people with higher levels of impulsivity are more likely to make fast, hasty, decisions and be more sensitive to reward value. This combination makes these individuals prone participating in high risk behaviours.

Topic Area: THINKING: Decision making

B134 Effective connectivity during risk-taking in heavy cannabis users

David Raymond¹, Adrian Paneto¹, Joshua Brown¹, Sharlene Newman¹;
¹Indiana University

Risk-taking and decision making has been shown to be mediated by several regions, such as the anterior cingulate cortex (ACC), the nucleus accumbens (NAc), the insula and the amygdala (Breiter et al., 2001; Fukunaga et al., 2012; Tom et al., 2007). The NAc has been shown to be a major component in addiction and has been associated with the processing of reward predictive cues and motivationally relevant stimuli (Kalivas, 2005). This suggests connectivity between the NAc and the ACC, a region strongly associated with decision making. This study looked to examine connective alterations between these regions, as well as others within this reward network, in heavy cannabis users during the Balloon Analogue Risk Task (BART), a risk-taking paradigm (Lejuez et al., 2002), using an effective connectivity analysis of fMRI data. Results show that while there is highly significant connectivity from the NAc to the ACC ($p < .001$) in control subjects as risk increased parametrically, there is no significant connectivity between the regions in heavy cannabis users. Connections from the insula and the amygdala to the ACC are similarly significant between groups, suggesting that while the subjective response to risk remains intact in cannabis users, the impaired connectivity from the NAc to the ACC may be leading to biased decision making.

Topic Area: THINKING: Decision making

B135 Emotional episodic future simulation reduces delay discounting but does not affect risk-taking

Adam Bulley¹, Beyon Miloyan², Gillian Pepper³, Matthew J. Gullo⁴, Julie D. Henry⁴, Thomas Suddendorf⁴;
¹Harvard University, ²Federation University, Australia, ³Newcastle University, UK, ⁴The University of Queensland, Australia

Humans frequently create mental models of the future, allowing outcomes to be simulated in advance. Recent evidence suggests that cuing the simulation of positive future events reduces delay discounting (the devaluation of reward with time until its receipt), while cuing the simulation of negative future events may increase it. The effect of positive future event cuing on delay discounting has been linked to a neural mechanism of connectivity between valuation hubs in the PFC and regions of the medial temporal lobes involved in mental simulation. We assessed the effects of simulating emotionally positive and negative future scenarios on decision-making in the context of both delay discounting and risk-taking ($N = 297$). Participants discounted the future less in a monetary intertemporal choice task when cued to imagine positive and negative future scenarios than they did when cued to engage in control neutral imagery. There were no effects of experimental condition on risk-taking in a behavioural task. Thus, although these results replicate previous findings suggesting episodic future simulation can reduce delay discounting, they indicate that this effect is not dependent on the valence of the thoughts and thus on whether valuation signals pertain to positive or negative cued events. These findings also suggest that the cued simulation effect does not necessarily generalise to other forms of impulsive decision-making without an explicit time dimension. Interpretations of these results are considered alongside suggestions for future research on the role of future event simulation in decision-making, and its neural substrates in prefrontal-mediotemporal interactions.

Topic Area: THINKING: Decision making

B136 Independent manipulation of the N2 and P2 components demonstrate boundary conditions of the Reward Positivity

Darin Brown¹, James Cavanagh¹; ¹University of New Mexico

The ERP component called the reward positivity (RewP) has garnered a great deal of attention for its conformance to reward prediction error. Although there is a great deal of work investigating how the RewP relates to features of reward processing such as reward magnitude and expectation, there is still very little known about its generators and factors contributing to its morphology. The RewP is characterized by a positivity linking the P2 and N2 components, suggesting that the N2 is diminished or overlapped by this reward-specific positive deflection. Here, we present data from a series of experiments aimed to probe the specific components of the RewP in order to gain a greater understanding of the information captured by this signal. In the first study, we boosted the N2 component through the presentation of novel rewarding stimuli. We found significant ERP differences between standard conditions (win > lose: $p < .001$), however no significant differences in the novel conditions ($p = .746$), suggesting signals of novelty supersede the signal of reward (i.e. the N2 out-competed the positive deflection). Next, we successfully manipulated P2 and P3 amplitudes using visual and auditory rewarding stimuli. Auditory wins showed an enhanced P2 (Sound > Image: $p < .001$), whereas visual wins show an enhanced P3 (Image > Sound: $p = .002$). These findings suggest that the reward-specific positive deflection can be shifted to add to existing peaks in the canonical ERP. Taken together, these studies reveal boundary conditions relating to the morphology of this reward-specific signal.

Topic Area: THINKING: Decision making

B137 Stress attenuates model-based learning in adolescents with high working-memory capacity

Raihyung Lee¹, Heyeon Park¹, Harim Park¹, Woo-Young Ahn¹, Seyul Kwak¹, Jeanyung Chey¹; ¹Seoul National University

Studies have demonstrated a stress-induced shift in human choice behavior from model-based to model-free learning strategies. A previous study in adults has reported that this deleterious effect of stress on model-based learning can be prevented by individual executive resources, such as working-memory (WM) capacity. The purpose of this study was to determine whether the same relationship between stress, executive resources, and choice behavior holds for adolescents. In this study, we instructed 55 young adolescents (age, 13.22 years) to perform a two-step decision-making task, which assessed model-based and model-free strategies, and a digit-span task, which assessed the WM capacity. Stress was quantified using the Perceived Stress Scale, which is a well-validated questionnaire for measuring chronic stress. Consistent with the findings of the previous study in adults, model-based learning reduced in adolescents with high stress scores, whereas model-free learning was not associated with stress in this study. However, contrary to the results of the adult study, model-based learning was more severely attenuated by stress in adolescents with higher WM capacity in this study. These results suggest that adolescents with high executive resources show increased susceptibility to stress-induced brain damage. The results are discussed in light of the cognitive reserve theory.

Topic Area: THINKING: Decision making

B138 The role of alpha power as a stimulus-specific updating signal in sensory cortex post feedback in a reinforcement learning task

Khoi Vo¹, Berry van den Berg^{1,2}, Benjamin Geib¹, Rene San Martin³, Marty Woldorff¹; ¹Duke University, ²University of Groningen, ³Centrode Neuroeconomia Universidad Diego Portales

Adaptive behavior is an outcome of successfully learning reward associations, whether for different stimuli or actions taken in an environment. Research on the neural mechanisms underlying the learning of these associations in humans has focused largely on the fronto-cortical/basal-ganglia reward circuits investigated with functional neuroimaging. However, few studies have

focused on how sensory cortices may contribute to this learning phenomena, or on the within-trial time course of neural processes underlying such learning. Here we addressed this research gap by recording EEG while participants ($n=30$) performed a probabilistic foraging task for points by learning the stimulus-outcome associations of discrete categories of stimuli (faces and houses). Participants showed matching behavior over the course of learning, eventually choosing the richer-association category at its reward-probability rate. Attentional bias prior to choice, as measured by the N2pc ERP component toward the richer category, developed over the course of learning. Neural processing became stimulus-category specific following reward feedback, reflected by decreased alpha power over face-selective regions (reflecting more cortical activity) after winning-versus-losing following a face choice, but not following a house choice. Importantly, greater decreases in alpha power corresponded to larger prediction error (PE) signal recovered from a two-parameter reinforcement learning model. This modeling/brain-measure correlation supports the view that the category-specific decreased alpha power over face-selective regions represents a sensory-updating signal akin to a PE signal in reinforcement learning. These results thus support the view that sensory cortices are involved in learning stimulus-outcome associations, while also delineating the temporally specific processes by which they do so.

Topic Area: THINKING: Decision making

B139 Tonic frontal theta as an assessment of medical decision making in the context of medical education

Jordan Middleton¹, Chad Williams¹, Bruce Wright², Olave E. Krigolson¹; ¹University of Victoria, Centre for Biomedical Research, ²University of Victoria, Division of Medical Science

Understanding medical decision making is essential for optimizing medical training. Medical decision making has been modeled using Dual Process Theory, which consists of Type 1 and Type 2 processes. Type 1 processes are characterized by fast decisions with reduced accuracy, whereas Type 2 processes are slow decisions with increased accuracy. Type 2 utilization has been proposed to be correlated with mid-frontal theta as measured by electroencephalography. In the present work, we used a medical diagnostic task to test the proposed link between Dual Process Theory and mid-frontal theta. Participants were asked to make a diagnosis between two liver diseases based on the values of ten physiological measurements. Feedback was provided to allow for learning. Once learned, the diagnosis difficulty was changed to create easy and hard trials, in order to investigate the difference between Type 1 and Type 2 processes. Behaviorally, participants took longer in hard trials (5.6s) than easy trials (4.9s; $p < 0.005$) and were less accurate (68% vs 96%; $p < 0.001$). Wavelet analysis revealed elevated tonic theta during the two seconds preceding the decision in hard trials ($p < 0.01$). These results suggest that tonic mid-frontal theta is an effective means to discriminate Type 1 and Type 2 medical decision making.

Topic Area: THINKING: Decision making

B140 Uncertainty-based arbitration between incremental and episodic control over decisions

Jonathan Nicholas¹, Daphna Shohamy¹; ¹Columbia University

Decisions between two familiar options can be made by consulting an average value constructed over many episodes or by retrieving value from a single episode. Previous work has demonstrated that artificial agents benefit from consulting single experiences when there is high uncertainty about the value of an incrementally constructed estimate (Lengyel & Dayan, 2008). Here we tested whether humans use similar uncertainty-based arbitration to guide how memory is used for decisions. To examine the effect of value uncertainty on choices, we designed a task that included cues for which average value could

be approximated and separate cues with only a single previous exposure. Participants (n=250) made a series of choices for possible reward. First, they used feedback to learn the value of two separate sets of cues associated with trial-by-trial reward: incremental cues (circles with value sampled from either a certain or an uncertain distribution) and episodic cues (trial-unique objects sampled from uniformly distributed value centered around the average value of the circles). Next, participants chose directly between the learned incremental and episodic value cues. When incremental cues were less certain, more valuable episodic cues were chosen at a greater rate. Furthermore, in a separate sample, this effect of uncertainty was found only in participants aware of the differences between the circle-reward associations. These results suggest that humans engage in greater episodic control over decisions when incrementally constructed estimates are uncertain, shedding light on the circumstances under which the computationally expensive process of sampling individual episodes is used for decisions.

Topic Area: THINKING: Decision making

Poster Session C

Sunday, March 24, 5:00–7:00 pm, Pacific Concourse

C1 ADHD Symptoms are Associated with the Modular Structure of Intrinsic Brain Networks in a Representative Sample of Healthy Adults

Kirsten Hilger^{1,2}, Fiebach Christian^{1,2,3}; ¹Department of Psychology, Goethe University Frankfurt, Frankfurt am Main, Germany, ²IDeA Center for Individual Development and Adaptive Education, Frankfurt am Main, Germany, ³Brain Imaging Center, Goethe University Frankfurt, Frankfurt am Main, Germany

Attention-deficit/hyperactivity disorder (ADHD) is one of the most common neurodevelopmental disorders with significant and often lifelong effects on social, emotional, and cognitive functioning. Influential neurocognitive models of ADHD link behavioral symptoms to altered connections between and within functional brain networks. Here, we investigate whether network-based theories of ADHD can be generalized to understanding variations in ADHD-related behaviors within the normal (i.e., clinically unaffected) adult population. In a large and representative sample, self-rated presence of ADHD symptoms varied widely; only one out of 291 participants scored in the clinical range. Subject-specific brain-network graphs were modeled from functional MRI resting-state data and revealed significant associations between (non-clinical) ADHD symptoms and region-specific aspects of between-module and within-module connectivity. Effects were located in brain regions associated with multiple neuronal systems including the default-mode network, the salience network, and the central executive system. Our results are consistent with network perspectives of ADHD and provide further evidence for the relevance of an appropriate information transfer between task-negative (default-mode) and task-positive brain regions. More generally, our findings support a dimensional conceptualization of ADHD and contribute to a growing understanding of cognition as an emerging property of functional brain networks.

Topic Area: ATTENTION: Development & aging

C2 An Empirical Investigation of Age-Related Differences in Mind-Wandering using Triangulation of Subjective, Behavioural and Electrophysiological Measures

Catherine Moran¹, Greta Warren¹, Rónán Ó Gráiligh¹, Joanne Kenney¹, David McGovern¹, Alan Smeaton², Paul Dockree¹; ¹Trinity College Dublin, The University of Dublin, ²Dublin City University

In mind-wandering, attention is disengaged from processing of the perceptual environment and redirected toward endogenously-generated mental content.

However, little is known about how the phenomenology of these endogenous states differs between younger and older adults. This study classifies and measures the nature and frequency of mind-wandering states and investigates age-related differences. A novel paradigm was employed using an adapted Continuous Gradual Target Detection task (McGovern et al., 2018; O'Connell et al., 2012) with triangulation of self-report, behavioural and electrophysiological assessments to decompose the signatures of mind-wandering. Thirty-two participants completed the task requiring identification of contrast changes of a continuously presented flickering (25Hz) annulus stimulus for an intermittent gradual contrast reduction. The task was pseudo-randomly interrupted by experience sampling probes asking participants to subjectively discriminate the phenomenology and intentionality of their thoughts. Behavioural performance indices were measured, and electrophysiological signatures were tracked in real-time using continuous EEG and pupillometry. Consistent with the literature, preliminary analysis showed that mind-wandering is frequent in human cognition. Groups differed in the propensity for and nature of mind-wandering. Older adults self-reported mind-wandering 31.68% of the time (21.12% unintentional; 10.56% intentional), while younger adults mind-wandered 62.97% of the time (33.44% unintentional; 29.53% intentional). Additional analyses were designed to examine the electrophysiological changes that anticipate unintentional and intentional mind-wandering states in younger and older adults to elucidate the emergence of different subtypes of mind-wandering as a function of age. Results are discussed in relation to the role of awareness in mind-wandering and different age-related metacognitive strategies.

Topic Area: ATTENTION: Development & aging

C3 An own-age bias in the hippocampus in young and older adults

Joshua D. Koen¹, Nedra Hauck², Michael D. Rugg²; ¹University of Notre Dame, ²University of Texas at Dallas

The present study examines the neural correlates of the own-age bias – differential neural activity for age congruent (same age) relative to age incongruent (different age) faces. Own-age biases are present in recognition memory tasks for faces, as well as in ERP correlates of face processing (e.g., the N170). Here, we examined own-age biases while healthy young and older adults viewed unfamiliar young and older adult faces. A subset of the faces was repeated immediately (lag 0) or after a delay (lag 11), and participants were to report (via button press) when an occasional inverted face was presented. Face 'repetition suppression' effects were most prominent in canonical regions previously implicated in face processing (e.g., FFA) after the short lag. These effects were larger for older than younger adults in the FFA, but there was no evidence of an own-age bias in face repetition suppression. The only cluster demonstrating a significant ($p < .05$, FWE, $k=5$) own-age bias effect was located in the right anterior hippocampus. Whereas images of old adult faces elicited greater hippocampal activity than young faces in older participants, this difference was reversed in young adults. This finding is striking given the importance of the hippocampus in episodic memory, and prior behavioral evidence of an own-age bias in recognition memory for faces. We conjecture that the increased hippocampal activity for same relative to different age faces reflects differential engagement of neural processes supporting the episodic encoding of faces, and might provide a mechanism underlying own-age biases in face memory.

Topic Area: ATTENTION: Development & aging

C4 Effects of working memory load on selective attention in school-age children

So-Yeon Kim¹, Hyojin Park¹, Kwanguk (Kenny) Kim²; ¹Department of Psychology, Duksung Women's University, ²Department of Computer Science, Hanyang University

Concurrent working memory (WM) load can reduce Stroop interference effects when WM processing overlaps with distractor processing in the attention task in neurotypical adults (NTA) (Kim, Kim, & Chun, 2005). The current study aimed to extend the previous findings of different effects of WM loads on attention tasks to children aged 10-14, in order to discover developmental trajectory of the interaction effects between attention and WM. Forty-seven NTA (aged 18-25) and 44 typically developed children (TDC: aged 10-14) performed a spatial Stroop task and verbal/spatial WM tasks. The target of the Stroop task was a word stimulus (LEFT/RIGHT) requiring verbal processing, whereas the distractor was an arrow stimulus requiring spatial processing. Results from NTA replicated the previous findings: Stroop interference effects increased when WM and target processing in the Stroop task overlapped, but the effects decreased when WM and distractor processing in the Stroop task used the same resources. However, concurrent WM load did not affect either target or distractor processing in TDC. That is, Stroop interference effects did not increase or decrease under the dual task condition with either types of WM tasks in TDC. Our findings indicate that the interaction effect between attention and WM differs between adults and children aged 10-14, probably reflecting immature development of WM functions in children in those age. Follow-up studies using our paradigm with neuroscientific methods can be useful to determine neural trajectory of the interaction effects between attention and WM in TD children as well as those with neurodevelopmental disorders.

Topic Area: ATTENTION: Development & aging

C5 Failing to Ignore: the declined functional connection between salience network and locus coeruleus in older adults

Tae-Ho Lee¹, Sunhyung Kim², Mara Mather³; ¹Virginia Tech, ²University of North Carolina, Chapel Hill, ³University of Southern California

We examined functional connectivity between the locus coeruleus (LC) and the salience network in healthy young and older adults to investigate why people become more prone to distraction with age. Recent findings that the LC plays an important role in focusing processing on salient or goal-relevant information from incoming multiple sensory inputs (Mather et al, 2016), we hypothesized that the connection between LC and the salience network (SN) declines in older adults, and therefore the SN fails to appropriately filter out irrelevant sensory signals. To examine this possibility, we used resting-like fMRI data, in which all task-related activities were regressed out (Fair et al 2007) and performed a functional connectivity analysis based on the time-course of LC activity. Older adults showed relatively reduced functional connectivity between the LC and SN compared with younger adults. In addition, SN was more coupled with the frontoparietal executive network (FPN) compared to the default-mode network (DMN) in older adults than younger adults, even though all task-related activities were regressed out initially. Together, these findings suggest that the LC fails to stimulate SN as a function of stimulus priority, and in turn SN fails to initiate FPN-DMN switching appropriately. A chronic lack of switching to DMN during low priority events may drain older adults' resources for attentional and executive control processes.

Topic Area: ATTENTION: Development & aging

C6 Losing money and motivation: Younger and older adults' response to loss incentive in a working memory task

Hyesue Jang¹, Cindy Lustig¹; ¹University of Michigan

How do monetary incentives affect motivation and cognition? Previous studies from our lab suggest that loss-based incentives reduce focused attention and increase mind-wandering in older adults. Here, we examined how loss incentive affected working memory performance and responses on self-report measures related to mind-wandering, motivation, and perceived mental demand (NASA-Task Load Index, Intrinsic Motivation Inventory, and

experiment-specific questions) in younger and older adults. Preliminary analyses (n = 20 young adults, n = 56 older adults) indicate that loss-based incentives did not significantly affect performance or self-reported mind-wandering. However, both age groups reported reduced motivation and increased frustration in the loss condition compared to the control. The effects of loss-based incentive were in different directions on perceived mental demand were different for the two age groups: Older adults reported increased mental demand at higher loads in the loss condition, whereas young adults showed the opposite trend. The pattern of results across studies suggest that when faced with loss incentive or other negative feedback, older adults in particular may disengage from the task if they can – as in the focused-attention study – thus avoiding negative emotion. However, the working-memory task requires a response on every trial, reinforcing task engagement despite greater frustration and perceived costs. The results may have implications for theories of cognitive and emotional engagement across the lifespan as well as nonlinear brain activation patterns as a function of demand (Charles, 2010; Hess, 2014; Reuter-Lorenz & Cappell, 2008).

Topic Area: ATTENTION: Development & aging

C7 Neurodevelopmental differences of attention mechanisms in children with Type 1 diabetes: an ERP study

Geisa Gallardo-Moreno¹, Vanessa Ruiz-Stovel¹, Andrés A. González-Garrido^{1,2}, Fabiola R. Gómez-Velázquez¹, Nayeli Contreras-Piña³, Miriam Jiménez-Maldonado^{2,3}, Teresita Villaseñor-Cabrera^{2,3}; ¹Instituto de Neurociencias, CUCBA, Universidad de Guadalajara, Mexico, ²O.P.D. Hospital Civil de Guadalajara, Mexico, ³Departamento de Neurociencias, CUCS, Universidad de Guadalajara, Mexico

Recent evidence indicates that young adults with Type-1 diabetes (T1D) develop different neuronal activation patterns, which can be studied during the performance of different cognitive tasks. These patterns have been explained as an expression of neural compensatory strategies devoted to maintain cognitive efficiency despite the deleterious effects of this autoimmune illness. In the present study, we aim to compare the ERP components in children with T1D, aged between 8 and 15, versus healthy matched controls while performing a sustained attention task with simultaneous EEG recording. We evaluated 17 right-handed patients, with normal IQ, without clinical antecedents of diabetic complications, and without developmental or neuropsychiatric disorders. The control group consisted of 15 healthy individuals matched by age, sex and educational level. The stimuli used in a classic CPT task consisted of neutral, happy and angry facial expressions that were pseudorandomly presented. The participants were instructed to respond only to target stimuli (happy facial expressions). There were no significant behavioral group differences. Interestingly, robust electrophysiological differences were observed, primarily in the P300 component, when grand-mean difference ERP waveforms (target minus non-target) were compared. The TD1 group exhibited an earlier, more widespread fronto-central P3 waveform with significantly larger amplitude. These findings could be a neurophysiological manifestation of compensatory strategies devoted to maintain cognitive efficiency while meeting attentional task demands. Since T1D is commonly diagnosed during childhood, such compensatory brain mechanisms could be part of illness-related neurodevelopmental differences between patients and healthy children.

Topic Area: ATTENTION: Development & aging

C8 Using fNIRS to Investigate the Neural Processes of Dimensional Label Learning

Rachel Eddings¹, Bhoomika Nikam¹, Kara N. Lowery¹, Aaron T. Buss¹; ¹University of Tennessee, Knoxville

Previous research suggests that dimensional label learning (DLL) involves mapping dimensional labels (i.e. color/shape) to featural labels (i.e. red/square), and featural labels to properties of objects (Sandhofer & Smith, 1999; Verdine et al. 2016). The goal of this study is to explore the neural basis of this process. Thirty 33-month-olds completed production, comprehension, and comparison tasks involving colors, canonical shapes, and embedded shapes. An fNIRS probe measured hemodynamic activity from left frontal, left temporal, and right parietal regions previously implicated in dimensional attention (Morton et al., 2010; Buss & Spencer, 2018). For production, participants were shown an object and asked, "what color/shape is this?" During comprehension, participants were shown an array of objects and asked, "which one is purple/a star?" For comparison, participants were shown two objects that matched across a single dimension and instructed to choose a third object that shared this similarity. Neural data showed activation in frontal, temporal, and parietal regions during comparison tasks. The extensive activation for this task could be due to higher complexity of cognitive processing and dimensional attention deployment. Comprehension tasks showed activation in frontal and temporal regions, whereas production tasks showed activation mainly in frontal regions. Patterns of activation differed based on dimension, with color engaging a fronto-temporal network and shape engaging a fronto-parietal network. Across these DLL tasks, activation was observed across a network of regions implicated in dimensional attention. Future work will explore whether patterns of activation during DLL tasks and changes in DLL predict developmental changes in dimensional attention.

Topic Area: ATTENTION: Development & aging

C9 High-definition tDCS of the prefrontal cortices modulates performance and neural activity during visuo-spatial processing

Yasra Arif¹, Rachel Spooner¹, Alex Wiesman¹, Michael Rezich¹, Elizabeth Heinrichs-Graham¹, Tony Wilson¹; ¹University of Nebraska Medical center

The dorsolateral prefrontal cortex (DLPFC) is known to play a critical role in visuo-spatial attention and processing, but the relative contribution of left versus right DLPFC remains poorly understood. In the current study, we applied active and sham high-definition transcranial direct stimulation (HD-tDCS) to left and right DLPFC and investigated the net impact on behavioral performance and neural oscillatory activity. Briefly, 25 healthy adults underwent 20 min of 2.0 mA left, right, and sham DLPFC HD-tDCS on three separate visits. Following stimulation, participants completed a visuospatial-discrimination task during magnetoencephalography (MEG). The resulting data were imaged in time-frequency windows of interest and time series were extracted from the peak voxel in bilateral occipital cortices. The behavioral results indicated a main effect of stimulation condition on reaction time and accuracy, with left DLPFC stimulation being associated with significantly delayed reaction times and decreased accuracy compared to the right. In regard to the neural data, active stimulation (left and right) was associated with a significant increase in spontaneous alpha power during the baseline in the right occipital cortices relative to sham. A main effect of condition was also observed in spontaneous theta activity, with significant increases following left DLPFC stimulation compared to right and sham, while sham was associated with increases bilaterally relative to right. Moreover, stimulation also significantly modulated spontaneous gamma activity in bilateral occipital cortices. In conclusion, our results showed spectrally-specific modulation by HD-tDCS at the network level, with divergent outcomes based on the stimulation target in the DLPFC.

Topic Area: ATTENTION: Spatial

C10 Sex differences on visuospatial tasks, solving the puzzle

Daniela E. Aguilar Ramirez¹, Kurt Robertson¹, Claudia L. R. Gonzalez¹; ¹University of Lethbridge

Mentally visualizing objects, understanding relationships between two- or three- dimensional objects, and orienting ourselves in space are only some examples of visuospatial abilities. Numerous studies have consistently shown that males outperform females in visuospatial tasks. Researchers have argued that perhaps the sex differences stem from different processing styles males and females use when solving a problem. Males tend to use a holistic or global stimulus approach whereas females use a detailed or local approach. To test this possibility, we designed an experiment using four jigsaw puzzles that necessitated different approaches to be solved. These included: a no detail image (i.e. single plain colour), a low detailed image (i.e. a sunset), and two highly detailed puzzles, one featuring a concrete image (i.e. a city) and one with an abstract image (i.e. jelly beans). We hypothesized that males would do better in the no- and low- detailed puzzles whereas females would do better on the highly detailed ones. Forty-seven young adult participants (females n=23, males n=24) took part in the study; time, number of pieces, and errors were recorded. The results showed partial support to our hypothesis: Females outperformed males in both detailed puzzles, but we found no sex differences for the no-detailed puzzles. This result suggests that females and males do use different cognitive styles during visuospatial processing. These different female and male cognitive processing styles should be taken into account when investigating sex differences on visuospatial abilities, as they may favor or hinder performance according to sex.

Topic Area: ATTENTION: Spatial

C11 Shifting the Visual Field Leftward or Rightward Differentially Modulates Resting State Functional Connectivity

Selene Schintu^{1,2}, Michael Freedberg^{1,3}, Steve Gotts⁴, Catherine A. Cunningham¹, Sarah Shomstein², Eric M. Wassermann¹; ¹National Institute for Neurological Disorders and Stroke, Bethesda, USA, ²George Washington University, Washington DC, USA, ³Henry M. Jackson Foundation for the Advancement of Military Medicine, Maryland, USA, ⁴National Institute of Mental Health, Bethesda, USA.

Prism adaptation (PA) is a visuomotor training to displaced vision. Right PA ameliorates neglect in patients, but is ineffective in healthy individuals. Left PA causes neglect-like behavior in healthy, but it is ineffective in patients. When the right hemisphere is damaged, loss of interhemispheric inhibition releases the left parieto-frontal network and can cause neglect. PA is hypothesized to modulate attention by inhibiting the posterior parietal cortex (PPC) contralateral to the prism deviation thus modulating fronto-parietal connectivity. To test this hypothesis, resting-state functional connectivity (FC) was measured before and after right and left PA. Forty participants underwent resting-state fMRI before and after left (N=20) or right (N=20) PA. Sensorimotor performance was assessed before and after PA, and after fMRI. Both the left and right PPC were seeded and changes in FC with the whole brain were quantified. Both left and right PA groups showed significant sensorimotor adaptation lasting until the end of the experiment. Left and right PA decreased PPC FC with other brain regions. Importantly, the changes were specific to the PA direction: Left PA decreased FC between the PPCs and frontal area, such as inferior frontal gyrus. Right PA reduced FC between the PPCs and posterior areas, such as the lingual gyrus and the pulvinar. These results show that PA acts on different brain regions according to the direction of the visual displacement and does not simply produce reciprocal changes. Left PA modulating the parieto-frontal FC may account for the behavioral effects observed in healthy but not in patients.

Topic Area: ATTENTION: Spatial

C12 Voluntary saccadic eye movements modulate visual cortex excitability through phase reset of perceptually relevant oscillations

Domenica Veniero¹, Joachim Gross¹, Gregor Thut¹; ¹Institute of Neuroscience and Psychology, University of Glasgow

Visuo-spatial attention is closely linked to saccadic eye movements. In order to carry out efficient visual processing of the upcoming attention locus, top-down signals from the prefrontal cortex influence visual cortex excitability. Here, we propose that the mechanism through which this occurs is the phase reset of ongoing oscillations generated within the visual cortex. To test this hypothesis, we applied transcranial magnetic stimulation (TMS) over the right primary visual cortex (V1) to induce phosphenes in the left visual field. We asked 15 healthy participants to make self-paced saccades to the left or to the right and measured the resulting V1 excitability changes, defined as phosphene perception rate, as a function of the time from saccade initiation (21 intervals, from 20 to 560ms). If saccades phase-reset the oscillatory activity over the occipital cortex, one would expect a periodicity in phosphene perception locked to the eye-movement initiation. To test for a cyclical pattern in phosphene perception rate, a curve-fitting procedure was applied fitting cosine models from 4 to 25 Hz. R-squared values were statistically evaluated using a bootstrapping procedure. Our results revealed that when participants performed saccades towards the phosphene location (leftward saccades), V1 excitability fluctuation was significantly ($p < 0.01$) described by oscillations in the theta (4-7 Hz) and beta-frequency band (16-18 Hz). Conversely, when saccades moved away from the phosphene location (rightward saccades), theta (4-7 Hz) and alpha (8-11 Hz) oscillations dominated ($p < 0.01$). We conclude that the phase reset of different oscillatory activity underlie visual cortex excitability changes caused by saccades onset.

Topic Area: ATTENTION: Spatial

C13 Cognitive functioning in post-traumatic stress disorder: a meta-analysis of evidence from animal models & clinical studies

Milou Sep^{1,2}, Elbert Geuze^{1,2}, Marian Joëls^{2,3}; ¹Military Mental Healthcare, Dutch Ministry of Defence, ²University Medical Center Utrecht, the Netherlands, ³University Medical Center Groningen, the Netherlands

After a traumatic experience, some people develop post-traumatic stress disorder (PTSD). To improve the prevention and treatment of PTSD in the future, (fundamental) research efforts need to align with clinical reality so that translational findings can foster clinical progress. In the case of PTSD, this implies attention for research in the cognitive domain (including learning & memory), which plays a crucial role in current clinical diagnosis and treatment. In a meta-analysis, we compared current knowledge on learning, memory and fear conditioning (FC) in PTSD patients to healthy controls. Subsequently, data from animal models of PTSD was compared to patient-data, to investigate how preclinical data relates to clinical data. Data searches were performed in Pubmed and the PRISMA guidelines were followed throughout the project. 184 articles were included in this study (60.9% preclinical; 53.8% FC). PTSD patients show enhanced learning and memory of emotional or fearful information but perform worse than healthy controls in learning and memory of neutral information. Preclinical data showed comparable results, with even stronger associations between PTSD and parameters of learning and memory. FC was predominantly assessed in preclinical studies, whereas clinical studies focussed mainly on learning and memory of emotional or neutral information. These discrepancies could inspire future (pre)clinical studies to adopt a more translational, thereby more valuable, set-up. Overall, the results underline the importance of the learning and memory performance in PTSD and suggest that animal models can be used to model the cognitive domain of PTSD.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C14 Dissociable processing of emotional and neutral body movements revealed by μ -alpha and beta rhythms

Audrey Siqi-Liu^{1,2}, Alison Harris¹, Anthony Atkinson³, Catherine Reed¹; ¹Claremont McKenna College, ²Duke University, ³Durham University, UK

Both when actions are executed and observed, electroencephalography (EEG) has shown reduced alpha-band (8-12 Hz) oscillations over sensorimotor cortex. This ' μ -alpha' suppression is thought to reflect mental simulation of action, which has been argued to support internal representation of others' emotional states. Despite the proposed role of simulation in emotion perception, little is known about the effect of emotional content on μ -suppression. We recorded high-density EEG while participants viewed point-light displays of emotional versus neutral body movements in 'coherent' biologically plausible and 'scrambled' configurations. Although coherent relative to scrambled stimuli elicited μ -alpha suppression, the comparison of emotional and neutral movement, controlling for basic visual input, revealed suppression effects in both alpha and beta bands. Whereas alpha-band activity reflected reduced power for emotional stimuli in central and occipital sensors, beta power at frontocentral sites was driven by enhancement for neutral relative to emotional actions. A median-split by autism-spectrum quotient score revealed weaker μ -alpha suppression and beta enhancement in participants with autistic tendencies, suggesting that sensorimotor simulation may be differentially engaged depending on social capabilities. Consistent with theories of embodied emotion, these data support a link between simulation and social perception while more firmly connecting emotional processing to the activity of sensorimotor systems.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C15 Dopaminergic effects on PTSD-associated mnemonic overgeneralization

Andrew Westphal^{1,2,3}, Nicholas Rodriguez^{1,2,3}, Andrew Kayser^{1,2,3}; ¹University of California, San Francisco, ²United States Department of Veterans Affairs, ³University of California, Berkeley

Post-traumatic stress disorder (PTSD) is theorized to promote the overgeneralization of threat-related affect to neutral environmental features. However, the neural basis for this overgeneralization, and its potential remediation, have not been addressed together in a symptomatic sample. In this pharmacological fMRI study, we used an emotional working memory paradigm to assess mnemonic and executive control functioning in 30 participants exhibiting a range of PTSD severity (CAPS range: 0 – 68, median 23). Each subject received both placebo and the catechol-O-methyl transferase inhibitor tolcapone (which increases cortical dopamine tone) in randomized, double-blind, counterbalanced fashion. In the emotional working memory task subjects viewed three consecutive face stimuli expressing fearful or neutral expressions. They then maintained either one or three faces across a delay in the presence of distractor stimuli, which were either emotionally arousing or neutral face or scene stimuli. After the delay period, participants judged whether a probe face stimulus matched the encoded stimulus. Mnemonic discriminability (d') and response bias were evaluated using linear mixed models. On placebo, participants with more severe PTSD exhibited worse mnemonic discriminability overall and a more liberal response bias toward fearful stimuli. Tolcapone improved overall mnemonic discriminability and reduced liberal response bias to fearful stimuli for those with more severe PTSD. Univariate general linear model analysis demonstrated that tolcapone led participants with more severe PTSD to further recruit task-relevant prefrontal and subcortical regions, consistent with previous work addressing treatment of PTSD-related cognitive impairment. Together these data suggest that augmenting cortical dopamine tone improves threat-related cognition in PTSD.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C16 Event Related Potentials of Negative-Valenced Visual Distractors on Visual Working Memory

Lauren Dacorro^{1,2}, Alan Leggit¹, Alexander Simon¹, Ken Rauen², Peter Wais¹, Mark Geisler²; ¹University of California, San Francisco, ²San Francisco State University

Negative-valenced images, when presented as distractors, diminish accuracy in working memory and increase activity in the emotional processing areas of the brain (Iordan, Dolcos, & Dolcos, 2013). The current study explored how negative distractors, compared to neutral distractors, decreased accuracy in visual working memory and how brain activity was affected. The task presented a colored square, followed by either a negative or neutral distractor image, and then another colored square. Participants (N = 41, 21 males) indicated whether the second square changed in color from the first. As participants completed this task, we recorded event related potentials through EEG on a 64-channel system. We compared the effects of the negative and neutral distractor images on the Late Positive Potential (LPP) in the brain (P3 and P4), as well as on the P100, N100, and P300 components from the averages of the P7, P8, P9, P10, PO7, and PO8 electrode sites. Trials with negative distractors, compared to neutral distractors, showed diminished accuracy ($t(40) = -3.16, p = .003$). Negative distractors, compared to neutral distractors, were associated with longer latencies for the N100 ($t(40) = 5.65, p < .001$) and P300 ($t(40) = 2.08, p = .044$). Negative distractors were associated with larger amplitudes for the mid-wave LPP in both the right ($t(40) = -3.06, p = .003$) and left ($t(40) = -2.89, p = .006$) hemispheres of the brain. Our task showed that negative distractors, compared to neutral distractors, were associated with decreased accuracy and changes in brain activity.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C17 Executive functioning predicts positive preferences in false recognition memory in older adults

Zhiwei Zheng¹, Juan Li¹; ¹Chinese Academy of Sciences

Normal aging is associated with motivational priorities shift from acquiring knowledge to emotion regulation. Consistently, accumulating evidence indicates an age-related increase in the preferences for positive over negative information in cognitive processing. In the present study, using the categorized pictures paradigm, we investigated whether older adults would show a greater increase in false recognition rates to positive versus negative lures in contrast to young adults. We also examined the effects of executive functioning on the preferences for positive over negative pictures in false recognition memory. Twenty-seven young and 26 older adults were presented with positive, neutral, or negative pictures from various categories during encoding and later completed a recognition test. In addition, all participants completed the Trail Making Tests to assess their executive functions. The results revealed that both older and young adults showed higher false recognition rates for positive pictures compared with negative pictures, and there was no significant Age by Valence interaction. Interestingly, we found that executive functioning was positively correlated with the positive processing preferences in false recognition rates in older but not young adults. These findings suggest that false recognition memory exhibits preferences toward positively-valenced information in young and older adults. Cognitive control processes are necessary for older adults to distort memory in emotionally gratifying ways. Further research is necessary to explore the neurocognitive mechanisms underlying the production of emotional false memory in older adults.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C18 Exploring the Facial Feedback Hypothesis in Moebius Syndrome

Jessica Jordan¹, Chris Baker¹, Leslie Ungerleider¹, Shruti Japee¹; ¹Laboratory of Brain and Cognition, NIMH, NIH

The facial feedback hypothesis states that feedback from skeletal muscles of the face can alter emotional experience. Therefore, individuals who cannot move their facial muscles, such as in Moebius Syndrome (MoS), may have difficulty experiencing and identifying emotion. MoS is a rare congenital disorder, resulting in paralysis of the face and lack of skeletal muscle feedback. We hypothesized that facial paralysis in MoS leads to impaired processing of facial expressions and explored this by having individuals with MoS and age-matched controls detect emotions in dynamic facial and body expressions. For the face task, participants were shown video clips of varying lengths showing faces morphed from neutral to fearful, happy and angry. For the body task, participants were shown varying lengths of video clips of body movements depicting neutral, fearful, happy or angry emotions. Participants indicated with a button press what emotion they thought was portrayed in each video. In separate control runs, while viewing the same stimuli, participants indicated whether the mouth was open or closed, or whether the arms moved. Psychometric data were used to determine each participant's duration threshold for 50% accuracy. Compared to healthy controls, individuals with MoS were impaired at detecting emotion from facial expressions, but not body expressions, while performing similarly on the feature-detection control task. Taken together, these results indicate that facial paralysis in MoS leads to a specific impairment in processing facial expressions, providing support for the facial feedback hypothesis.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C19 Growth mindset supports cognitive performance and learning in children: Behavioral and neural evidence

Jeremy Rudoler¹, Lang Chen¹, Hyesang Chang¹, Miram Rosenberg-Lee^{2,1}, Emma Adair¹, Vinod Menon¹; ¹Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, CA, ²Department of Psychology, Rutgers University, Newark, NJ 07102, United States

Growth mindset, the belief that one's cognitive abilities can be improved through effort, has been linked to higher academic achievement. However, its underlying neural mechanisms remain unknown. Here we address critical gaps in our understanding of growth mindset by (i) examining the relationship between growth mindset and cognitive performance; (ii) investigating the neural systems associated with growth mindset; and (iii) characterizing the relationship between growth mindset and learning gains associated with cognitive tutoring in children. Growth mindset and mathematical skills were first assessed in 79 children (43 females; mean age 8.17 yrs; mean FSIQ: 107.2). Fifty-four of these children completed a 4-week math tutoring, aimed at enhancing basic numerical skills. Children with higher growth mindset performed better on a math task involving simple addition problems, and they showed increased activations in right striatum, right insula/inferior frontal gyrus, dorsolateral prefrontal cortex, and supplementary motor area. Increase in growth mindset scores after tutoring predicted improvements in accuracy on the math task. Our study provides novel evidence that growth mindset influences cognitive performance and learning in children by upregulating brain systems associated with motivation, cognitive control, and working memory.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C20 Neural and Behavioral Mechanisms Underlying the Relationship between Everyday Pain and Cognitive Performance

Joanna E. Witkin¹, Steven R. Anderson¹, Taylor Bolt², Maria M. Llabre¹, Elizabeth A. Reynolds Losin¹; ¹University of Miami, ²Emory University

While the extant literature examining the relationship between pain and cognition has primarily involved patients with chronic pain and healthy subjects undergoing experimental pain inductions, few studies have examined the relationship between everyday pain complaints and cognitive performance.

The relationship between everyday pain (measured via self-reported pain intensity and pain interference in daily activities) and cognitive performance (measured via accuracy on a working memory n-back task) was examined utilizing a structural equation modeling approach. Neuroimaging and behavioral outcomes were accessed from the Human Connectome Project in a large sample of participants (N=416). Task-related brain activation in the ventromedial prefrontal cortex (vmPFC, previously associated with the evaluative aspects of pain) and self-reported negative affect were included as mediators to investigate potential mechanisms underlying the relationship between everyday pain and cognitive performance. Based on recent findings by Bolt and colleagues (2018), we sought to disentangle brain region from network-level influences on the relationship between everyday pain and cognition by specifying a separate structural model containing a latent construct for default mode network (DMN) activity. Our results demonstrated greater everyday pain intensity was associated with worse cognitive performance via increases in both DMN and vmPFC activity. In contrast, greater everyday pain interference was associated with worse cognitive performance via increased self-reported negative affect. These findings demonstrate that the negative correlation between pain and cognition extends to everyday pain complaints in healthy populations. Furthermore, our results suggest distinct contributions of ROI and network-level brain activity on the association between everyday pain and cognitive performance.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C21 Neural responses of love: a meta-analysis of functional neuroimaging studies in maternal and passionate love

Hsuan-Chu Shih¹, Chih-Mao Huang^{1,2}; ¹Department of Biological Science and Technology, National Chiao-Tung University, Taiwan, ²Cognitive Neuroscience Laboratory, Institute of Linguistics, Academia Sinica, Taiwan

Maternal love and passionate love are crucial for perpetuation of the species and involve the attachment behaviors with a highly rewarding experience. Neurobiological studies of attachment in mammals and recent human neuroimaging studies suggest that the coordination of oxytocinergic pathway contributes to the formation and maintenance of maternal and passionate love as well as results in a tight coupling with dopaminergic reward system. In the present study, we investigate the common and specific neural substrates between maternal love and passionate love in human by performing a quantitative meta-analysis of functional MRI studies using activation likelihood estimation approach. Twelve published fMRI studies related to maternal love and nine published studies of passionate love were included. The meta-analytic results showed that both types of love recruited distributed neural networks associated with cognitive, affective, and rewarding systems, including left putamen, bilateral medial caudate nucleus, substantia nigra, ventral tegmental area and bilateral thalamus. Furthermore, maternal love showed greater activation in bilateral superior frontal gyrus, right inferior frontal gyrus, bilateral hypothalamus and left amygdala which may involve more cognitive-emotional regulation of attachment behavior. In contrast, passionate love specifically recruited left insular activation that may represent the attachment behavior for interpersonal relations. Our findings suggest the similar but distributed brain networks associated with oxytocinergic and dopaminergic systems that relate to cognitive, affective, and motivational processing for perceiving maternal and passionate love, and provide neuroimaging evidence to support the notion that maternal love and passionate love share a common evolutionary origin and neurobiological functions in neural level.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C22 Predicting whole-head brain activity with traits related to empathy in healthy subjects

Anna Aksiuto¹, Janne Kauttonen¹, Iiro Jääskeläinen¹, Mikko Sams¹; ¹Aalto University

Empathy plays a crucial role in social dynamics. Strengths of personality traits related to empathy vary in normal population. We examined level of empathy along with narcissistic, psychopathic and autistic personality features with nine psychological questionnaires, including Five Factor Narcissistic Inventory, Autism Quotient and Self Report Psychopathy Scale. We measured brain hemodynamic activity of 42 healthy subjects with fMRI during 110-min naturalistic stimulation and 10-min resting state. Inter-subject correlation (ISC) of brain activity predicted similarity of empathy and narcissistic scores in various temporal, occipital and parietal loci in a representational similarity analysis. For instance, individuals high on narcissistic traits revealed higher ISC in parahippocampal gyrus and intraparietal sulcus, whereas for low narcissistic features ISC was higher in sensorimotor cortex and insula. In addition, differences were found in grandiose vs. vulnerable types of narcissism, the former showing higher ISC in superior temporal gyrus, parieto-occipital sulcus and premotor cortex and the latter in parahippocampal cortex and postcentral sulcus. Furthermore, we found ISC differences for autistic traits with higher autistics scores predicting increased synchrony in intraparietal sulcus, auditory cortex and hippocampus, whereas fusiform gyrus and somatosensory cortex were more synchronized with lower scores. Finally, similarity of full-brain resting-state Functional Connectivity patterns were associated with the level of psychopathic and empathic traits. Our results suggest that traits related to empathy can be predicted from neuronal activity and might have potential in studying brain activity patterns in empathy-related disorders.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C23 Prefrontal and visual representations during encoding of emotional information

Doyoung Park¹, Sue-Hyun Lee¹; ¹Korea Advanced Institute of Science and Technology

Emotional arousal has been reported to enhance memory encoding, but it seems that not all types of event details but some focused components are enhanced by emotional processing. These prior results suggest that during encoding of emotional events compared to neutral ones, there is more active top-down modulation that affects individual event components specifically. To test this idea, cortical activity was monitored with fMRI while participants encoded or retrieved emotional pictures compared to neutral pictures. The participants also performed two post-scan tests: the sentence test, which highlights high-level semantic information, and the image test, which emphasizes low-level visual information. Using multi-voxel pattern analysis, we found that the representational similarity between the primary visual cortex (V1) and the dorsolateral prefrontal cortex (dlPFC) was greater during the encoding of emotional pictures than during the encoding of neutral ones. Moreover, the representational similarity between prefrontal and visual cortex during encoding of emotional pictures was positively correlated to the behavioral performance in the sentence test but not in the image test. These results suggest that during the encoding of emotional information compared to neutral one, there is a stronger relationship between the visual and the prefrontal representations, suggesting more top-down modulation on sensory input during encoding of emotional events.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C24 Reduced working memory capacity under threatening context

Richard Ward¹, Hannah Sallman¹, Carter Ginter¹, Salahadin Lotfi¹, Han-Joo Lee¹, Christine L. Larson¹; ¹University of Wisconsin - Milwaukee

An abundance of research has provided evidence that anxiety adversely affects cognition. One domain in particular, working memory, has been shown to be negatively impacted by anxiety. Prior evidence suggests that anxiety leads to an overall reduction in working memory capacity, and that anxious individuals experience deficits in their ability to filter task-irrelevant threatening stimuli. Based on this prior work, we aimed to investigate the effects a threatening context has on working memory capacity and the ability to filter task-irrelevant neutral stimuli. One event-related potential, the contralateral delay activity (CDA), indexes the number of items retained in working memory, thus serving as a neurophysiological index of working memory capacity. Thirty undergraduate participants completed a change detection task under two contexts, threat of shock and no shock, while electroencephalography (EEG) was recorded. The change detection task consisted of three conditions: two target, two target and two neutral distractor, and four target loads. The two target and two neutral distractor condition was incorporated to calculate the ability to filter task-irrelevant distractor stimuli. CDA was calculated by computing the difference between the contralateral and ipsilateral waveforms for occipital/parietal channel clusters. We observed a significant main effect for context, indicating a reduced CDA amplitude during threat of shock. However, we did not find that filtering of task-irrelevant stimuli differed between threat and safe contexts. These results suggest that working memory capacity is reduced under threatening contexts, but individuals still maintain the ability to filter distracting information from working memory.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C25 The Effect of Working Memory Span on Resolving Emotional Conflicts

Sertuğ Gürel¹, Şule Taşlıyurt¹, Zeynep Başgöze^{1,2}; ¹Başkent University, ²University of California, Berkeley

This study aims to examine the effect of Working Memory Span (WMS) on resolving emotional conflicts. 40 participants (M age: 22.4) completed Operational Working Memory Span (OSPAN) Test and emotional Word-Face Stroop (WFS) Task, where participants evaluated the valence of words superimposed on affective faces (sad, happy, neutral). The words appeared both in congruent (e.g. negative word on sad face) and incongruent conditions (e.g. negative word on happy face). Participants completed Positive Negative Affect Schedule before, Beck Depression Inventory (BDI) and Beck Anxiety Inventory (BAI) after completing the tasks. A 2x2 repeated measure ANOVA with 2 within subject factors (congruence & valence) revealed a significant main effect of valence ($F(1,38) = 18.27, p < .01, \eta^2 = 0.32$) and a marginally significant main effect of congruency ($F(1,38) = 3.44, p = .071, \eta^2 = 0.081$), indicating that participants performed faster towards positive and congruent stimuli compared to negative and incongruent stimuli. No correlation is found between WFS scores and OSPAN. Although no correlation is found between OSPAN and BDI, BAI and current positive mood scores, a significant negative correlation is observed between OSPAN and negative mood ($r = -.27, p < .05$). In conclusion, our study demonstrated that even if negative mood might have a detrimental effect on WMS, there is no clear link between WMS and emotional conflict resolution capacity, contrary to the often-reported link between WMS and cognitive conflict resolution, measured with classical Stroop Tasks. Therefore, WM span might not provide a direct advantage when conflicts occur in an emotional level.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C26 Stopping natural desires: defining the hypersexuality network in impulse control disorders in Parkinson's disease

Ignacio Obeso¹, José Ángel Pineda-Pardo¹, Lydia Vela¹, Fernando Alonso¹, Jose A. Obeso¹; ¹CINAC

Humans are prone to approach natural stimuli with positive connotation such as food or sex. Impulse control disorders (ICD) is a side-effect of dopamine agonist medication to treat motor symptoms in Parkinson's disease (PD) whereby desire towards natural rewards increases and uncontrolled actions occur as a result. Male PD+ICD ($n=18$), PD-ICD patients ($n=16$) performed the task while on and off medicated (after overnight withdrawal) and compared to healthy male controls ($n=16$). The erotic stop-signal task inside the fMRI presented participants either an erotic or non-erotic image (1s), followed by a go signal sometimes replaced with a stop signal (33%). Behaviorally, PD+ICD patients while medicated were slower to inhibit actions that followed an erotic image as compared to unmedicated conditions. Failed inhibition under erotic stimuli influence produced BOLD increment in PD+ICD (while medicated) in the left caudate [$-4\ 12\ 6; z = 433; p = .005$]. When stopping was successful in the erotic condition, however, PD+ICD significantly activated while medicated (compared to off medication) the left caudate [$-6\ 0\ 16; z = 487; p = .001$] in addition to cortical regions such as the right pre-SMA [$7\ 22\ 43; z = 387; p = .005$] and ACC [$4\ 24\ 20; z = 399; p = .005$]. Connectivity analysis during successful stops revealed that PD+ICD patients recruit the caudate in combined forces with pre-SMA and contralateral caudate (left side). Hypersexual ICD seems to be driven by overrepresentation of limbic activity combined with reduced top-down control.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

C27 The impact of depressive rumination on the course of depressive symptoms and cognitive performance in time

Martin Pastnák^{1,2}, Gabriela Vechetova^{1,3}, Magdalena Bartoskova¹, Marcela Sevcikova^{1,3}, Jiri Stipí^{1,4}, Marek Vranka^{1,4}, Marek Preiss¹; ¹National Institute of Mental Health, Czech Republic, ²Third Faculty of Medicine, Charles University, Czech Republic, ³First Faculty of Medicine, Charles University, Czech Republic, ⁴Faculty of Arts, Charles University, Czech Republic

Aim: According to the Analytical Rumination Hypothesis (ARH) depressive symptoms facilitate the process of rumination, which temporarily increases the ability to analyse complex problems preceding depression and thus increases the probability of lowering depressive symptoms in time. Moreover, cognitive performance is decreased, as the mental capacity is occupied by the process of rumination. The aim is to elucidate the impact of depressive rumination on cognitive functioning in time. Methods: Clinically depressed individuals ($N=79$) and matched healthy controls ($N=44$) were assessed at baseline and after a month. Depression severity was assessed by MADRS. Self-report scales on rumination (ARQ, subscales Causal Analysis - CA and Problem Solving Analysis - PSA) and perceived level of problem complexity (PCQ) were used. Cognitive performance was assessed using Trail Making Test (TMT) and Auditory Verbal Learning Test (AVLT). Results: In patients, the severity of depressive symptoms has decreased and the dominant type of rumination has changed in time. Depressive symptoms (MADRS) positively correlated with the severity of ruminations (ARQ) and with the subjective problem complexity (PCQ), and negatively correlated with the capacity of auditory verbal memory (AVLT 1-5). Regression model showed that rumination type ratio (CA, PSA) was a predictor of the depression severity change in time. Conclusion: In patients, the severity of depression decreases in time and cognitive performance improves but remains worse compared to controls. Rumination is present in patients with depression and the type of rumination changes in time. The characteristics of prevailing rumination type predict the development of depressive symptoms.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C28 The Influence of Media Violence Exposure on the Neural Correlates of Explicit Emotional Face Processing and Subsequent Response Inhibition

Zoa Glab¹, Laura A. Stockdale^{1,2}, Sylena Wilson¹, Marley Hornewer³, Sara Temelkova¹, Rebecca L. Silton¹, Robert G. Morrison¹; ¹Loyola University Chicago, ²Brigham Young University, ³University of Michigan

Research has shown that exposure to violent media is related to increased aggressive and decreased prosocial behavior. Theoretically, researchers have argued that desensitization to the emotions of others may be a mechanism underlying these changes. Recent studies of short-term and chronic exposure to media violence using implicit emotion paradigms tend to support this hypothesis. In contrast, when participants explicitly identify angry faces, exposure to media violence has been related to increased speed and accuracy. These results suggest that media violence may impact implicit and explicit emotion processing differently. In the present study EEG data were collected while participants (N = 28) categorized facial expressions as either happy or angry during a stop-signal task (SST). Prior to completing the SST, participants watched a violent and a non-violent film during two experimental sessions which were one-week apart. Within-subject analyses showed that SST accuracy and RT did not differ based on film exposure. However, increased N170 amplitude and decreased Early Posterior Negativity (EPN) latencies were observed after exposure to the violent film. Unlike in implicit emotion studies involving media violence, participants did not display modulations in stop-signal locked P300 amplitudes or latencies. Similar to previous studies using an implicit emotion SST, these results suggest that conscious attention to emotion modulates the neural correlates of emotional face processing after short-term exposure to media violence; however, the specific effects are not identical.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C29 Validity and response of neural biomarkers for pain response and cognitive modulation in the context of mindfulness-based intervention

Joseph Wielgosz^{1,2,3}, David Perlman³, Jeanette Mumford³, Tor Wager⁴, Richard Davidson³; ¹Stanford University, ²VA Palo Alto Healthcare System, ³University of Wisconsin-Madison, ⁴University of Colorado Boulder

Neuroimaging-based biomarkers offer a novel approach for investigating how pain response and pain modulation are affected by structured intervention. Here, we used a complementary pair of distributed functional activation signatures, one targeting direct nociceptive processing (Neural Pain Signature; NPS) and the other targeting pain-modulatory cognition (Stimulus Intensity-Independent Pain Signature; SIIPS-1), to study the effects of mindfulness training on acute pain response. In Step 1, we assessed the validity of both signatures in a novel participant sample and experimental environment. Both NPS and SIIPS-1 were effective in discriminating physical pain experience from related but non-painful conditions, including: cognitive dot-probe with pain-related words (AUC = 0.98, 0.86 respectively); pain ratings (AUC = 0.98, 1.00); non-painful warmth (AUC = 0.84, 0.84); pain anticipation (AUC = 0.88, 0.86); and pain recovery (AUC = 0.84, 0.87). In Step 2, we applied neural signatures to an intervention paradigm wherein participants (n=124) were randomly assigned to an eight-week Mindfulness-Based Stress Reduction (MBSR) course, an active control intervention (Health Enhancement Program; HEP), or a waitlist control condition. MBSR participants showed a significant decrease in both pain unpleasantness (p=.028) and NPS response (p=.021). Meanwhile, HEP participants showed a decrease in both subjective pain intensity (p=.046) and unpleasantness (p=.007) but no change in neural signature responses. No change in subjective report or neural pain signature was observed in the waitlist group. Results demonstrate the validation and use of novel neuroimaging-based pain markers in the context of an intervention study and shed light on mechanisms of pain modulation in mindfulness-based interventions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

C30 Task Related Brain Connectivity Decreases After Cognitive Training

James Kent¹, Hyun Kyu Lee², Chris Wendel¹, Fred Wolinsky¹, Eric Foster¹, Michael Merzenich², Michelle Voss¹; ¹University of Iowa, ²Posit Sciences

Cognitive training remains a controversial figure in the world of interventions. Coupled with a rapidly aging population, determining the efficacy and mechanism of cognitive training is essential for understanding how to provide improved quality of life for the elderly. The Plasticity-based Adaptive Cognitive Remediation (PACR) program is a computerized training program designed to improve cognition by challenging participants with a variety of tasks requiring attention and inhibitory control. While we have previously presented PACR's benefit on processing speed and working memory; there has not been an investigation of the neural patterns that may accompany the behavioral changes. We collected imaging data while the participants were at rest and performing a cognitive control (flanker) transfer task. In the scanner the training group improved speed of response in all conditions, especially in the incongruent condition (p<0.05), while maintaining accuracy suggesting transfer of training. We performed connectivity analyses for both the resting state (control=23, PACR=21) and task data (control=17, PACR=21) using a predefined parcellation atlas (Schaefer 2018) with 16 networks. Only task connectivity revealed a training effect for one network (limbic (i.e. inferior-temporal and orbital-frontal); p=0.008) and a trend for three other networks (DefaultA; p=0.087, DorsAttnA; p=0.062, SomMotB; p=0.084, all presented p-values are FDR corrected). Specifically, task connectivity was reduced in these networks after training relative to the active control group. Overall, results showed improved processing speed for the training group was coupled with less functional connectivity in specific association networks during task but not rest.

Topic Area: EXECUTIVE PROCESSES: Development & aging

C31 The effects of CBT-I on Cognitive Functioning in individuals with Insomnia and Mild Cognitive Impairment

Kathleen O'Hora¹, Clara Lee¹, Alison Buchanan¹, Beatriz Hernandez^{1,2}, Jamie M. Zeitzer^{1,2}, Leah Friedman^{1,2}, Donn Posner^{1,2}, Clete Kushida¹, Jerome A. Yesavage^{1,2}, Andrea N. Goldstein-Piekarski^{1,2}; ¹Mental Illness Research Education and Clinical Center, VA Palo Alto Health Care System, Palo Alto, CA, USA., ²Stanford University, Stanford, CA, USA.

Insufficient sleep, a common condition in older adults with mild cognitive impairment (MCI), may exacerbate cognitive impairments, potentially representing a causal factor and treatment target for MCI. We extend a recent study that demonstrated that Cognitive Behavioral Therapy for Insomnia (CBT-I) improves both sleep and cognitive functioning in older individuals with comorbid insomnia and MCI by utilizing a study of components of CBT-I. Eighty-five adults (mean age=68.75 34% male) with insomnia completed the Montreal Cognitive Assessment (MoCA) at baseline to determine cognitive status. MCI was defined as MoCA < 26. In addition, the Insomnia Severity Index (ISI), and a cognitive battery which included tasks assessing inhibition, task-switching, verbal memory recall and recognition, and overall cognitive functioning (trail making) were administered at baseline and six months after receiving either the behavioral, cognitive, or both components of CBT-I treatment. 21(25%) participants were classified as having MCI. Two-way repeated measures ANOVAs with one within (time) and one between (MCI status) subject factors revealed significant main effects of time in reducing ISI (p<0.0001), marginally improving inhibition (p=0.0501), verbal memory recall (p=0.01563), story recall (p=0.0007648), and trails task performance (p=0.0019) across all participants. There were no significant time x MCI status interaction effects for these measures (p's>0.05). These findings replicate and extend work demonstrating that non-pharmacological insomnia treatments

can improve insomnia symptoms and may improve cognitive abilities in individuals with and without MCI. They also add additional support to the hypothesis that sleep is an intervention target for improving cognitive abilities in those with insomnia.

Topic Area: EXECUTIVE PROCESSES: Development & aging

C32 Acute Pain Disrupts Sustained Attention

Gene Brewer¹, Mattew Robison¹, Derek Ellis¹, Chris Blais¹, Paul Karoly¹;
¹Arizona State University

The current study evaluated the effect of acute pain on sustained attention during completion of a psychomotor vigilance task. In Experiment 1 we fit Ex-Gaussian distributions to each participants' response times and found that acute pain selectively influences the relative frequency of slow responses (i.e., increases in tau). In Experiment 2 we localized the deleterious effect of acute pain using thought probes that were randomly interspersed throughout the vigilance task (i.e., increases in task-unrelated thoughts about pain). In Experiment 3 we used pupillometry to test specific hypotheses regarding fluctuations in arousal caused by acute pain that was predicted by theories regarding the role of the locus coeruleus-norepinephrine (LC-NE) system in sustained attention (i.e., increases in baseline pupil size and decreases in task-evoked pupillary response). Taken together, the results from these studies underscore a role of the LC-NE system in modulating sustained attention and suggests that acute pain interferes with its proper functioning.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C33 Assessing causal contributions of parietal cortex to learned cognitive flexibility

Christina Bejjani¹, Peter Whitehead¹, Anthony Sali², Yu-Chin Chiu³, Tobias Egner¹;
¹Duke University, ²Wake Forest University, ³Purdue University

Adaptive behavior is characterized by our ability to create, maintain, and update rules by which we categorize and respond to stimuli across changing contexts (cognitive flexibility). Previously, we deployed an fMRI version of a standard task-switching paradigm in which the frequency of switch trials varies over time, ranging from 25% to 50% to 75%. Consistent with previous literature, we found a behavioral interaction between trial type (switch vs. repeat) and switch likelihood (25%, 50%, 75%) such that switch costs were reduced when switch trials were more frequent ("learned switch-readiness"). We then fit a reinforcement learning model to the behavioral data, tracking how participants learn the likelihood of switch trials over time. Using the trial-wise prediction error estimates in model-based fMRI analyses, we found that activity within the left inferior parietal cortex (LIPC) prominently tracked trial-by-trial updating of switch likelihood (unsigned prediction error), implicating this region as a potential key player in learning switch-readiness. In the present experiment, we followed up on this correlational finding with a causality test: we probed whether the normal function of LIPC is necessary for adapting switch readiness to different contexts by disrupting its activity via fMRI-guided TMS. Comparing behavioral performance under LIPC TMS with control site (vertex) TMS, we found little preliminary evidence (n = 18; preregistered target n = 26) that the LIPC is causally involved in learned cognitive flexibility. This suggests that a wider network of interacting brain regions beyond the LIPC likely mediates learned changes in switch-readiness.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C34 Behavioral and Functional Magnetic Resonance Imaging Evidence of Flow State Dynamics During Naturalistic Gameplay

Richard Huskey¹, Justin Robert Keene², Shelby Wilcox¹, Robyn Adams³, Christina J. Najera², Natalie Petit¹;
¹The Ohio State University, ²Texas Tech University, ³Michigan State University

Media interaction has been theorized to result in flow - a rewarding state of engagement and attention directed at and induced by an immersive task when there is a balance between task difficulty and individual skill. The synchronization theory of flow outlines a neuropsychological framework to identify the neural mechanisms of this state, specifically that flow results from the synchronization of cognitive control and reward networks (Weber et al., 2009). How exactly these networks dynamically synchronize, and how dynamic interactions between task difficulty and individual skill contributes to this synchronization is yet to be clarified. To examine these processes, we behaviorally validated (n=74) Secondary Task Reaction Times (STRTs) as a dynamic index of reward modulated cognitive control during naturalistic gameplay in three experimental conditions: boredom (low-difficulty), frustration (high-difficulty), and flow (balanced-difficulty). Additionally, subjects (n=35) completed this task while undergoing fMRI. Replicating previous findings, results show that self-reported feelings of flow and enjoyment are highest, and that STRTs are longest, for the balanced difficulty condition. Interestingly, we also find time-windowed STRTs are invariant within conditions but differ between conditions. We also replicate previous graph theoretic results showing lowest global efficiency brain network organization occurs during flow while extending these into an analysis of brain network dynamics. Our results offer support for synchronization theory's core predictions and demonstrate that flow is a motivationally relevant, cognitively involved, yet metabolically efficient state. Broadly, these results provide a starting point to link dynamic changes in media content to the unfolding of psychological states like flow.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C35 Connectivity of cognitive control networks at rest and task switching performance

Pauline Baniqued¹, Joseph Schenker¹, Mark D'Esposito¹;
¹University of California, Berkeley

Essential to human cognition is the ability to respond to changing demands, and to allocate attention to a specific task despite distracting stimuli. This ability has been related to two "cognitive control" networks: the cingulo-opercular (CO) network linked to maintaining tonic alertness, and the frontoparietal (FP) network linked to trial-to-trial behavioral adjustments. We examined whether the connectivity of these networks at rest predicts task-switching performance. Functional magnetic resonance data were acquired for 23 subjects who each underwent a 10-minute task-free scan. In the switching task, on each trial, a cue indicated the task to be performed: male/female judgment after the "FACE" cue, and indoor/outdoor judgment after the "PLACE" cue. After a delay, a superimposed face/scene image was presented, to which participants responded based on cue instructions. We analyzed the difference between reaction times for switch vs. repeat trials ("switch cost"). We found that higher whole-brain modularity (higher within-module vs. between-module connectivity) was correlated with larger switch costs. Higher modularity in the CO network was correlated with smaller switch costs, while higher modularity in the FP network was marginally correlated with larger switch costs. These results suggest that greater between-network connectivity in select networks may be a more "optimal" state for adapting to complex task demands, consistent with findings of increased network integration during cognitively-demanding tasks. These results highlight unique contributions of the CO and FP networks to cognitive control, and provide support for the idea that superior complex task performance is associated with less task-related network reconfiguration.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C36 Corticostriatal white-matter tracts supporting habitual behavior in the lab and in real life

Irene van de Vijver¹, Aukje Verhoeven¹, Sanne de Wit¹; ¹University of Amsterdam, the Netherlands

Goal-directed and habitual performance on an outcome-devaluation paradigm (the Slips-of-Action Task; SoAT) have been related to distinct frontostriatal pathways, between caudate nucleus and ventromedial prefrontal cortex, and between putamen and premotor cortex, respectively. Our first aim was to replicate this neural distinction in a larger sample, and our second aim was to extend this investigation to real-life habit formation. 207 young adults underwent structural MRI and performed the SoAT. We correlated individual differences in striatally-seeded white-matter tract probabilities with the tendency towards habitual behavior, or 'slips' of action. Preliminary results indicate no correlation with the previously reported frontostriatal pathways. Rather, connectivity between the striatum and sensorimotor, parietal, and occipital cortices predicted higher levels of goal-directed performance. Next, a subset of 65 participants was instructed to take a (placebo) pill every day for two weeks, and to report on the experienced automaticity. Automaticity was related to the number of pills successfully taken, and, interestingly, participants reporting higher automaticity also showed greater habit tendencies on the SoAT. The number of pills successfully taken correlated positively with tracts between the striatum and bilateral frontopolar cortex, in line with its supposed role in prospective memory. After correcting for the number of pills taken, automaticity correlated negatively with tracts between the striatum and bilateral insula and anterior cingulate cortex, areas that have been related to self-awareness. These results suggest that depending on the context, habitual behavior is subserved by a diverse network of brain areas, the co-operation of which requires further investigation.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C37 Disentangling the roles of cue visibility and knowledge in learning cognitive control

Christina Bejjani¹, Ziwei Zhang¹, Jack Dolgin¹, Tobias Egner¹; ¹Duke University

Recent research suggests that people can learn to link the control process of task-switching to predictive cues, such that switch costs are attenuated under conditions of high vs. low switch-likelihood. However, the precise conditions that shape such contextual "control-learning" are not well understood. Farooqui and Manly (2015) raised the possibility that control-learning is more effective when cues of control-demand are presented subliminally. The current study thus aims to replicate and extend these findings by manipulating conscious cue perception and predictive cue knowledge independently so as to better understand how people optimally adapt cognitive control settings across environments. Crucially, across four experiments, we manipulate both whether these control-demand cues are subliminal or supraliminal and whether participants have been explicitly told the information provided by the cues or implicitly learn that the cues predict control-demand, such that our experiments form a 2 (cue visibility: subliminal vs. supraliminal) x 2 (cue knowledge: explicit vs. implicit) factorial design. This allows us to determine the respective, and potentially interactive, effects of cue awareness and cue knowledge on control-learning, thus linking streams of research on action control, associative learning, and conscious processing. This study is a Preregistered Direct Replication with Stage 1 in-principle-acceptance at Psychological Science (<https://osf.io/tznvzb/>). Data collection is ongoing, but will be completed, and data for all four experiments analyzed, before the Cognitive Neuroscience Society conference.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C38 EEG reveals different mechanisms for cognitive control retention, based on trait working memory ability

Jacqueline R. Janowich¹, James F. Cavanagh¹; ¹University of New Mexico

To cross a busy street, we use cognitive control not only to plan an action, but also to execute that action at the appropriate time in the future. However, it remains unknown how we retain control-demanding, abstract goal information for future use. Do we engage active maintenance processes as if holding the goal like a sensory item in working memory (WM), or do we employ goal-updating processes to efficiently activate the new goal state? In this study, we aimed to elucidate the electrophysiological mechanisms differentially elicited to retain visuo-spatial WM information vs. abstract rules. We developed a novel EEG paradigm in which participants (n=50) were tasked each trial to retain either a common rule, a rare, control-demanding rule, or a visuo-spatial WM stimulus. We applied LASSO classification to identify retention-period EEG activities that dissociated visuo-spatial stimuli (active maintenance) from common rules, and then applied those classification weights to determine if the processing of rare, control-demanding rules (i.e. goal-updating) differed significantly from active maintenance. Regression analysis demonstrated that individual differences in complex span (trait WM) score was significantly predictive of out-of-sample (transfer) classification of the control-demanding retention activity (p=.019). In participants with higher trait WM, control-demanding goals were processed more similarly to common goals than to visuo-spatial WM stimuli (goal-updating ~ WM). In participants with lower trait WM, control-demanding goals were processed like visuo-spatial WM stimuli (goal-updating = WM). In conclusion, electrophysiological activities underlying goal retention differ based on control demands, and vary based on individual WM abilities.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C39 Impaired cognitive flexibility and brain network of obsessive-compulsive disorder.

Hirofumi Tomiyama¹, Keitaro Murayama¹, Tomihiro Nakao¹; ¹Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan

Background: Obsessive-compulsive disorder (OCD) is a psychiatric disorder characterized by persistent intrusive thoughts and repetitive actions. Many previous studies have reported that OCD patients perform poorly in many neuropsychological domain. Especially, attentional set-shift impairments has been implicated in OCD and its relatives. However, the neural basis of these abnormalities is not fully understood. This study investigated brain network associated with the cognitive flexibility of OCD. Methods: We obtained 3.0-Tesla resting state magnetic resonance imaging (rsfMRI) scans and measured the cognitive flexibility of 38 medication-free OCD patients and 39 healthy control subjects using the Wisconsin Card Sorting Test (WCST). We explored the brain network associated with the impaired cognitive flexibility of OCD. Results: We found a significant difference in the performance of WCST of the OCD group compared with the HC group [t(31)=2.859, p=.006]. In OCD group, large-scale brain network alterations are correlated with these impairments. Conclusions: These results could offer preliminary insight that potential alteration of large-scale brain network could associate with the impaired cognitive flexibility in OCD patients.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C40 On the Relationships Between Autistic Traits, Executive Functioning, Self-Control, and Exercise

Lauren Mason¹, Brandon Zimiga¹, Regina Anders-Jefferson¹, Katerinne Alvarado¹, Lesley Primero¹, Matthew Frost¹, Jessica Gohil¹, Melissa Gonzalez¹, Celeste Lopez¹, Yocelyne Silva¹, Kenneth Paap¹; ¹San Francisco State University

The primary goal was to explore relationships between autistic tendencies in typical college students (measured with the Autism-Spectrum Quotient) and measures of executive functioning. In Study 1 (n=129) there were no significant relationships between autistic tendencies and either Stroop interference or mental flexibility as reflected in a morphing ambiguous figures task, but higher autistic tendencies were associated with smaller switch costs in a cued switching task. Similarly, higher scores on the attention deficit subscale were associated with faster conjunctive visual search. Study 2 replicated the surprising results in the color-shape switching task and also examined the association between autistic tendencies and self-report measures of executive functioning. Correlations between objective measures of executive functioning in computer-controlled tasks and self-report measures of control deficits in everyday life were disappointingly low. A second goal was to examine the negative relationship ($r = -0.36$) between autistic tendencies and physical exercise. Using a new scale of physical activity Study 2 showed that the negative relationship is moderated by the type of activity (teams sports, activities that can be performed alone, etc.), the aerobic intensity of the exercise, and the social and communicative demands of the activity. Both studies replicated our previously published work showing that self-reported team-sports ability predicts better performance on standard measures of executive functioning. The positive relationships between autistic tendencies in typical college students and some measures of executive functioning support recent research using participants with diagnosed deficits that "symptoms" on the autistic spectrum are in some contexts beneficial.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C41 The effects of task switching on alpha and gamma oscillations predict behavioral switch costs

Amy L. Proskovec^{1,2}, Alex I. Wiesman², Tony W. Wilson^{1,2}; ¹University of Nebraska - Omaha, ²University of Nebraska Medical Center

Cognitive flexibility is often examined using task-switch paradigms, in which individuals either switch between tasks or repeat the same task on successive trials. The behavioral costs of switching in terms of accuracy and reaction time are well established, but the oscillatory dynamics underlying such costs are poorly understood. Thus, we examined 25 healthy adults who performed a task-switching paradigm during magnetoencephalography (MEG). All MEG data were transformed into the time-frequency domain and significant oscillatory responses were imaged separately per condition (i.e., switch, repeat) using a beamformer. To determine the impact of task switching on the neural dynamics, the resulting images were investigated using paired-samples t-tests. Whole-brain correlations were also computed using the switch-related difference images (switch – repeat) and the switch-related behavioral data (i.e., switch costs). Our key results indicated stronger decreases in alpha and beta oscillations, and greater increases in gamma oscillations in nodes of the cingulo-opercular and fronto-parietal networks during switch relative to repeat trials. Additionally, behavioral switch costs were positively correlated with switch-related differences in right frontal and inferior parietal alpha oscillations, and negatively correlated with switch effects in anterior cingulate and right temporoparietal gamma oscillations. That is, participants who had a greater decrease in alpha or increase in gamma in these respective regions had smaller behavioral switch costs, which suggests that these oscillations are critical to supporting cognitive flexibility. In conclusion, we provide novel data linking switch effects and gamma oscillations, and employed a whole-brain approach to directly link switch-related oscillatory differences with switch-related performance differences.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

C42 Characterizing the relationship between working memory capacity and load-related increases in fMRI activity

Catherine R. Walsh¹, Jean-Baptiste Pochon¹, Kristen D. Enriquez¹, Holly Truong¹, Agatha Lenartowicz¹, Sandra K. Loo¹, Catherine A. Sugar¹, Carrie E. Bearden¹, Robert M. Bilder¹, Jesse Rissman¹; ¹University of California, Los Angeles

A fruitful functional neuroimaging approach for identifying regions involved in working memory (WM) has been to vary the number of to-be-maintained items and examine the degree to which BOLD activity increases as storage demands increase. Studies using delayed-match-to-sample paradigms are capable of isolating WM load effects during both encoding and maintenance, but the relationship of such load effects to trait-level individual differences in WM capacity is under-explored. In the present study, we collected an extensive battery of behavioral measurements of WM capacity from a large sample (N=170) of adult participants, who also underwent fMRI scanning while performing a delayed face recognition task. Each trial of the fMRI task involved the encoding of one face (low load) or three faces (high load), which needed to be maintained across a 7.5 s delay period followed by a match/nonmatch discrimination. Regression analyses identified regions where the magnitude of load-related activity increases was predicted by individual differences in a composite index of WM capacity. Participants with higher capacity estimates showed significantly greater load effects in the intraparietal sulcus and frontal eye fields (regions commonly associated with top-down visuospatial attention) during the encoding-period. However, during the delay-period, capacity was disproportionately correlated with load effects in rostralateral and dorsolateral prefrontal cortex. Thus, the relationship of fMRI load effects to behavioral differences in WM capacity differs markedly as information processing progresses from stimulus encoding to active maintenance. This distinction may be critical for Research Domains Criteria (RDoC) efforts to relate neurocognitive markers of WM capacity to psychopathology.

Topic Area: EXECUTIVE PROCESSES: Working memory

C43 Concurrent alpha and gamma band synchronization coordinates the maintenance of visual features and object representation in working memory

Hamed Haque¹, Sheng H. Wang¹, J. Matias Palva², Satu Palva²; ¹Helsinki Institute of Life Sciences, Neuroscience Center, University of Helsinki, Finland, ²Helsinki Institute of Life Sciences Neuroscience Center, University of Helsinki, Finland, Center for Cognitive Neuroimaging, Institute of Neuroscience and Psychology University of Glasgow, UK

Visual working memory (VWM) sustains visual information online for future usage. The information is maintained as integrated object representations rather than as a collection of sensory features. However, the mechanisms underlying the maintenance of sensory features and object representations in VWM is poorly understood. We investigated whether large-scale synchronization of neuronal oscillations could be such a mechanism. We recorded concurrent magneto- and electroencephalography (MEEG) from 21 healthy human participants during a delayed-match-to-sample task in which the participants memorized different features or feature conjunctions. We then estimated phase synchronization among all cortical parcels and frequencies between 3 to 120 Hz from source-reconstructed MEEG data. Phase synchronization in the high-alpha (10-13 Hz) and gamma (30-60 Hz) bands characterized memory retention in all conditions. Alpha- but not gamma-band synchronization was also strengthened by the working memory load. Alpha-band synchronization was observed primarily within visual and between visual and frontal regions while gamma-band synchronization connected brain regions within and between frontoparietal and dorsal attention networks. These results support the idea that concurrent large-scale alpha and gamma band synchronization coordinates the maintenance of visual features and coherent object representation in memory.

Topic Area: EXECUTIVE PROCESSES: Working memory

C44 Independent representation of active and latent decision boundaries in working-memory-guided behavior

Paul Muhle-Karbe^{1,2}, Mark G. Stokes^{1,2}, Nicholas E. Myers^{1,2,3}; ¹Department of Experimental Psychology, University of Oxford, ²Oxford Centre for Human Brain Activity, Wellcome Centre for Integrative Neuroimaging, University of Oxford, ³Helen Wills Neuroscience Institute, UC Berkeley

Recent evidence suggests that working memories (WM) are encoded in qualitatively different states depending on their momentary task-relevance. Relevant items are thought to be encoded in spiking activity that is primed to drive behavior, whereas currently irrelevant items can be held in a latent state that minimizes interference but is accessible later. It is unclear how latent working memories are transformed to drive active decision circuits when behavioral priorities change. We used time-resolved decoding of WM items using electroencephalography (EEG) in a task that required cued priority switches between decision boundaries, permitting independent decoding of active and latent boundaries on trials when their priority status switched (requiring transfer from a latent to an active state) vs. when the priority status was repeated. WM switches created transient performance costs that recovered after a single trial. EEG revealed that this behavioral cost is driven by lingering over-representation of the latent item. On priority switch trials, both the newly active and the previously active item could be decoded. Intriguingly, active and latent items were represented in distinct neural patterns: training a decoder on the active item did not permit decoding of the latent one, and vice versa. Importantly, the magnitude of latent item decoding tracked participants' performance cost after switches. On priority repeat trials, only the active item could be recovered from EEG activity, with decoding of the latent item returning to chance. These findings suggest that priority shifts incur transient competition between items for active representation.

Topic Area: EXECUTIVE PROCESSES: Working memory

C45 Individuals with autism exhibit atypical pupillary responses under cognitive load

Michael C. Granovetter^{1,2}, Charlie S. Burlingham³, David J. Heeger³, Marlene Behrmann¹; ¹Carnegie Mellon University, ²University of Pittsburgh, ³New York University

One proposal for a neural mechanism underlying features of autism spectrum disorders (ASD) is that there is a disruption in the homeostasis of cortical excitation and inhibition. Norepinephrine is a global modulator of the balance of excitatory and inhibitory neural activity and is critical for regulating an array of cognitive processes. Using pupillometry—a non-invasive technique for inferring cortical norepinephrine release—we investigated whether individuals with ASD exhibit inherent differences in pupillary responses, relative to typical individuals, in the context of a one-back working memory task. 16 adults with autism and 16 neurotypical age-matched controls performed a one-back letter detection task while pupil size was continuously measured at a rate of 1000 Hz. There were no significant differences in the number of correct responses to repeated letters between individuals with ASD and controls. However, there were between-group differences in the impulse response function (IRF) of pupil dilation during correct responses: a support vector machine, trained iteratively with a random subset of individual participants' IRFs, revealed above chance accuracy in classification of group (autism, typical) on data from left-out participants. These findings indicate that even on a task in which behavioral performance by ASD individuals is comparable to that of neurotypical controls, there are nonetheless group differences in pupil responses. This suggests that cortical norepinephrine (and potentially acetylcholine) is modulated differently in individuals with ASD.

Topic Area: EXECUTIVE PROCESSES: Working memory

C46 Neural Underpinnings of Orthographic Working Memory: Inferences from Lesion Data

Venu Balasubramanian^{1,2}; ¹Seton Hall University, ²Johns Hopkins University School of Medicine

Early neuropsychological models of writing postulated the existence of orthographic working memory (OWM) but conceded that its neural underpinning was unknown (Roeltgen, 1993). A few cognitive neuropsychological case reports of dysgraphia as well as fMRI studies reported OWM impairments following lesions of left temporo-parietal lesions (Balasubramanian et al, 2013), right cerebellar cortex (Fischer-Baum et al, 2018), intraparietal sulcus (Rapp et al 2016), and left frontal, parietal, temporal lobe, and cortico-subcortical lesions (Cloutman et al, 2009). Thus, the neural underpinnings of OWM are not clear at this point. The current study examines the lesion characteristics in four cases with agraphia. Methods. Subjects. CBH, a 59-year-old, right-handed female with a history of bilateral parietal lobe lesion, JL, a 66-year-old, right-handed female with left posterior temporo-parietal cortex and bilateral white matter atrophy, LK, a 45-year old, right-handed male with an infarct involving the left temporal region and a portion of the left frontal cortex, and basal ganglia (BG), SE, a 69-year-old right-handed female, with lesion in the right frontal lobe and the right head of caudate and putamen. Procedure. Clinical evaluation included administration of the Boston Diagnostic Aphasia Examination (BDAE). Experimental tests administered include 1) Johns Hopkins University Dysgraphia Battery and 2) Psycholinguistic Assessment of Language Performance in Aphasia (PALPA), specifically the letter length subtests of Reading and Spelling Tests. Results: Impaired OWM was evident in all four subjects. The lack of convergence of results from the previous imaging and lesion studies, including the present one, warrants further research, possibly using network/connectome theory.

Topic Area: EXECUTIVE PROCESSES: Working memory

C47 Prefrontal Control of Cross-Frequency Coupling in Posterior Regions

Elizabeth Johnson^{1,2}, Mohsen Dezfouli³, Saeideh Davoodi³, Robert Knight¹, Mohammad Daliri³; ¹University of California, Berkeley, ²Wayne State University, ³Iran University of Science and Technology

How does the human brain orient attention to relevant information in working memory (WM)? The prefrontal cortex (PFC) is widely considered to play a crucial role in WM, but the mechanisms of prefrontal control over more posterior regions are not well-understood. Previously, we showed that WM for everyday 'what', 'where', and 'when' associations depends on multiplexed oscillatory systems, in which signals of different frequencies support bidirectional interactions between the PFC and posterior regions. Here, we sought to further examine the (1) cross-frequency coupling (CFC) mechanism of information selection, a purported neural code for WM, and (2) causal role of the PFC in supporting this mechanism. Fourteen individuals with unilateral PFC lesions and 20 age- and education-matched controls completed a single-trial WM task while 64-channel electroencephalogram (EEG) data were collected. On each trial, two common shapes were presented sequentially in a top/bottom spatial orientation. A test cue was then presented mid-delay to retroactively cue information relevant to one of four spatiotemporal features of the shape pair being maintained in WM. In healthy controls, selection of the relevant top/bottom spatial feature or first/second temporal feature was linked to CFC between alpha phase and gamma amplitude in temporo-parietal regions. WM performance and CFC were attenuated in the PFC lesion group. These results reveal a posterior CFC mechanism for orienting attention to relevant information in WM and a functional role for the PFC in governing this mechanism. Findings are considered in the context of different models of prefrontal control over WM.

Topic Area: EXECUTIVE PROCESSES: Working memory

C48 Top-down modulation of delayed response for visual short-term memory

Bo-Cheng Kuo¹; ¹National Taiwan University

Previous evidence has revealed that top-down mechanisms can modulate the maintenance-related activity of visual short-term memory (VSTM). However, little is known that whether the VSTM retrieval/comparison process can be influenced by the same mechanisms. To address this I exploited alpha-band activity (8-14 Hz) as an index of spatiotopically selective processes with electroencephalography (EEG). Participants (N = 17) performed a cued variant VSTM task in which they viewed a memory array of four peripheral items, followed by a short delay, and later by a probe array of four items. A spatially informative cue was presented to shift attention either to the location of a to-be-remembered item during the delay (retro-cues), or simultaneously with the probe (post-cues). Participants decided whether the probe item was the same as the cued item from the memory array. I found that the retro-cues benefit delayed responses relative to the post-cues. I analysed the time-frequency alpha power and phase-locking value (PLV) from the EEG data based on the probe onset. I showed a significant posterior alpha lateralisation with decreased power contralateral to the attended hemifield and increased power contralateral to the unattended hemifield preceding the probe onset for the retro-cue trials. Moreover, I found a significant lateralised PLV with higher PLV contralateral to the attended hemifield than the PLV contralateral to the unattended hemifield during the comparison process only for the retro-cue trials. No such effect was observed for the post-cue trials. Together, these results elucidate that top-down mechanisms can modulate comparison process for delayed responses.

Topic Area: EXECUTIVE PROCESSES: Working memory

C49 Transcranial direct current stimulation over bilateral anterior temporal lobes modulates hippocampal-occipital functional connectivity and visual working memory precision

Weizhen Xie^{1,2}, Lilian Azer¹, Hyung-bum Park¹, Marcus Cappiello¹, Weiwei Zhang¹; ¹University of California, Riverside, ²National Institutes of Health

Although the medial temporal lobe (MTL) is traditionally considered a region dedicated for long-term memory, recent neuroimaging and intracranial recording evidence suggests that the MTL may contribute to certain aspects of mnemonic representations, including those in working memory. The current study examines whether and how the MTL contributes to precision of visual working memory (VWM) representations using transcranial direct current stimulation (tDCS) and functional magnetic resonance imaging (fMRI). On different sessions/days, participants received 1.5 mA offline tDCS over bilateral anterior temporal lobes (ATL) with left cathodal and right anodal electrodes for either 20 min (active) or the first 1 min of a 20-min time window (sham) in a counterbalanced order. Immediately afterward, they performed a VWM color recall task inside a fMRI scanner for 20 min, followed by a 7.5-min resting-state fMRI scan, during which participants were looking at a fixation cross on the screen. Behavioral results showed that tDCS over ATL reduced VWM precision, with little effect on the number of retained VWM items. In addition, ATL tDCS modulated hippocampal-occipital functional connectivity during the VWM task in a psychophysiological interaction analysis using the left hippocampus as a seed, even though no main effect of tDCS on MTL activity was obtained. Critically, this disruption in hippocampal-occipital functional connectivity was also observed during resting-state fMRI at more than 20 min after tDCS. Together, these results suggest that tDCS over bilateral ATL could impact intrinsic functional association between MTL and occipital cortex, leading to reduced VWM precision.

Topic Area: EXECUTIVE PROCESSES: Working memory

C50 Conflict Monitoring and Resolving Lexical-Prosodic Incongruence of Emotion Prosody Identification in Children with High-Functioning Autism

Feng-Ming Tsao¹, Wei-Chin Hsu², Hwei-Mei Liu³; ¹National Taiwan University, ²National Taiwan University of Science and Technology, ³National Taiwan Normal University

Children with high-functioning autism (HFA) suffer from emotional prosody production impairment, however, studies reported mixed results on emotional prosody perception. In lexical-prosodic incongruent words, e.g., "happy" with sad prosody, listeners monitor the lexical-prosodic conflicts, then utilize pitch information to recognize emotions. Additionally, listening experience with lexical tones might facilitate tone-language speaking HFA children to perceive pitch patterns of emotional prosody. This fMRI study aimed to explore brain correlates between monitoring conflicts and recognizing emotion prosody in HFA children. School-aged HFA children (n = 10, 8-12 years of age) and typically-developing (TD, n =11) children participated in this study. The fMRI tasks were blocks of emotional prosody and lexical tone. In emotional prosody task, stimuli were emotion words, varying with emotional prosody (sad, happy, and neutral). In lexical tone task, stimuli were [pa] from the Tone 2 (rising) to Tone 4 (falling) lexical tone continuum. In each fMRI trial, participants heard speech stimuli, then recognizing emotions or lexical tones accordingly. When prosody was incongruent with lexical meaning of words, results of fMRI analysis showed the deactivations of HFA children than TD children in Wernicke's area, Broca's area, inferior parietal lobule, and precuneus. In contrast, the HFA children exhibited stronger activation than TD group in prefrontal cortex (BA10) and anterior cingulate cortex (ACC). The correlation analysis showed positive associations between activation level (BOLD signal change %, in ACC & BA10) and recognizing emotional prosody. The results implicated that HFA children combine monitoring lexical-prosodic conflicts and inferring other's mind to recognize emotion prosody.

Topic Area: LANGUAGE: Development & aging

C51 Electrophysiological correlates of auditory discourse processing in bilinguals across the lifespan

Angela Grant^{1,2}, P. Tristin Best¹, Natalie Phillips^{1,2}; ¹Concordia University, ²Centre for Research on Brain, Language, and Music

Our study examines auditory discourse comprehension in highly proficient English/French bilinguals. We compare a capacity view of language comprehension, which predicts reduced sensitivity to discourse compared to lexical cues in the second language (L2) due to increasing working memory demands, with the noisy channel model, which predicts the reverse. We tested young (18-35 yrs; n=32) and older (60+ yrs; currently n=7) bilinguals, as increasing age is associated with declines in working memory. The two groups are matched on education and the older adults (OAs) were screened for normal vision and hearing. The OA performance on the operation span task is both lower (M=69.4%) and more variable (SD=27.5%) than younger adults' (YA; M=82%, SD=16%). Our ERP paradigm uses three-sentence stories with prime and target words in the final sentence whose lexical association is manipulated, as is the congruence of the target with the preceding discourse. For YAs, we found that the N400 effect was sensitive to discourse congruence, but was qualified by an interaction such that the effect of discourse congruence was larger and more widespread regardless of lexical association in the L2, whereas the topography of the L1 effect was sensitive to lexical association. For OAs, we also observe a discourse congruence effect, which is later (700ms) compared to the young adults and limited to the L1. The differential sensitivity to L2 discourse cues with age provides partial support for both models, indicating a need for a more nuanced view of each that accounts for age-related changes in cognition.

Topic Area: LANGUAGE: Development & aging

C52 Parental Reflective Functioning and Children's Emergent Reading Skills: ERP and longitudinal behavioral measures

Airey Lau^{1,2}, Karen Froud², Kenneth Pugh^{1,3}; ¹Haskins Laboratories, Yale University, ²Teachers College, Columbia University, ³University of Connecticut

The conventional approach to education relies on schools to teach children skills that are necessary for future success. However, there is overwhelming evidence that parental involvement is also critical for the development of many cognitive skills crucial for learning. One theory that explores parental influences on learning suggests that parents who have high reflective functioning skills are better able to prepare their children for social and cognitive skills (such as pre-literacy skills) acquisition. This study aims to investigate if parental reflective functioning skills are correlated with children's pre-literacy skills (e.g. phonological awareness) and reading-related neural development. The current study used the event-related potential (ERP) method to investigate whether young children whose parents have higher reflective functioning exhibit a left-lateralized neural response to a phoneme-discriminating task typically seen in skilled readers. Preliminary results from 17 pre-readers suggest that activation of regions in the left temporal cortex (indicated by the presence of N2 and P2 ERP components during a phoneme-decoding task) is correlated with better phonological awareness and with higher parental reflective functioning skills. In addition, parental reflective functioning skills, along with the children's phonological awareness, are shown to be significant predictors of children's reading ability one year later. This study suggests that parental influence may play a crucial role in children's reading and neural development, thus providing important implications on the need to reform parental leave policies.

Topic Area: LANGUAGE: Development & aging

C53 Segmentation of the Frontal Aslant Tract (FAT) and its relation to verbal fluency development in children

Dea Garic¹, Diana P. Behar¹, Hector Borges¹, Valentina Lino¹, Armando Torres¹, Anthony S. Dick¹; ¹Florida International University

The frontal aslant tract (FAT) is a bilateral long association fiber pathway (Catani et al, 2012) that is thought to play an important role in verbal fluency and speech production (Dick, Garic, Graziano, & Tremblay, 2018). The FAT is most commonly thought to connect the inferior frontal gyrus (pars opercularis and pars triangularis) to the pre-supplementary motor area (pre-SMA) and supplementary motor areas (SMA) (Catani et al, 2013). Since it is frequently thought of as a language pathway, most studies have focused on only the left hemisphere FAT. Our study aims to expand on previous findings by examining the relationships between both the left and right hemispheric segments of the FAT and verbal fluency. We tracked the FAT in 129 typically developing participants (70 females, age= 0-18 years, M=8.67) and related the microanatomical properties of the FAT with NEPSY II verbal fluency outcomes. Results show that higher mean diffusivity of the left FAT is related with higher scores on the scaled semantic NEPSY II measure for both the pre-SMA to pars opercularis segment ($\beta=.93, p<.05$) as well as for the pre-SMA to pars triangularis segment ($\beta=.93, p<.05$). Inversely, higher mean diffusivity in right FAT predicts lower scores on scaled phonemic NEPSY II measures for both the pre-SMA to pars opercularis segment ($\beta=-1.21, p<.05$) as well as the SMA to pars triangularis segment ($\beta=-1.23, p<.05$). These findings provide initial support that the right and left FAT could serve different functions for language development.

Topic Area: LANGUAGE: Development & aging

C54 Bilingual Language Processing: An ERP Study of Cognate Status

Yazmin E. Medina¹, Jamie Renna¹, Phillip J. Holcomb¹, Katherine J. Midgley¹; ¹San Diego State University

Bilinguals have the ability during a conversation in one language to manage activation of words in the other language. To investigate the underlying mechanisms of between language activation, we previously used a production task in which Spanish/English bilinguals had to translate displayed words into the other language (see "perro" say "dog", see "table" say "mesa"). Words included cognates, non-cognates and false-cognates (false-cognates share form but differ in meaning). We did not observe the typically larger N400 for non-cognate or false-cognate items, but for false-cognates, consistent with the increased demands required to suppress the production of the form-overlapping incorrect translation, we found a greater late negativity (~800 ms). The present study explores differences between that task and a language-comprehension task using the same items. We predicted that the demands of comprehension (i.e. greater competition in lexical-semantic processing for non-cognates and false-cognates) would emerge on the N400. In the same participant population in San Diego, we used a go/no-go semantic comprehension task (press to animal names in either language). When summing across languages, consistent with prior research, our Spanish/English bilinguals showed a subtle yet predicted pattern of differences between the three types of items in the N400 epoch; false-cognates showed the largest N400, followed by non-cognates and then cognates. Interestingly, unlike prior results for cognates, L1 (Spanish) items showed the largest effects. Comparable effects in English (L2) were much smaller. This pattern, reversed in predictions for L1 and L2 cognate effects, may reflect a change of dominance for reading in these bilinguals.

Topic Area: LANGUAGE: Lexicon

C55 Distinct effects of intensive perceptual and articulatory rehearsal in neural learning of novel word-forms with familiar and unfamiliar phonology

Lilli Kimppa¹, Teija Kujala¹, Taru Käkönen¹, Mira Roikonen¹, Mika Koverola¹, Ilari Kousa¹, Lari Linden¹, Yury Shtyrov²; ¹University of Helsinki, ²Aarhus University

Behavioural learning and neural memory-trace formation for new words can be accomplished rapidly, after brief perceptual exposure. Whether such neural learning operates for active productive rehearsal, an essential part of normal language learning, is not known. We compared the effects of perceptual and articulatory training in learning novel spoken word-forms with familiar and unfamiliar phonology. EEG was recorded during repetitive exposure (160 trials) to acoustically closely matching native words as well as novel native and non-native word-forms. Stimuli were first familiarised by passive listening, after which they underwent further attentive listening or articulation and a final passive exposure period. Behavioural discriminability of the learnt items did not differ significantly between perceptual and articulatory conditions, akin to previous findings with longer training periods. All word types were recognised well above chance; the native forms better than non-native forms. The stimuli elicited two negative-going responses (50 ms and 140 ms) after word disambiguation point. Response increase at ~50 ms was previously reported to reflect memory-trace formation to new words. The novel native forms manifested a significant response increase within the first 50 trials in both active training periods. For the novel non-native items, similar increase occurred during articulatory rehearsal only. However, comparison of responses before and after training revealed a significant increase to non-native items in the perceptual condition, implying that extended exposure was required for the memory-trace formation. In conclusion, both rehearsal methods enhance the memory-trace formation for new native words while rapid neural learning of non-native word-forms benefits from articulation.

Topic Area: LANGUAGE: Lexicon

C56 Interactions between transposed-letter ERP priming effects and orthographic neighborhood density

Cecile Mahnich¹, Jonathan Grainger², Phillip Holcomb¹, Gabriela Meade^{1,3}; ¹San Diego State University Research Foundation, ²Laboratoire de Psychologie Cognitive, Aix-Marseille Université & CNRS, ³University of California, San Diego

Transposed letter (TL) primes are formed by flipping two letters in a word (e.g., huose-HOUSE). These primes facilitate processing of targets more so than substitution primes in which the letters in these same positions are replaced (e.g., hvese-HOUSE). More specifically, the TL priming effect is characterized by faster lexical decision responses and smaller amplitude N400s for targets following TL primes compared to those following substitution primes. If words were represented such that each letter was assigned to a specific position, then these two types of primes should be equally as effective at activating the target representation. Rather, these results are interpreted to suggest that there is some degree of flexibility in the letter positional coding scheme. Here, we asked whether the degree of this flexibility differs as a function of orthographic neighborhood density. We reasoned that words from high-density orthographic neighborhoods (i.e., that look similar to many other words in the lexicon) should be represented more precisely. If this is true, then TL primes should be less effective at activating the corresponding lexical representation and we should find smaller TL priming effects for high-density neighborhood words. We found evidence of TL priming for both high- and low-density neighborhood words with the most notable difference between conditions being in terms of the distribution of the N400 effect. These results suggest that lexical representations are flexible enough to be activated by TL primes, even when the word comes from a high-density orthographic neighborhood.

Topic Area: LANGUAGE: Lexicon

C57 The critical connection: How damage of the arcuate fasciculus impacts language processing in aphasia

Maria V. Ivanova^{1,2,3}, Allison Zhong¹, And Turken², Brian Curran², Nina F. Dronkers^{1,2,4}; ¹University of California, Berkeley, CA, USA, ²Center for Aphasia and Related Disorders, VA Northern California Health Care System, Martinez, CA, USA, ³National Research University Higher School of Economics, Center for Language and Brain, Moscow, Russia, ⁴University of California, Davis, CA, USA

The aim of the study was to determine specific contributions of the arcuate fasciculus (AF) to language abilities in post-stroke patients with aphasia (n=33). Structural and diffusion-weighted MRIs (64 directions, 2mm isovoxel, b=2000s/mm²) were performed on a Siemens Verio 3T scanner. Deterministic tractography based on spherical deconvolution was used to determine the macro- (normalized tract volume) and microstructural (Hindrance Modulated Orientation Anisotropy) integrity of the AF. The AF in the left and right hemispheres were manually reconstructed using a modified 3-segment model (Catani, Jones, & ffytche, 2005) and a modified 2-segment model (Glasser & Rilling, 2008). Overall, the AF and its subsegments were significantly related to an array of language abilities (as indexed by the Western Aphasia Battery). After accounting for lesion volume, the long segment (connecting inferior frontal areas with posterior temporal) was related to a broad range of language comprehension abilities, while the posterior segment (connecting temporal areas to inferior parietal cortex) – to lexical-semantic processing. When damage to specific cortical areas was taken into account, the long segment of the AF remained an important predictor for comprehension abilities, while the posterior segment of the AF continued to make a vital contribution to lexical-semantic processing, as well as overall language abilities. The right AF was not significantly related to language outcomes. Our results highlight the

contribution of the AF and its subcomponents beyond known cortical language areas and point to the importance of considering additional tract segments that should also be incorporated into future models of language processing.

Topic Area: LANGUAGE: Lexicon

C58 Tracking the time-course of visual word recognition using different types of word-like stimuli

Natasja Massa¹, Karen Emmorey¹, Katherine J. Midgley¹, Phillip J. Holcomb¹; ¹San Diego State University

The ability to rapidly recognize visually perceived words is fundamental to skilled reading. The present study used ERPs to track the time-course of the neuro-cognitive processes involved in visual word recognition. Prior work has shown that the lateral distribution of the N170 is sensitive to early processing differences between linguistic (words) and nonlinguistic (symbol strings) stimuli, while later ERP components such as the N250 and N400 are sensitive to sub-lexical and lexico-semantic processes, respectively. We contrasted ERPs to minimally different categories of word-like visual stimuli in a group of monolingual English speakers engaged in a go/no-go repetition detection task. ERPs were time-locked to five types of visual stimuli including words (e.g., “table”), pseudohomophones (e.g., “brane”), pseudowords (e.g., “wruck”), random consonant strings (e.g., tblnr), and strings of symbols (e.g., \$%&*^). The early N170 was larger over the left hemisphere compared to the right hemisphere for all stimuli composed of letters, while symbol strings generated a more bilateral response. There was no difference in the laterality of the early N170 among any of the letter-based categories and it was only slightly later (after 200 ms) that these stimulus categories started to differ. Between 200 and 300 ms there were differences between consonant strings and the three orthotactically legal stimuli (which did not differ from one another). All three orthotactically legal categories produced greater negativities than either consonant strings or symbol strings. These results will be discussed in the context of recent models of word recognition and orthographic tuning.

Topic Area: LANGUAGE: Lexicon

C59 A concurrent investigation of relationships between language production and comprehension in schizophrenia

Eric J Tan^{1,2}, Susan L Rossell^{1,2}; ¹Centre for Mental Health, Swinburne University of Technology, Melbourne, Australia, ²Department of Psychiatry, St Vincent's Hospital, Melbourne, Australia

Deficits in both language production and comprehension are a recognized aspect of schizophrenia. Predominant communication models of language processing in healthy individuals posit a feedback-type relationship between elements of production and comprehension where both are linked and active during speech. This maiden investigation aims to clarify this association between language production and comprehension in schizophrenia across both single words and sentences. 43 DSM-IV diagnosed schizophrenia/schizoaffective disorder patients (mean age=41.67, standard deviation=9.89) were recruited. Audio recordings were made during conversations with the interviewer on general topics including daily activities, social and general functioning and current mood. Recordings were transcribed and analysed using the Systematic Analysis of Language Transcripts (SALT) software from which language production variables were extracted, including type-token ratio, single word speech errors, and sentence-level errors. All participants also completed two language comprehension tasks assessing single word and sentence comprehension. Spearman's correlations indicated that within the patient group, better single word comprehension performance was significantly associated with better type-token ratio, increased single word omissions and more word errors (p<.01). Better sentence comprehension performance was significantly associated with better type-token ratio and a reduced number of utterances with omissions and lesser sentences with

phrasing errors ($p < .01$). These original findings are aligned with previous work suggesting a concordance between healthy language production and comprehension processing. It occurs across different language levels and that there is an intact language feedback loop in schizophrenia. This has implications for understanding the mechanisms underlying communication disturbances in schizophrenia and informs avenues of potential remediation.

Topic Area: LANGUAGE: Other

C60 The Supplementary Use of Praat in order to Effectively Train Phonemic Awareness

Rebekah Tozier¹, Ethan Torpy², Kytja Voeller³; ¹Western Institute for Neurodevelopmental Studies and Interventions

Phonemes are the smallest meaningful units of speech sound. Phonemic Awareness (PA) requires the ability to relate the speech sound to the mental representation of the oral-motor movements which create the sound. This ability has been shown to underlie successful phonological processing and literacy development. Studies suggest that the primary, underlying component of phonemic awareness is the ability to feel and describe these oral-motor gestures and relate them to specific phonemes. Individuals who lack PA also lack the ability to feel/describe the oral-motor movement that create phonemes. We have developed a systematic, research-based training program for children with dyslexia. Our focus is to identify ways in which to improve the training process. The case studies presented here demonstrate how Praat (phonetic processing software) produces a visual graphic representation of sound waves, which feature intensity, formant, and pitch, as well as a spectrogram. This Describes the effectiveness of using Praat as an adjunctive treatment to increase the effectiveness of PA training. Four subjects who had made little progress after numerous training trials showed very rapid improvement in accuracy when we introduced Praat into their treatment programs. One child initially struggled to master phonemes (average of 38 trials for three consonants pairs). After Praat was introduced, he accurately analyzed speech features, such as aspiration and voicing. Using Praat to examine his speech sounds provided rapid feedback. Within just one week, the child's accuracy for speech sounds had increased to 100% accuracy.

Topic Area: LANGUAGE: Other

C61 Benefits of semantic predictability to the on-line building of linguistic structures

Yayue Gao¹; ¹Zhejiang University

Speech comprehension profits from prior knowledge, e.g., semantic predictability. However, the underlying neural mechanism of semantic benefits remains unclear. In a speech stream, one possibility is that semantic predictability facilitates the neural representations of all the linguistic units including sentences, phrases and words. Another is that semantic predictability has influences on the building of linguistic structures, i.e., it facilitates the neural representation of superordinate structures (e.g., sentences) and suppresses that of subordinate linguistic structures (e.g., phrases). The current study investigated how semantic predictability modulated the mental construction of linguistic structures. When participants were listening to isochronous syllable sequences, neural responses tracking the syllabic, phrasal and sentential rate were concurrently monitored using magnetoencephalography (MEG). The semantic predictability, between phrases within a sentence, was manipulated in varying levels. Results showed that, in a quiet listening environment, the semantic predictability had influences on the structure building, i.e., it facilitated sentential responses and suppressed phrasal responses at bilateral auditory cortices. In a noisy listening environment, the semantic predictability had similar influences on the structure building at bilateral auditory cortices and furthermore facilitated both sentential responses and phrasal responses at the right sensorimotor cortex.

Altogether, during on-line speech comprehension, there are two patterns of semantic benefits: Semantic predictability 1) mainly has influences on the building of linguistic structures and 2) furthermore facilitates the neural representation of all linguistic units in a noisy listening environment.

Topic Area: LANGUAGE: Semantic

C62 Delta-gamma phase-locking indexes composition of predicates

Jonathan R. Brennan¹, Andrea E. Martin²; ¹University of Michigan, ²Max Planck Institute for Psycholinguistics

Neuronal assemblies putatively carry and exchange information through cross-frequency coupling (CFC; Lisman & Jensen, 2013). In speech and language processing, CFC may integrate information on different timescales (e.g., linking acoustics signals to phonemic and syllabic representations; Giraud & Poeppel, 2012). A natural extension of this claim is that CFC functions similarly to support the inference of more abstract higher-level linguistic structures (Martin, 2016). Hale et al. (2018) showed that syntactically-driven parsing decisions predict EEG responses in the time domain; here we ask whether phase synchronization (Canolty & Knight, 2010) between high frequency (i.e., gamma) bursts and lower-frequency carrier signals (i.e., delta, theta) increases as the abstract linguistic structures of compositional meaning (i.e., predicates, as denoted by the offset of verb and adjective phrases) accrue. We used a naturalistic story-listening EEG dataset from Hale et al. to assess the relationship between predication and cross-frequency phase alignment. We partitioned each participant's single-trial data into sets corresponding to words that completed one, two, or three or more phrases. Within each partition, we computed the pairwise circular correlation between phase across frequencies (delta, theta, gamma) per-subject. An effect was observed between delta and gamma bands when comparing between words that completed a single phrase with those that complete three or more phrases. The coordination of excitatory and inhibitory cycles across assemblies appears to increase with unfolding compositional meaning, resulting in phase-locking to predication. This may reflect the transfer of information between 'reader-integrator'-like ensembles (Buzsáki, 2010) that detect or infer linguistic structure and meaning.

Topic Area: LANGUAGE: Semantic

C63 Influence of event knowledge on semantic expectation and integration: An ERP study

Elisabeth Rabs¹, Francesca Delogu¹, Heiner Drenhaus¹, Matthew W. Crocker¹; ¹Saarland University

Psycholinguistic research has established that event knowledge influences a word's processing difficulty. Less clear, is the precise nature of this influence as indexed by ERPs: Some studies attribute it to semantic expectancy, reflected in N400 amplitude (Metusalem et al., 2012), while others attribute it to integration difficulties reflected in P600 amplitude (Delogu et al., 2018). We present an ERP study (N=32) in which context sentences introduced one active and one inactive event (either completed or didn't happen), such as "Roberta entered the pharmacy after leaving the post office / instead of going to the post office.", followed by a target sentence continuing either the active or the inactive event ("She handed over the prescription / parcel."). Amplitude differences between active-event and the two inactive-event targets, in the N400 or the P600 time window suggest that both components are sensitive to event knowledge. Targets matching the active event show a reduced N400 compared to targets matching either one of the inactive events. The P600 seems to be differentially affected by the two inactive-event targets: it is more pronounced over posterior electrode sites in an earlier (600-800ms) time window for targets matching the "not happening" event and more pronounced over fronto-central electrode sites in a later (800-1000ms) time window for

targets matching the completed event. Together, these results suggest that a) event knowledge provides facilitation for expected target words indexed by the N400, and b) the P600 is differentially sensitive to the nature of integration difficulty, for the two inactive conditions.

Topic Area: LANGUAGE: Semantic

C64 N400, dispositional affect and sentence processing

Veena Dwivedi¹, Janahan Selvanayagam²; ¹Brock University, ²Western University

We used event-related brain potentials (ERPs) in a sentence processing study to investigate modulation of the N400 ERP component by affective state. In this 2x2 study, 22 participants read sentences manipulated by direct object type (congruent vs. incongruent) and object determiner type (definite vs. demonstrative). Thus, sentences were of the form: (i) The connoisseur tasted the wine on the tour vs. (ii) The connoisseur tasted the #roof... and (iii) The connoisseur tasted *that wine ... vs. (iv) The connoisseur tasted *that #roof... We expected that ERPs at incongruent direct objects (#roof) vs. congruent objects (wine) would elicit N400 effects. Furthermore, given that in the absence of previous context, using the demonstrative determiner that is also anomalous, we expected that this additional violation would amplify the N400 effect in (iv), the 'double violation' condition (Hagoort, 2003). Next, affective state is known to influence cognitive processing (Loftus et al., 1987). Here we investigate whether this relation extended to linguistic processing. Regarding affect, we hypothesized that individuals with more positive traits would display a more global processing style (Chwilla et al., 2011). These individuals would therefore be more sensitive to violations in meaning that were derived from pragmatic context and/or experience in the world (also called 'heuristics'). Results revealed a significant N400 effect, for definite #roof vs. wine, where amplitude differences correlated with individuals displaying more positive traits. Interestingly, N400 effects were attenuated for that wine/that #roof. We discuss these results in terms of the negative-going waveform observed at the determiner position.

Topic Area: LANGUAGE: Semantic

C65 Native language affects visual processing by activating categorical template of objects via the modulation of alpha oscillations

Piermatteo Morucci¹, Francesco Giannelli², Nicola Molinaro¹; ¹Basque Center on Cognition Brain and Language, ²University of Barcelona

Linguistic labels are known to facilitate visual processing during object recognition, detection and discrimination tasks. These effects have usually been explained within a predictive framework, which emphasizes the role of prior knowledge in shaping sensory experience. Under this view, verbal labels preactivate top-down categorical representations of the cued object, that alter subsequent bottom-up visual processes. Despite studies showing this label advantage to occur very early during visual processing, direct evidence of object preactivation is scarce. The present work aimed at (i) testing whether words affect visual perception by altering pre-stimulus activity in sensory areas; (ii) investigating whether multilingual experience modulates the label advantage. Twenty-six Basque-Spanish proficient bilinguals performed a cue-picture matching task with cues presented in Basque (L1) or Spanish (L2), while their EEG were recorded. Results showed that only words in L1 affected early processing of target images by modulating early electrophysiological signals associated with bottom-up visual processes, specifically the N150 and the activity in theta (4-7Hz). Crucially, time-frequency analysis of the interval between the word and the target image showed that words in L1 led to an increase of oscillatory activity in the alpha-band (8-12 Hz). This pre-target activity is likely to reflect the neural fingerprint of the preactivated object. These results suggest that words affect visual processing by activating categorical template of cued objects via the modulation of alpha oscillations, providing

strong evidence for a predictive view of language-perception interactions. Moreover, these findings suggest that early language exposure largely shapes the predictive mechanisms affecting visual perception.

Topic Area: LANGUAGE: Semantic

C66 Neural correlates for comprehending perspective-independent and perspective-dependent spatial expressions in ASL and English

Stephen McCullough¹, Christopher Brozdowski¹, Karen Emmorey¹; ¹San Diego State University

In ASL spatial relationships are conveyed by the location of the hands in space. To express "The candle is on the box," a 1-handshape representing the candle is positioned on top of a flat handshape representing the box. To understand perspective-dependent expressions (e.g., "The candle is to the right of the ball"), a 180° mental transformation is required for face-to-face signing. In contrast, English expresses spatial relationships with prepositional phrases, and no linguistic spatial transformation is required. In an event-related fMRI experiment, deaf ASL signers and hearing English speakers viewed ASL or audio-visual English descriptions of either a perspective-independent relation (in, on, below, above) or a perspective-dependent relation (left, right, behind, in front of) between two objects. The control condition was non-spatial descriptions of the colors of two objects (e.g., "The candle is blue and the ball is red"). After 20% of trials, a picture of two colored objects was presented that either matched or mismatched the spatial configuration or the colors described in the preceding sentence. In contrast to the non-spatial control, perspective-dependent expressions engaged the superior parietal lobule (SPL) bilaterally for both ASL and English. For perspective-independent expressions, activation in SPL was more right-lateralized for ASL and more left-lateralized for English. The direct contrast between ASL spatial expressions revealed greater SPL activation for perspective-dependent expressions, while the direct contrast for English revealed no difference in SPL activation between spatial expression types. The results suggest both overlapping and distinct neural regions support spatial language comprehension in ASL and English.

Topic Area: LANGUAGE: Semantic

C67 Preliminary ERP evidence for different rapid feedforward orthographic and phonological masked-priming effects

Hana Zimman¹, Stephanie Osmond¹, Karen Emmorey¹, Katherine J. Midgley¹, Phillip J. Holcomb¹; ¹San Diego State University

Several Event-Related Potential (ERP) studies have found that visual-word recognition is carried out largely in a rapid feedforward fashion, with orthographic processing preceding phonological processing, followed by semantic processing. In the present study, we extend this work to congenitally deaf readers who have less precise phonological representations. Here we report the initial results from hearing readers (data collection from deaf readers is on-going). In a masked priming paradigm participants performed a go/no-go semantic categorization task pressing to occasional animal names. ERPs were time-locked to target words preceded by masked primes (60 ms prime, 70ms SOA). Target words could be primed by themselves (Repetition Condition), or by an orthographically related item (Transposed Letter Condition, e.g., "syurp") or by a phonologically related item (Pseudohomophone Condition, e.g., "brane"). All three types of related targets were contrasted with appropriate control primes and priming was assessed in two time windows; the N250 (200-350 ms), and the N400 (350-550 ms). Similar to previous studies, hearing readers produced robust lexico-semantic N400 priming effects (350 to 550 ms) for all three categories of priming. However, while the effects of repetition priming and transposed letter priming started in the early N250 epoch, the effects of pseudohomophone priming did

not start until the later N400 epoch. These results are consistent with the fast feedforward model of visual word recognition and provide the baseline against which comparisons with deaf readers can be made. We predict that deaf readers will show stronger orthographic and weaker phonological priming compared to hearing readers.

Topic Area: LANGUAGE: Semantic

C68 Temporal Dynamics of lexical and semantic features of spoken words: an MEG study.

Lorenzo Vignali^{1,2}, Yangwen Xu^{1,2}, Jacopo Turini³, Olivier Collignon^{1,4}, Davide Crepaldi², Roberto Bottini^{1,2}; ¹University of Trento, ²International School for Advanced Studies, ³Goethe University, ⁴University of Louvain

The temporal dynamics of spoken word recognition are highly debated. While some studies suggest serial processing of sublexical and lexico-semantic information (e.g., Kocagoncu et al., 2017), others reported parallel processing since early stages (e.g., Lewis & Poeppel, 2014). The current study employed multiple linear regression to predict MEG-evoked responses in 20 native Italian speakers during the semantic judgment of 438 Italian spoken words. MEG responses were modeled around the uniqueness point (UP) based on four predictors: Lexical Neighborhood size (LN), word Frequency, Vision (a semantic regressor generated from the rating of several visual features in the database of Binder et al., 2016) and participants' response as a covariate of no interest. Sensor-level time course of event-related regressor coefficient (ERRC) showed LN-related activity from 350 ms before the UP to 240 ms after the UP, probably indicating lexical competition between similar wordforms. Frequency effects peaked at ~200 ms after the UP. The vision-related semantic regressor peaked at ~400 ms after the UP and remained significant. Source-level maps of ERRCs localized the LN effects in the bilateral supramarginal gyri and the superior temporal sulcus (STS). Frequency effects mapped mainly around the left STS and the inferior frontal gyrus (IFG). Early stages (~400 ms after the UP) of the Vision-related activity involved the bilateral IFG, the left STS, and the left ventral occipitotemporal cortex. Our results attested different processing stages of information associated with spoken words, in support for more serial information processing during spoken word recognition.

Topic Area: LANGUAGE: Semantic

C69 The language of arithmetic in children: solution correctness and problem size influence N400 amplitude

Danielle S. Dickson¹, Amandine E. Grenier¹, Nicole Y. Y. Wicha¹; ¹The University of Texas at San Antonio

Children's arithmetic fluency relies on accurate long-term memory representations for immutable arithmetic facts, including the correct answers to single-digit multiplication problems. Some of these facts appear to be less well-encoded and/or harder to retrieve than others. Most prominently, children are less fluent (slower/less accurate) at producing the answers to large problems (8 x 7) compared to small problems (4 x 3), a phenomenon known as the problem-size effect. This experiment utilized the prevalence of this effect to examine how semantic memory representations for arithmetic knowledge are structured and accessed in elementary school children. Online EEG was recorded as children judged the correctness of single-digit multiplication problems. Arithmetic problem size (small, large) and solution correctness (correct, incorrect) were manipulated in a 2x2 design. ERPs were measured time-locked to the proposed solutions. The amplitude of the N400, indexing semantic memory access, was compared across conditions. There were main effects of correctness and size, with more facilitated (smaller) N400s for small problems and correct solutions reflecting easier access to meaning given the preceding operations. There was also an interaction between size and correctness on the N400 because there was only an effect

of size on correct solutions and not on incorrect solutions. This suggests that at this stage in development, the N400 problem-size effect may be driven by differences in frequency of exposure to the full problem, which would only affect responses to correct solutions.

Topic Area: LANGUAGE: Semantic

C70 Paragrammatism: a lesion-symptom mapping study

William Matchin¹, Alexandra Basilakos¹, Dirk den Ouden¹, Brielle Stark², Julius Fridriksson¹, Gregory Hickok³; ¹University of South Carolina, ²Indiana University, ³University of California, Irvine

Kleist (1914) proposed two kinds of syntactic disturbances in the speech of patients with aphasia: agrammatism (the simplification of grammatical structure and omission of function words/morphemes), and paragrammatism (the misuse of grammatical elements and structures, leading to "sentence monsters"). Matchin and Hickok (in review) proposed that agrammatism results from damage to a morpho-syntactic sequencing system in the inferior frontal gyrus pars triangularis (IFGtri), while paragrammatism results from damage to a hierarchical syntactic system in the posterior middle temporal gyrus (pMTG). Although damage to the IFG is associated with agrammatism (Wilson et al., 2010; den Ouden et al., in review), the lesion distribution associated with paragrammatism is largely unknown. We performed a lesion-symptom mapping study in 29 patients with chronic aphasia secondary to a single-event left hemisphere stroke. Using the Kleist (1914) criteria, four expert raters classified patients' spoken narrative discourse samples as showing no deficit, agrammatic deficit only, paragrammatic deficit only, or both deficits, with consensus obtained through discussion. We tested three regions of interest (ROIs) previously associated with syntactic processing: the pMTG, the anterior MTG (aMTG), and the IFGtri. Damage to the pMTG was significantly associated with paragrammatism ($p = 0.0062$) and not agrammatism ($p = 0.7147$), damage to the aMTG was not significantly associated with either paragrammatism (0.1090) or agrammatism ($p = 0.0666$), and damage to the IFGtri was associated with agrammatism ($p = 0.0001$) but not paragrammatism ($p = 0.7610$). Our results support the hypothesis of Matchin & Hickok that paragrammatism results from damage to the pMTG.

Topic Area: LANGUAGE: Syntax

C71 Age differences in the neural underpinnings of voluntary vs involuntary memory retrieval.

Sarah E. Henderson¹, Jessica Callegari¹, James A. Desjardins¹, Sidney J. Segalowitz¹, Karen L. Campbell¹; ¹Brock University

Voluntary episodic memory relies on intentional controlled retrieval, while involuntary episodic memory comes to mind automatically. Consistent with findings of reduced executive control with age, recent work suggests that voluntary memory declines with age while involuntary memory is relatively preserved (Berntsen et al., 2017). However, the neurophysiology underlying these age differences has yet to be established. The current study used EEG to test 31 young and 34 older adults during voluntary vs involuntary retrieval (manipulated between-subjects). Participants first encoded sounds, paired and unpaired with pictures, during an initial behavioural session. EEG was then recorded as they listened to the sounds, with participants in the involuntary group deciding in which ear the sound was loudest, and those in the voluntary group additionally attempting to recall the associated pictures. Participants later listened to the sounds again and indicated if they had remembered the associated pictures during the sound task. Older adults said they remembered as many pictures as young adults (with no effect of voluntariness), but their objective memory was lower on a final cued recall test. ERP data suggest that the intention to retrieve shifts the entire processing function forward in time (as early as 100ms post-stimulus onset), while aging relates to a cumulative delay in processing. Only older adults in the involuntary

condition and young adults in the voluntary condition showed neural markers of successful retrieval. The findings suggest that involuntary memory may be better preserved with age than voluntary memory and the intention to retrieve affects early cue processing.

Topic Area: LONG-TERM MEMORY: Development & aging

C72 Autobiographically significant concepts within older and younger adults

Rachel Lambert¹, Anne-Marie Minihane², Saber Sami², Michael Hornberger², Louis Renault¹; ¹School of Psychology, University of East Anglia, ²Norwich Medical School, University of East Anglia

Previous investigations in Autobiographically Significant Concepts (ASC) have shown that when semantic concepts, such as famous names, become associated with a personal episode, these concepts become more episodic in nature. This results in superior recognition memory and increased amplitude of the late positive component (LPC) observed with EEG. The present study investigated ASC in older and younger adults and examined the impact of time and type of memory, associated factual knowledge and familiarity on the AS effect. Participants were 51 younger adults (18-35 years), and 48 older adults (65-85 years). They completed a Dead or Alive semantic judgement task on a series of famous faces, followed by an old-new episodic recognition task. A questionnaire was then administered to determine familiarity, factual knowledge and memory information associated with each of the presented stimuli. A subset of 19 older adults with APOE 3-4 or APOE 3-3 status completed the same tasks while their EEG was recorded. Results showed faster reaction times and higher accuracy for stimuli associated with a personal memory across both age groups. This AS enhancement effect was resilient when fact and familiarity were controlled for and was present irrespective of time or type of associated memory. Significant differences in the level of improvement was found between the two APOE groups within the semantic task, and there was a significant reduction in the LPC in older adults. This study provides insight into semantic-episodic interactions within older and younger adults, particularly the influence of episodic memory when completing semantic guided-tasks.

Topic Area: LONG-TERM MEMORY: Development & aging

C73 Effect of Aging Stereotype Activation on Older Adults' Memory and Neural Activity

Yung-Tsen Chen¹, Kelly E. Faig¹, Ian M. McDonough², Greg J. Norman¹, David A. Gallo¹; ¹The University of Chicago, ²The University of Alabama

Ageist stereotype threat can impact older adults' memory performance, but the underlying mechanisms are poorly understood. This is the first study using functional magnetic resonance imaging (fMRI) to examine the mechanisms underlying ageist stereotype effects in older adults. Sixty-nine cognitively normal participants (mean age = 63.6) were randomly assigned to either a stereotype activation or control group. On the first day all participants completed episodic and working memory tasks, and on the second day instructions explicitly activating aging stereotypes (or a control passage) was given just before they took these same tests during fMRI brain scanning. Behavioral results showed no overall stereotype effect on working memory or episodic memory performance, yet similar to prior work, regression analyses indicated that education and retirement status moderated the impact of stereotype activation on episodic memory performance. Self-report and physiological measures (e.g., heart rate variability) revealed that the stereotype manipulation did not increase anxiety or stress. Using fMRI, stereotype activation was found to increase activity in posterior midline regions (e.g., mid-cingulate, posterior cingulate cortex, and precuneus), which have been associated with processing stereotype threat and self-referential thoughts, as well as the superior and middle temporal gyrus, potentially

implicating emotion regulation. Stereotype activation also altered functional connectivity between these regions and prefrontal regions associated with self-relevant ideas and attentional focus. These results suggest that activating aging stereotypes might impact performance by activating task-irrelevant thoughts and associated changes in how older adults approach a task, but not necessarily by activating a threat or anxiety response.

Topic Area: LONG-TERM MEMORY: Development & aging

C74 Micro and macro sleep changes associated with tau and β -amyloid pathology in the aging human brain

Joseph Winer¹, Bryce Mander^{1,2}, Randolph Helfrich^{1,3}, Anne Maass^{1,4}, Theresa Harrison¹, Suzanne Baker⁵, Robert Knight¹, William Jagust^{1,5}, Matthew Walker¹; ¹University of California Berkeley, ²University of California Irvine, ³University of Oslo, ⁴German Center for Neurodegenerative Diseases, ⁵Lawrence Berkeley National Laboratory

The burden of Alzheimer's disease (AD), and the number of people it impacts, represents an unquestioned public health crisis. One key need is for the development of biomarkers of underlying AD pathophysiology that are sensitive, noninvasive and potentially scalable, but additionally, demonstrate independent sensitivity to each of the two hallmark features of AD—tau and β -amyloid (A β). A second interrelated issue is determining when, during the adult lifespan, such biomarkers begin showing their future forecasting sensitivity of AD pathology, measured in old age. In the present study we address these two issues by combining overnight polysomnography recording, retrospective sleep evaluations, and positron emission tomography (PET) measurements of A β and tau pathology in healthy older adults. Greater medial temporal lobe tau burden predicted the severity of impaired sleep spindle-slow wave oscillation coupling over the prefrontal cortex (0.47, $p=0.01$). β -amyloid burden was not associated with the degree of coupling impairment, but instead uniquely predicted the diminished amplitude of <1 Hz slow wave activity ($r=-0.36$, $p=0.04$). In addition, retrospective questionnaires revealed that self-reported changes in sleep duration over the lifespan were predictive of late-life A β and tau burden, but with distinct timing signatures for each pathology. These findings suggest that micro and macro measures of sleep can dissociably predict A β and tau burden, and indicate that sleep disruption may serve as a novel biomarker and possible therapeutic target in aging and dementia.

Topic Area: LONG-TERM MEMORY: Development & aging

C75 Predictors of individual differences in recognition memory in healthy ageing

Helena Gellersen¹, Ben G. Farrar¹, Alexandra N. Trelle², Richard N. Henson¹, Jon S. Simons¹; ¹University of Cambridge, ²Stanford University

This study investigated individual differences in recognition memory of perceptually similar objects in healthy ageing. We teased apart the contributions of strategic retrieval processes and representational quality by contrasting Forced Choice (FC) and Yes/No (YN) recognition memory tasks, where the latter places higher demands on strategic retrieval. 110 older and 55 young adults performed object recognition memory tests, neuropsychological tests measuring executive functioning (EF; as proxy for strategic retrieval abilities), and object and scene perceptual discrimination tasks with low and high feature overlap (as proxy for representational quality). Older adults performed worse on both high ambiguity discrimination tasks and had lower scores on both memory tasks. FC and YN scores were entered into two multivariate regression models with age, MoCA score, and low-level perceptual ability as control variables and scores on EF and high ambiguity scene and object discrimination as predictors of interest. YN scores were best explained by a model containing age and EF, while FC scores were additionally predicted by high ambiguity object discrimination. Even when controlling for both FC scores and age in the YN model, EF still emerged as a

significant predictor. In conclusion, decline in strategic retrieval processes and representational quality are two major factors underlying age-related memory decline. Their relative contributions depend on task demands, with high representational quality being insufficient to achieve accurate performance when demand for strategic retrieval increases. Future directions include manual segmentation of MTL subregions to elucidate the association between grey matter volume and performance in these cognitive tasks.

Topic Area: LONG-TERM MEMORY: Development & aging

C76 The effects of rTMS on source memory and underlying neurocognitive mechanism in normal older adults

Xiaoyu Cui¹, Weicong Ren^{1,2}, Juan Li¹; ¹Institute of Psychology, Chinese Academy of Sciences, Beijing, China, ²Hebei Normal University, China

Source memory is one of the cognitive abilities that are most vulnerable to aging. Luckily, the brain plasticity could be modulated to compensate for the decline. The repetitive transcranial magnetic stimulation (rTMS), a relatively noninvasive neuro-modulatory technique, could directly modulate neural excitability in the stimulated cortical areas. Here we are interested in whether the application of rTMS could enhance the source memory performance in the normal older adults. In addition, we used ERPs to explore the underlying mechanism of the rTMS effect on the source memory. Subjects (68±4.7 years) were randomly assigned to the intervention (n=15) and control groups (n=15). The intervention group received 10 sessions (20 min/session) of 10 Hz rTMS applying on the right dorsolateral prefrontal cortex (F4), and the control group received 10 sessions of sham stimulation. Both groups performed a source memory test before and after the intervention. Behavioral results showed that the rTMS increased the source memory performance compared with the control group (p =0.06); ERP results showed that during retrieval phase, in comparison with the control group, the rTMS increased a 500-700ms old/new effect at the right frontal area (p =0.075), which could reflect the process of recollection. These results suggest that rTMS could improve source memory performance in older adults via facilitating their recollection-based processing during retrieval.

Topic Area: LONG-TERM MEMORY: Development & aging

C77 Verbal and Visual Memory in Metabolic Versus Control Participants Across the Adult Lifespan

Tracey Slonim¹, Andres Fiello¹, Lori Haase-Alasantro², Claire Murphy^{1,2}; ¹San Diego State University, ²University of California, San Diego

Metabolic syndrome (MetS) is an established risk factor for developing dementia. Extant literature demonstrates a relationship between poor vascular health and decreases in cognitive functioning for older adults. This research will examine neuropsychological test performance in young, middle-aged, and older adults with and without MetS. Participants were categorized by age and metabolic status as follows: Young: n=42, 52.4% Metabolic; Middle-Age: n=41, 56.1% Metabolic; Older: n=45, 51.1% Metabolic. Participants were administered the following cognitive assessments as part of a larger study: California Verbal Learning Test-II (CVLT-II) and Brief Visuospatial Memory Test-Revised (BVMT-R). Multivariate analyses of variance were used to examine the relationship between age group, metabolic status, and neuropsychological test performance. Bonferroni post-hoc analyses were used to determine significant differences on performance between age groups. As expected, there were main effects of age on all neuropsychological tests administered. The CVLT-II total list learning [F(1,111)=6.75, p=.002, eta-squared=.110], short delay free [F(1,111)=8.41, p<.001, eta-squared=.134], and cued recall [F(1,111)=6.03, p=.003, eta-squared=.100], and long delay free [F(1,111)=10.18, p<.001, eta-squared=.157], and cued recall performances [F(1,111)=5.93, p=.004, eta-squared=.098], were significantly different between age groups. The young adults performed significantly better

than the older adults on the CVLT-II overall (p<.05). BVMT-R total learning [F(1,108)=10.94, p<.001, eta-squared=.171], and delayed recall [F(1,108)=5.35, p=.006, eta-squared=.092] performances were significantly different between age groups. Young adult performance was significantly higher on BVMT-R total learning compared to middle and older adult performances (p=.039 and p<.001, respectively). Young adults also scored significantly better on BVMT-R delayed recall compared with older adults (p=.004). There were no main effects of MetS, nor significant interactions between metabolic status and age group. Consistent with the current literature, memory decreases significantly in older adults. The sequelae of MetS may not manifest until later in life and may be overshadowed by the impact of aging on memory.

Topic Area: LONG-TERM MEMORY: Development & aging

C78 An ERP study of dream lucidity and reality monitoring

SHIH-KUEN CHENG¹, Moo-Rung Loo¹; ¹Institute of Cognitive Neuroscience, National Central University, Taiwan

Dream lucidity refers to the degree to which a dreamer is aware of the difference between the dream context and the real world. It has been considered to be a spectrum, ranging from totally not knowing one is dreaming to fully aware of being in a dream. The lucidity in a dream is therefore related to the discrimination between self-generated precepts in a dream and externally derived experiences when being awake, a capacity resembling the "reality monitoring" in source memory. This experiment investigated the relationship between dream lucidity and reality monitoring. 25 participants rated the lucidity of their dreams for 7 consecutive days. They then engaged in a reality monitoring task to differentiate words associated with pictures or mental images. The behavioral results showed that participants performed better in both the old/new recognition and source judgments for imagined trials than perceived trials. They also showed more internalization errors (misattributing perceived pictures as an imagined one) than externalization errors (misattributing imagined object as perceived pictures). A correlational analysis found the lucidity to be positively correlated with the externalization bias and negatively correlated with the number of internalization errors. Importantly, the "late posterior positivity", an ERP wave that has been linked to visual imagery, was of greater magnitude for hit trials to the imagined objects than the perceived pictures, and the difference negatively correlated to the number of externalization errors. These results suggested that people with high lucidity performed better in reality monitoring and tend to misattribute imagined items to perceived ones.

Topic Area: LONG-TERM MEMORY: Episodic

C79 Close, but not quite: Memory precision across spatial frames of reference over the lifespan

Natalia Ladyka-Wojcik¹, Iva K. Brunec¹, Nathanael Shing², Jackson Liang¹, Jennifer D. Ryan^{1,2}, Rosanna K. Olsen^{1,2}, Morgan D. Barense^{1,2}; ¹University of Toronto, ²Rotman Research Institute

Aging is associated with deficits in flexibly accessing spatial information across egocentric (first-person) and allocentric (map-based) frames of reference. Marked difficulty in spatial memory may also be an early indicator of neurodegenerative aging, including mild cognitive impairment (Antonova et al., 2009). However, little is known about how age-related decline in switching frames of reference affects fine-grained memory for item locations. In the present study, we investigated differences in performance among healthy older adults, older adults at-risk for mild cognitive impairment (i.e., MoCA score <26), and healthy younger adults on a computer-based spatial memory task. Participants learned three novel virtual environments from an egocentric frame of reference, with each environment containing five unique item locations. Their memory precision for these locations was subsequently tested in the

same frame of reference (egocentric) and a switched frame of reference (allocentric). Kolarik et al.'s (2016) sliding window analysis was adapted to assess memory precision for item location. Compared to younger adults, at-risk older adults showed poorer precision for both frames of reference, whereas healthy older adults showed relative impairment only in the switched condition. In addition, we correlated memory precision across age groups with hippocampal resting-state functional connectivity, a connectivity pattern shown to reliably predict spatial memory performance (Persson et al., 2018). Taken together, these findings provide novel insights into the mechanisms supporting memory for fine-grained location information across spatial frames of reference, and suggest that this ability may be sensitive to the early stages of neurodegenerative aging.

Topic Area: LONG-TERM MEMORY: Episodic

C80 Configuration Manipulation Impacts Neural Patterns in Medial Temporal Lobe in Associative Memory Retrieval

Jordan Chamberlain¹, Chloe Hultman², Valeria Martinez¹, Catherine Carpenter¹, Amy Overman², Nancy Dennis¹; ¹The Pennsylvania State University, ²Elon University

Associative memory retrieval is more difficult when stimuli are presented in a manner incongruent from that of encoding. Likely reflecting this increased level of difficulty, regions within the fronto-parietal network, hippocampus, and parahippocampal gyrus exhibit increased activation during incongruent, compared to congruent retrieval. Conversely, visual regions exhibit increased activation during congruent compared to incongruent retrieval, likely reflecting the recapitulation of the encoded stimuli. Yet overall differences in activation tell us little about what factors contribute to neural representations underlying this phenomenon, nor how behavior contributes to these representations. We used multivariate pattern analyses to examine the effect of display congruency on neural representations across the retrieval network. While a multivariate pattern classification analysis revealed neural patterns within early and late visual cortex associated with congruency were distinguishable, a representational similarity analysis demonstrated that patterns associated with behavioral responses in the same regions were highly similar. Interestingly, our representational similarity analysis showed that neural patterns within hippocampus distinguished objective oldness of the association and perceived novelty of the configurations. Furthermore, congruency contributed to more distinct representations for recollection than familiarity within the hippocampus, but not within parahippocampal gyrus. Finally, congruency impacted controlled retrieval processing within the fronto-parietal network differently for recollection compared to familiarity, showing more distinct representations for recollection across display configurations. Results suggest that neural patterns in higher order retrieval regions are influenced by visual configural manipulations whereas neural patterns within early and late visual cortex are unaffected by configural manipulations when the content is the same across conditions.

Topic Area: LONG-TERM MEMORY: Episodic

C81 Dynamic Integration of the Hippocampus during Episodic Counterfactual Thinking

Christopher Camp¹, Benjamin Geib¹, Matthew Stanley¹, Natasha Parikh¹, Felipe De Brigard¹; ¹Duke University

The human brain is a large-scale complex system, and the patterns of interconnections between brain regions play an essential role in human cognition. Recent research has indicated that the way in which the hippocampus is functionally interconnected with the rest of the brain network is systemically related to both the accuracy and the phenomenology of episodic remembering. Building on this prior research, we examine the integrative properties of the hippocampus in episodic memory and episodic

counterfactual thinking—thoughts about alternative ways one's past events could have occurred but did not. After constructing functional whole-brain networks derived from an event-related fMRI study, we used graph theoretic measures to investigate changes in the integrative properties of the hippocampus when simulating episodic memories, plausible episodic counterfactuals, and implausible counterfactuals. Our analyses revealed that while there was no difference in the betweenness centrality of the left hippocampus between episodic memory and plausible episodic counterfactual conditions, the betweenness centrality of the left hippocampus in the implausible episodic counterfactuals condition was significantly lower than in both the episodic memory and plausible episodic counterfactual thinking conditions. Importantly, these differences in betweenness centrality were not driven by changes in the strength of hippocampal connections between conditions. Moreover, the left hippocampus actually changed more in betweenness centrality between plausible and implausible counterfactual thinking conditions than any other node in the network. We discuss the implications of these findings for the functions of episodic memory and episodic counterfactual thinking.

Topic Area: LONG-TERM MEMORY: Episodic

C82 High Ruminators Use Different Neural Processes During a Recognition Memory Task

Nicole A Forner¹, Robert S Ross¹; ¹University of New Hampshire

Rumination occurs when an individual becomes "stuck" and cannot navigate away from an unwanted thought. A high tendency to ruminate is linked to overgeneralization of episodic memory and cognitive inflexibility. High ruminators may be utilizing different neural processes during memory tasks that involve cognitive control. Source memory tasks involve increased cognitive control due to the need of remembering one specific detail of a memory. Our study uses EEG recorded during a source memory task to assess differential brain oscillations in high compared to low ruminators (n = 28, 14 high ruminators). The source memory task instructs participants to remember an object as well as the side of the screen the object is presented on during study. During the test phase the previously studied objects are mixed with new objects and for each object the participant must make a recognition judgement. Additionally, if they believe the object was previously studied, they also report which side of the screen the object was on during encoding. Preliminary analysis of accuracy and reaction time show no differences between high and low ruminators. However, during retrieval high ruminators exhibit less desynchronization in the beta oscillatory band (13-30Hz) 250-1500ms post cue over posterior parietal/occipital areas when successfully remembering just the item and when successfully remembering both the item and context. Beta activity exhibits a similar pattern during encoding. The oscillatory differences between high and low ruminators support the hypothesis that high ruminators may encode a less detail rich representation of the memory.

Topic Area: LONG-TERM MEMORY: Episodic

C83 Memory benefits of sleep reactivation depend on the size of the targeted group

Eitan Schechtman¹, James W. Antony², Anna Lampe¹, Kenneth A. Norman², Ken A. Paller¹; ¹Department of Psychology, Northwestern University, Evanston, IL 60208, USA, ²Princeton Neuroscience Institute, Princeton University, Princeton, NJ 08544, USA

Memory consolidation during sleep has been studied using targeted memory reactivation (TMR), in which sensory stimulation with learning-related cues has been found to consistently alter memory storage. For example, olfactory cues can alter memory for a group of learned object locations previously studied in the context of a particular odor. Alternatively, auditory cues have

been shown to selectively enhance individual object-location memories or, more recently, pairs of such memories. These results leave open the question of whether reactivating multiple memories dilutes the TMR effect or engages competition between memories. Does the benefit spread equally among the items of a group, regardless of how many there are? Here we examined learning of object locations in an auditory-TMR paradigm. A single sound (e.g., meow) was associated with a group of images belonging to the same category (e.g., differentiable images of cats). Sounds were thus associated with sets of six images, two images, or one image. All image locations were learned to criterion, after which some of the associated sounds were presented during non-REM sleep. Results showed that bigger set sizes tended to have bigger TMR effects, suggesting a potential role of context reactivation. Effects of TMR on individual memories within a cued group also differed as a function of set size, suggesting that competition may play a role within reactivated groups, possibly limiting reactivation capacity.

Topic Area: LONG-TERM MEMORY: Episodic

C84 Neural entrainment to naturalistic rhythm: Effects on memory

Paige Hickey¹, Hannah Merseal², Catherine Gross¹, Annie Barnett-Young¹, Alexandra Cohen¹, Aniruddh Patel¹, Elizabeth Race¹; ¹Tufts University, ²Wheaton College

Temporal regularities in the environment, such as regular auditory rhythms, can entrain attention and facilitate perceptual processing at temporally-predicted moments in time (i.e., in synchrony with the beat). Recently, we demonstrated that rhythmic temporal predictions can also influence the encoding of novel events into memory: visual information that appears in-synchrony with the beat of background music is better remembered than visual information appearing out-of-synchrony with a background beat. The current study investigated whether the entrainment of neural oscillations supports this rhythmic facilitation of memory. During EEG recording, participants classified pictures of objects that appeared either in-synchrony or out-of-synchrony with the beat of background rhythmic music. Participants then received a surprise memory test in which they made an old/new recognition memory decision about previously-viewed and novel pictures. Behaviorally, responses at encoding were faster and subsequent memory was greater for on-beat compared to off-beat pictures, indicating that background auditory rhythms create temporal expectations that modulate memory. At the neural level, entrainment to the background rhythm was observed as a peak in spectral power at the beat frequency (1.25 Hz) and harmonic frequencies (2.5Hz, 5.0Hz) as measured by steady state evoked potentials (SSEPs). Critically, the magnitude of the SSEP at the beat frequency positively correlated with the magnitude of the on-beat memory benefit, with individuals having greater power at the beat frequency demonstrating superior subsequent memory for on-beat compared to off-beat items. Together, these results provide evidence for a link between neural entrainment and temporal predictions that enhance memory encoding.

Topic Area: LONG-TERM MEMORY: Episodic

C85 Predictors of sleep-dependent memory consolidation

Dan Denis^{1,2}, Verda Bursal¹, Craig Poskanzer¹, Lily Charron¹, Robert Stickgold^{1,2}; ¹Beth Israel Deaconess Medical Center, ²Harvard Medical School

A large body of evidence has shown that sleep plays a critical role in the consolidation of memories. It is less clear how the brain selects and prioritizes which memories get consolidated during sleep. Here, we used EEG to identify neural activity during initial memory encoding that can be used to predict subsequent memory consolidation during sleep. Participants learnt pairs of words at a computer, followed immediately by a cued recall test. Six hours later, participants performed a second recall test. N = 20 participants stayed awake for the full six hour period, whilst N = 25 had a two-hour nap opportunity

followed by four hours awake. EEG was recorded throughout encoding, recall, and the nap. The nap group showed superior memory retention at the delayed test compared to the wake group. Theta (4-8Hz) activity at the moment of encoding significantly predicted memory consolidation in the nap group. A mediated regression model showed that this relationship was mediated by sleep spindles. Additionally, successful memory recall after sleep was associated with significantly lower theta activity than successful recall following a period of wake. These results show that neural activity occurring during initial memory encoding contains information that can be used to predict consolidation processes. Our results suggest that theta activity during encoding may act as a potential 'tagging' mechanism for consolidation. Finally, we found that sleep reduces the amount of theta activity associated with successful memory recall. This may reflect a sleep-dependent transfer of information from mediotemporal to neocortical networks.

Topic Area: LONG-TERM MEMORY: Episodic

C86 Structural and Functional MRI Evidence for Distinct Medial Temporal and Prefrontal Roles in Context-Dependent Relational Memory

Hillary Schwab¹, Curtis L. Johnson², Michael R. Dulas¹, Bradley P. Sutton¹, Joel L. Voss³, Neal J. Cohen¹; ¹University of Illinois at Urbana Champaign, ²University of Delaware, ³Northwestern University

Declarative memory is supported by distributed brain networks in which the medial temporal lobes (MTL) and prefrontal cortex (PFC) serve as important hubs. Identifying the unique and shared contributions of these regions to successful memory performance is an active area of research, and a growing literature suggests that these structures often work together to support declarative memory. Here we present data from a context-dependent relational memory task in which participants learned that individuals belonged in a single room in each of two buildings. Room assignment was consistent with an underlying contextual-rule structure in which male and females were assigned to opposite sides of a building and the side-assignment switched between buildings. In two experiments, neural correlates of performance on this task were evaluated using multiple neuroimaging tools: diffusion tensor imaging (DTI), magnetic resonance elastography (MRE), and functional magnetic resonance imaging (fMRI). Structural and functional data from each individual modality provided complementary and consistent evidence that the hippocampus and the adjacent white matter tract (i.e., fornix) supported relational memory whereas the ventromedial PFC (vmPFC) and the white matter tract connecting vmPFC to MTL (i.e., uncinate fasciculus) supported memory-guided choice behavior. Together these data suggest that MTL and PFC structures differentially contribute to and support contextually guided relational memory.

Topic Area: LONG-TERM MEMORY: Episodic

C87 Successful Encoding of Item and Source Information is Predicted by Graded Neural Activity

Eleanor Liu¹, Joshua Koen², Christopher Hawkins¹, Michael Rugg¹; ¹Center for Vital Longevity and School of Behavioral and Brain Sciences, University of Texas at Dallas, ²Department of Psychology, University of Notre Dame

Neural activity during encoding of study items is predictive of subsequent memory performance. Subsequent memory effects (SMEs) for item memory can be defined as greater activity for later remembered than forgotten study items, while SMEs for source memory are defined as greater activity for later remembered items associated with accurate retrieval of a target (i.e., source) detail. We investigated SMEs associated with incidental encoding of item and source memory in healthy young adults. While undergoing fMRI during study, participants were cued to make one of two judgments (size or location) on pictures of objects and animals. Participants' memory accuracy and confidence was tested outside the scanner for both the images (item memory)

and the study judgment (source memory). SMEs were examined by splitting trials into 3 bins: trials attracting high confidence correct item and source decisions (source hit), trials attracting high confidence correct item but inaccurate source memory judgments (source miss), and trials attracting where item memory was inaccurate or accurate and associated with a low confidence decision. We observed graded source memory SMEs (source hit > source miss > item miss) in bilateral fusiform and left ventral anterior prefrontal cortex. SMEs reflective of item memory (source hit = source miss > item miss) were observed in right ventral anterior, bilateral dorsolateral, and left dorsomedial prefrontal cortex, and in the left anterior hippocampus. The results point to regional dissociations in sensitivity of encoding-related neural activity to source-diagnostic features of a study episode.

Topic Area: LONG-TERM MEMORY: Episodic

C88 The core episodic simulation network dissociates as a function of subjective experience and objective content

Preston P. Thakral¹, Kevin P. Madore², Daniel L. Schacter¹; ¹Department of Psychology, Harvard University, ²Department of Psychology, Stanford University

Episodic simulation – the mental construction of a possible future event – has been consistently associated with enhanced activity in a set of neural regions referred to as the core network. In the current functional neuroimaging study, we assessed whether members of the core network are differentially associated with the subjective experience of future events (i.e., subjective vividness) versus the objective content comprising those events (i.e., the amount of episodic details). During scanning, participants imagined future events in response to object cues. On each trial, participants rated the subjective vividness associated with each future event. Participants completed a post-scan interview where they viewed each object cue from the scanner and verbally reported whatever they had thought about. For imagined events, we quantified the number of episodic or internal details in accordance with the Autobiographical Interview (i.e., who, what, when, and where details). To test whether core network regions are differentially associated with subjective experience or objective episodic content, imagined future events were sorted as a function of their rated vividness or the amount of episodic detail. Univariate analyses revealed that some regions of the core network were uniquely sensitive to the vividness of imagined future events, including the hippocampus (i.e., high > low vividness), whereas other regions, such as the lateral parietal cortex, were sensitive to the amount of episodic detail in the event (i.e., high > low episodic details). The present results indicate that members of the core network support distinct episodic simulation-related processes.

Topic Area: LONG-TERM MEMORY: Episodic

C89 Theta entrainment after learning enhances episodic memory

Nathan Whitmore¹, Ken A. Paller¹; ¹Northwestern University

Converging evidence from computational, animal, and human models suggests that theta-band EEG oscillations (3-7 Hz) play a role in memory functions, but their precise role remains mysterious. Sensory entrainment paradigms allow researchers to induce theta waves while participants perform memory tasks, providing a way to link theta to specific memory mechanisms. Whereas memory can be enhanced by theta entrainment during learning, an open question is whether theta also benefits offline memory consolidation. To address this question, we investigated theta entrainment during a post-learning period when active rehearsal was discouraged. Participants (N=22) first viewed pictures of 30 common objects and were told to remember the objects they saw. Immediately afterwards, they took free recall and recognition tests. Then they performed a continuous performance test (CPT) for 25 minutes (responding whenever “X” appeared), followed by the same two

memory tests. During the CPT, we produced entrainment by flickering the brightness of the screen. Each participant performed this procedure two times using different sets of pictures, with delay-period entrainment at individualized theta frequency and at a control frequency (30 Hz). Order of theta and control entrainment was counterbalanced. Participants recalled significantly more object names following theta entrainment than following control entrainment. Furthermore, theta entrainment evoked theta-frequency EEG activity over occipital and frontal-central scalp areas, and the amplitude of this activity predicted memory benefits. In conclusion, theta entrainment not only facilitates encoding, but also facilitates offline consolidation.

Topic Area: LONG-TERM MEMORY: Episodic

C90 Under Pressure: The Null Effects of Psychosocial-Stress on Episodic Memory Consolidation

Elizabeth McManus¹, Deborah Talmi¹, Hamied Haroon¹, Nils Muhlert¹; ¹The University of Manchester

Whilst stress is thought to influence episodic memory, evidence using psychosocial-stress is less conclusive. We systematically explored how post-learning psychosocial-stress influences memory using three experiments. In each experiment, participants underwent the Trier Social Stress Test or a cognitively-matched low-stress control task after learning. Each experiment used 36 participants, evenly distributed between conditions. Participants were aged 18-30. Self-reported anxiety levels were measured at 5 time points: overall psychological-stress was calculated using an area under the curve analysis. Across all studies, the stress condition was associated with higher anxiety than the control condition, indicating an effective stress manipulation. During experiment 1, participants learned a list of neutral words, with recognition assessed immediately after learning and 24 hours later. Experiment 2 used the same design with negative emotional, categorised neutral and random neutral words. Experiment 3 used paired neutral word stimuli and an old/new recognition task with word-pair free recall. We found no significant differences for any memory measures, between stress and control groups in any of these experiments (Cohen's $d=0.041-0.42$), suggesting minimal effects of stress on word recognition. No significant correlations between anxiety and memory recognition scores were shown ($r=-0.155-0.107$). Bayes factors strongly supported the null for overall recognition across all studies ($BF < 0.33$), and tended to favour the hypothesis of no effect for remember/know discriminations ($BF < 0.45$). Findings suggest minimal effects of post-learning psychosocial-stress on item and associative recognition of words. Consistent null findings across these studies strongly supports the suggestion that psychosocial-stress has little influence on word consolidation.

Topic Area: LONG-TERM MEMORY: Episodic

C91 An ERP analysis comparing visual and verbal long-term memory mechanisms through access-based forgetting.

Shelby Smith¹, Scott Wittman², Caleb Robinson², Jada Johnson², Joshua Grzywana², Alaina Myers², Amber Seaman², April Taylor², Krista Price², Austin Tatum², Richard Ward³, Stephanie Simon-Dack²; ¹University of New Hampshire, ²Ball State University, ³University of Wisconsin - Milwaukee

Memory for images functions differently than memory for words. In access-based forgetting, retrieval of some information is impaired by the retrieval of associated information. This occurs, though, with both images (Maxcey & Woodman, 2014; Rugo et al., 2017) and words (Anderson, Bjork, & Bjork, 1994). The current study investigated where during memorial processing the difference in verbal and visual memory manifests. Ten participants performed picture and word recognition tasks while EEG was recorded. A paired-samples t-test showed no difference in accuracy for sorting old/new categories between

pictures and words, replicating that access-based forgetting is not specific to one modality of information, $t(8) = -1.39$, $p = .20$. In eliciting a P2 for words and P3 for pictures in the centroparietal region, paired-samples t-tests showed P2 amplitude for non-practiced words was significantly larger than amplitude for practiced, baseline, and lure words, respectively, $t(8) = 2.61$, $t(8) = 2.60$, $t(8) = 4.54$, $ps < .05$. However, P2 amplitudes for practiced, baseline, and lure words were not different from each other, all $ps > .80$. Thus, perceptual mechanisms processing words in an access-based forgetting paradigm recruit attention earlier (150ms to 250ms) than processing pictures (270ms to 320ms) and recruit more attentional resources when faced with lack of practice to better modulate memory activation toward suppressing salient, or practiced words (Freunberger et al., 2007). Results suggest these classic differences in visual and verbal memory may be a function of latency and degree of attentional recruitment.

Topic Area: LONG-TERM MEMORY: Other

C92 Associative Information in the Hippocampus and the Visual Cortex during Cued Recall

Joonyoung Kang¹, Sue-Hyun Lee¹; ¹Korea Advanced Institute of Science and Technology

Memory retrieval in our daily life often occurs when we perceive certain stimuli that are matched with a portion of the encoded memory. In this cued recall process, the hippocampus is thought to be critical for binding diverse elements of the full memory trace. Especially, declarative memory models have proposed that the hippocampus stores an index to cortical patterns of neural activity that were generated during encoding of the entire memory. To investigate how the hippocampal representation is related to the sensory representation during cued recall, we performed an event-related functional magnetic resonance imaging (fMRI) experiment with a simple object association task. In the task, participants learned eight object pairs outside the scanner one day prior to the scan. During the scan, they were instructed to recall the associated object for each given cue. We measured neural responses elicited during cue presentation and recall phase. Using multi-voxel pattern analysis, we found that the response patterns of the hippocampus showed greater similarity between paired objects compared to unpaired objects. In addition, the same tendency was also found in the object-selective visual cortex. However, while the significant similarity for the paired objects was observed in the hippocampus at delayed time points after the onset of the cue, the responses of the visual cortex showed the significant similarity immediately after the beginning of the cue. These results suggest a possibility that different cortical areas outside the hippocampus contribute to the representation of associative information in the visual cortex.

Topic Area: LONG-TERM MEMORY: Other

C93 Neural correlates of judgments of learning: an EEG study

Beatriz Martin-Luengo¹, Seungah Lee¹, Lylia Mikhailova^{1,2}, Andriy Myachykov^{1,3}, Yuri Shtyrov^{1,4,5}; ¹Institute of Cognitive Neuroscience, National Research University - Higher School of Economics, Russia, ²Faculty of Biology, Nizhny Novgorod State University, Russia, ³Northumbria University, United Kingdom, ⁴Aarhus University, Denmark, ⁵Saint Petersburg State University, Russia

Judgments of learning (JOLs) are subjective metacognitive evaluations about the future memorability of a piece of information recently learned. We use them, for example, when allocating time to study for an exam or learning new vocabulary for a language class. Yet, how exactly the brain estimates its future memory performance is unknown and neural correlates of JOLs remain scarcely investigated. The present study aimed to fill this gap by investigating

the brain's electrophysiological activity during a JOL task manipulated for different parameters. In an EEG recording, participants were presented with words in an easy-or difficult to-read font (the contrast aimed at controlling perceptual processing) that defined animate or inanimate objects (semantic level). For each word, participants had to choose on a 0-100% scale the confidence they had that they would remember it in near future. We observed differences in neural activity related to JOL confidence. Specifically, the P2 response, believed to reflect attentional recruitment and its modulation of perceptual processing, was enhanced over parietal areas for low-confidence (0-30%) responses, as opposed to middle (40-60%) and high (70-100%) ones; this enhanced reoccurred in a later time window at 1000-1300 ms. We did not observe any differences between animate and inanimate, or easy- and difficult-to-read words. We conclude that metacognitive processes are reflected in both late and early (when the stimulus is still being processed) time windows of event-related brain activity. This result challenges the mainstream view that metacognitive processes can only take place at substantial delays after the stimulus presentation.

Topic Area: LONG-TERM MEMORY: Other

C94 The Effects of Target-lure Similarity to False Alarms on Memory Specificity: An fMRI Study

Emily R. Maxwell¹, Whitney D. Allen¹, Daniel K. Bjornn¹, Nathan M. Muncy¹, Michael J. Larson¹, C. Brock Kirwan¹; ¹Brigham Young University

Memory specificity is an important aspect of everyday life and is dependent on both pattern separation and pattern completion. Recent research using eye tracking argued that pattern completion does not fully explain false alarms to similar (lure) items and suggested that poor encoding was a better explanation; however, prior research using eye-tracking showed mixed results for the contribution of encoding. Here, we used fMRI and eye-tracking to test the contribution of encoding to activity differences in the hippocampus (HC) for mnemonic discrimination accuracy. We predicted that (a) HC activity on test trials for repetitions would be moderated by study trial eye fixation count and (b) the HC suppression moderated by study trial fixation count during test trials of lures would be greater for lure-false alarms (LFA) than for lure correct rejections (LCR). Data were analyzed from 35 young, healthy adults (17F, age=22 ±2.4). Participants completed a continuous-recognition paradigm where they were tasked with identifying same, similar, and new while being measured with a combined eye tracking-fMRI technique. HC activity on test trials for repetitions was suppressed as a function of eye tracking study trial fixation count in the left hemisphere, but not in the right. Fixation-moderated suppression in the HC subregions DG/CA3 and CA1 did not differ between LCRs and LFAs to similar items. These results show that study trial fixation count moderates left HC activity to repeat items, but these results fail to support the contribution of encoding to HC subfield activity differences commonly observed between LCRs and LFAs.

Topic Area: LONG-TERM MEMORY: Other

C95 Transformation of event representations along middle temporal gyrus

Anna Leshinskaya¹, Sharon L. Thompson-Schill¹; ¹University of Pennsylvania

When learning about events through visual experience, one must not only identify which events are visually similar, but also retrieve those events' associates—which may be visually dissimilar—and recognize when different events have similar predictive relations. How are these demands balanced? To address this question, we taught participants the predictive structures among four events, which appeared in four different sequences, each cued by a distinct object. In each, one event ('cause') was predictably followed by another ('effect'). Sequences in the same relational category had similar predictive structure, while across categories, the effect and cause events were

reversed. Using fMRI data, we measured associative coding, indicated by correlated responses between effect and cause events; perceptual coding, indicated by correlated responses to visually similar events; and relational category coding, indicated by correlated responses to objects in the same relational category. All three models characterized responses within right middle temporal gyrus (MTG), but in different ways: perceptual and associative coding diverged along the posterior to anterior axis, while relational categories emerged anteriorly in tandem with associative coding. Thus, along the posterior-anterior axis of MTG, the representation of the visual attributes of events is transformed to a representation of both specific and generalizable relational attributes.

Topic Area: LONG-TERM MEMORY: Other

C96 Mnemonic Constraints on Value-Based Decision Making

Zhihao Zhang¹, Shichun Wang¹, Andrew Kayser^{2,3,4}, Ming Hsu^{1,2}; ¹Haas School of Business, University of California, Berkeley, ²Helen Wills Neuroscience Institute, University of California, Berkeley, ³Department of Neurology, University of California, San Francisco, ⁴Department of Neurology, VA Northern California Health Care System

Our understanding of value-based decision making is primarily derived from “stimulus-based decisions” (SB-D), in which a choice is made from a pre-defined menu. Such focus may overlook important constraints that other cognitive processes, such as memory, impose on decisions. Here we examine an important class of “memory-based decisions” (MB-D), such as choosing a restaurant from memory. In contrast with SB-D, we hypothesize that MB-D require subjects to first construct an internal choice set based on semantic memory, after which they choose based on valuation of the options in the choice set. We collected independent datasets for brands from two product categories (fast food restaurants and running shoes) to define three measures: semantic memory, measured by a brand-related semantic fluency task (N=240); valuation, measured by choices in SB-D (N=1405); and MB-D, measured by menu-free brand choices in the same category (N=1405). Semantic memory was modeled as an associative network inferred from fluency data. Both memory and SB-D data then served as input to a two-stage model embodying our hypothesis, the output of which provided out-of-sample predictions for MB-D. The two-stage model improves substantially over the baseline preference-only model (SB-D) or memory-only model ($p < 0.001$), supporting the critical role of memory-preference interaction in MB-D. Collection of neuroimaging data to address the neural mechanisms of MB-D is underway. Together these initial findings support the proposed mechanism involving the intermediate construction of an internal choice set through recall, and identify important mnemonic constraints on value-based decision making.

Topic Area: LONG-TERM MEMORY: Semantic

C97 Using fMRI to explore the effects of task instructions and response strategy

Sebastien Helie¹, Farzin Shamloo¹, Madison Fansher², Shawn Ell³; ¹Purdue University, ²University of Michigan, ³University of Maine

Category representations can be broadly classified as containing within-category information or between-category information. Hélie, Shamloo, & Ell (2017) showed that regular classification learning instructions (A/B) promote between-category knowledge in rule-based categorization whereas conceptual learning instructions (YES/NO) promote learning within-category knowledge with the same categories. Here we explore how these tasks affect brain activity using fMRI. Participants learned two sets of two categories. The computational models from Hélie et al. (2017) were fit to the behavioral data to determine the type of knowledge learned by each participant. fMRI contrasts were computed to compare BOLD signal between the two tasks and between the two types of knowledge. The results show that participants in the YES/NO

task had more activity in premotor motor areas and supramarginal/angular gyrus. In contrast, participants in the A/B task had more activity in the lingual gyrus, fornix, thalamus, and caudate. These results suggest that participants in the YES/NO task may use more abstract rules and switch rule as a function of the stimulus displayed on the screen. In contrast, activity in the A/B condition is more consistent with participants applying direct Stimulus → Response rules based on stimulus recognition. With regards to knowledge, participants who learned between-category knowledge had more activity in the supramarginal/angular gyrus and in BA45/46. These results suggest that participants may look at the stimulus and then recall the appropriate rule for categorization in this trial. This response strategy may be more efficient than keeping all rules in working memory for every trial.

Topic Area: LONG-TERM MEMORY: Skill learning

C98 ‘Print tuning’ as neurophysiological marker of early typical and delayed reading acquisition

Ben Maassen^{1,2}, Toivo Glatz³; ¹University of Groningen, The Netherlands, ²University Medical Center Groningen, The Netherlands, ³Catholic University Leuven, Belgium

The visual N170 is an occipitotemporal electrophysiological ERP-component which provides a measure for print tuning – the cortical specialization to processing of written text. Print tuning emerges in beginning readers during the first two years of reading education and is left-lateralized in advanced readers. In earlier studies with adults and adolescents we found the N170 component to be more pronounced in typical readers as compared to individuals with reading disability. We present two ERP studies which further explore the emergence of print tuning during the early stage of typical and delayed reading acquisition. In study 1 print tuning as measured from 21 typical and poor readers of Dutch in second grade of mainstream primary education, exhibited a robust, enhanced N170 response for words compared to symbols in the left hemisphere, and a positive, almost linear relation between reading fluency and the size of the print tuning effect. In study 2 the effect of a seven weeks computer-based literacy training was evaluated in a cross sectional sample of 36 first graders with behavioral tests and the visual print-tuning N170 paradigm. Conventional analyses of averaged ERPs pointed to an overall presence of left-lateralized print tuning, that was larger at the second than the first assessment. Single trial analyses showed evidence of print tuning in the more proficient readers, but returned null results for the experimental factors session and type of training (math versus literacy). Thus, further studies are needed to understand the precise relation between print tuning and reading development or delay.

Topic Area: METHODS: Electrophysiology

C99 A Wearable Heart Monitor For Measuring Changes Of The Sympathetic Nervous System

Viktoriya Babenko¹, Neil Dundon¹, Matthew Cieslak², Alan Macy³, Richard Scott³, Alexandra Stump¹, Morgan Fitzgerald¹, Shefali Verma¹, Cepideh Razavi¹, Scott T. Grafton¹; ¹University of California, Santa Barbara, ²University of Pennsylvania, ³Biopac Systems, Inc.

Quantitative measures of sympathetic nervous system (SNS) including metrics of cardiac mobilization provide insight into motivational states, stress reactivity, reward sensitivity, task engagement and decision making. Typically, combination of electrocardiogram (ECG) and impedance cardiography (ICG) data estimate pre-ejection period (PEP) or left ventricular ejection time (LVET) to define changes in SNS activity. Reliance on ICG remains challenging because labeling of the time point corresponding to the opening of the aortic valve is not accurately visible on all participants. Here we present a wearable heart monitor that directly records opening and closing of the aortic valve to bypass the limitations of ICG. An electro-resonator transmits electrical energy

directly into the human body. The heart's mechanical motion influences the signal received by the electro-resonator during each heartbeat. In study 1, we recorded measures of ICG, ECG, and the resonator (a single 2.5cm diameter, round electrode) on each of the five auscultation points to establish that the second auscultation point produced the most reliable results across participants. In study 2, participants engaged in physical stressors known to cause significant responses of the SNS, such as the cold pressor task and Valsalva Maneuver. Using a combination of ECG and the resonator, beat-to-beat changes in PEP ($p < 0.001$) and LVET ($p < 0.001$) could be detected with the physical stressors in all subjects. With these findings, we introduce an improved method and open-source software for acquiring high temporal resolution recordings of cardiac contractility as a means for tracking changes of SNS activity.

Topic Area: METHODS: Electrophysiology

C100 Complexity Matching to EEG Response of Speech and Music

Adolfo G. Ramirez-Aristizabal¹, Daniel C. Comstock¹, Christopher T. Kello¹;
¹University of California Merced

Both speech and music have Hierarchical Temporal Structures (HTS) e.g., phonemes occur over short time scales and words at longer time scales. Previous electroencephalography (EEG) studies have demonstrated that neural activity can track the rhythm in complex auditory signals. Complexity Matching (CM) theory poses that coupled complex systems have similar HTS functions, and we use Allan Factor (AF) variance to quantify HTS. This approach has not been applied to understand CM between complex auditory stimuli and corresponding neural activity (done here via fitting dipole models to Independent Components). Thus, the present study applied the AF measure to both complex auditory stimuli and neural activity, to assess similarity in HTS. During 32-channel EEG recording, participants ($n = 11$) listened to five ~4.5-minute audio clips of speech and music, one of which (classical music) was repeated. While AF analyses revealed divergent scaling for the different auditory stimuli, AF analyses of EEG amplitude envelopes showed marginal differences in their $1/f$ scaling; no direct CM found. Post-hoc tests showed that the difference in EEG AF was restricted to an effect of repeating the classical music. EEG responses to different acoustic signals were further discriminable by training a support vector machine classifier on low frequency amplitude fluctuations (68% classification accuracy for .1 to .5 Hz). These results suggest that EEG amplitude fluctuations have a relationship with the amplitude structure of auditory signals and point the way to future studies that account for mediating factors, such as attention, on the brain response to speech and music.

Topic Area: METHODS: Electrophysiology

C101 Is it possible to distinguish true and spurious cross-frequency coupling?

Felix Siebenhüner¹, Sheng H Wang¹, Gabriele Arnulfo^{1,2}, Lino Nobili^{1,2}, Matias Palva^{1,3}, Satu Palva^{1,3}; ¹University of Helsinki, Finland, ²University of Genoa, Italy, ³University of Glasgow, United Kingdom

Neuronal activity is characterized by oscillations and phase synchronization at multiple frequencies. Cross-frequency coupling (CFC) mechanisms are assumed to be central for the regulation of neuronal processing among spectrally distributed oscillations and networks. Two forms of CFC, phase-amplitude coupling (PAC) and $n:m$ -cross-frequency phase synchrony (CFS), have been shown to characterize resting- and task-state electrophysiological activity and have been proposed to underlie integration and coordination of neuronal processing across frequencies. However, the validity of CFC observations has been questioned because the estimation of CFC may be confounded by filtering artefacts caused by non-sinusoidal waveforms. The core assumption behind CFC is that the interaction is observed between two

distinct processes, whereas analyses of non-sinusoidality assume a single underlying process for the signal. While it is impossible to distinguish true CFC and spurious CFC caused by non-sinusoidalities when analyzing a single source (local CFC), CFC is necessarily true when found between two separable sources. We advance here a method to distinguish true from potentially spurious inter-areal CFC. We studied human resting state brain dynamics with stereo-electroencephalography (SEEG) and source-reconstructed magnetoencephalography (MEG) data and observed both CFS and PAC among a wide range of frequencies. We show that a significant fraction of the observed CFC was true and not explainable by non-sinusoidalities. Interestingly, the anatomical profiles of CFS and PAC differed from each other and were similar between SEEG and MEG. In conclusion, these results provide conclusive evidence for genuine inter-areal cross-frequency coupling in human resting state networks.

Topic Area: METHODS: Electrophysiology

C102 Measuring Operator Understanding of ADAS via the P3

Steven Chong¹, Dean Cisler¹, Stephanie Tulk-Jesso¹, Caryl Baldwin¹;
¹George Mason University

The event-related potential (ERP) P3 component, elicited in an auditory oddball task, has commonly been used to study mental workload; but it is also sensitive to other biological and cognitive factors (see review in Polich & Kok, 1995). The aim of this study was to determine if the P3 can be used as an index of an operator's acceptance and understanding of advanced driver assistance system (ADAS) technologies. Bayliss (2003) demonstrated that the P3 component worked equally well in controlling a BCI in a virtual reality environment as via a computer monitor. In the present study participants performed an auditory oddball task while interacting with various ADAS components in a driving simulation. The paradigm resulted in significantly greater amplitude P3 responses to infrequent relative to frequent stimuli demonstrating support for its use in this context. Moreover, significant differences were also found in P3 amplitude between baseline periods and periods interacting with different ADAS components. Current results indicate that the P3 in an auditory oddball task can be used to index operators' acceptance and understanding of ADAS capabilities and limitations.

Topic Area: METHODS: Electrophysiology

C103 Brainstem atrophy in Gulf War Illness

Yu Zhang¹, Timothy Avery^{1,2}, Andrei Vakhtin^{1,2}, Danielle Mathersul^{1,2}, J. Wesson Ashford^{1,2}, Peter Bayley^{1,2}, Ansgar Furst^{1,2}; ¹War Related Illness and Injury Study Center (WRIISC), VA Palo Alto Health Care System, ²Stanford University

Background: Gulf War illness (GWI) in veterans who served in the 1990-91 Persian Gulf War is manifested by multiple chronic symptoms, including pain, fatigue, neurological, gastrointestinal, respiratory, and skin problems. In this study, we assessed potential cortical and subcortical atrophy patterns associated with GWI and the relationship between regional atrophy and GWI symptoms using a large subjects' cohort. Methods: Three-Tesla structural MRI scans from 111 GWI veterans (Age=49±6, 90% Male) and 59 healthy controls (Age=51±9, 63% Male) were collected at the California War Related Illness and Injury Study Center (WRIISC-CA) and Image Data Archive (LONI-IDA), respectively. Diagnoses of GWI were determined based on self-reports and clinical interviews, with all GWI veterans meeting both Fukuda/CDC and Kansas criteria for chronic multi-symptom illness. MRI images were segmented and parcellated using FreeSurfer v6.0. Volumes in 17 subcortical and 68 cortical regions and 3 brainstem sub-regions were measured and normalized by total intracranial volume. Results: Multivariate analyses revealed significant subcortical atrophy but no cortical differences in GWI relative to controls. Substantial atrophy in the brainstem (4% relative to

controls, $P=0.002$) and the thalamus ($P=0.02$) was observed. In a subsample of 58 GWI veterans who completed the CDC Symptom Inventory, GWI veterans with smaller brainstems had marginally increased severities ($P=0.06$) of fatigue and depression symptoms when compared to GWI veterans with larger brainstems. Conclusion: The findings suggest that the brainstem is selectively affected in GWI and this in turn may moderate related symptoms such as fatigue and depression.

Topic Area: METHODS: Neuroimaging

C104 fMRI pattern similarity analyses reveal working memory and perceptual coding at both regional and brain-network level

Maria Z. Gehred¹, Joset A. Etzel¹, Todd S. Braver¹; ¹Washington University in St. Louis

Pattern similarity analyses have been used to identify coding properties of different brain regions, but rarely to compare regional and network-level properties in higher cognitive domains. In the current study, we leverage the Human Connectome Project (HCP) dataset and an established cortical parcellation scheme (Gordon atlas) to examine the coding of working memory (WM) load (0-back, 2-back) versus perceptual category (Face, Place) in the N-back task. We compared effects observed at the community level (FrontoParietal, Visual) with a whole-brain analysis focused on cortical parcels in order to determine relative sensitivities. As expected, we observed a robust dissociation at the community level, with FrontoParietal strongly reflecting WM load-based coding, and Visual reflecting perceptual coding. Community-level analyses seemed most robust for perceptual coding, as most of the parcels within the Visual community (28 of 39) showed weaker coding than the community as a whole. Likewise, across the whole-brain, only 8 parcels, all located within the Visual community, showed stronger coding than the community. A different picture emerged when examining load-based coding, as most FrontoParietal parcels (14 of 24) showed equivalent or stronger coding than the FrontoParietal community as a whole. A number of cortical parcels in other communities related to working memory (Dorsal Attention, Cingulo-Opercular) also displayed stronger coding. Additionally, the strength of load-based coding in these parcels predicted better behavioral performance (d'). These results highlight the utility of pattern similarity analyses for examining not only perceptual coding, but also the coding of working memory load at both network and regional levels.

Topic Area: METHODS: Neuroimaging

C105 Hierarchical Bayesian Analyses for Modeling BOLD Time Series Data

M. Fiona Molloy¹, Giwon Bahg¹, Xiangrui Li¹, Mark Steyvers², Zhong-Lin Lu¹, Brandon M. Turner¹; ¹The Ohio State University, ²University of California, Irvine

Hierarchical Bayesian analyses allow for systematic purification of data while quantifying uncertainty. This technique is particularly useful in analyzing neural time series data, such as the fMRI BOLD response. Hierarchical Bayesian models expand upon the general linear model (GLM) commonly used in analyzing fMRI data by providing single-trial estimates and allowing for additional constraints across conditions, subjects, and/or regions of interest (ROIs). However, these models can be difficult to implement. Here, we demonstrate how to construct and fit these models within R, using user-friendly Bayesian software packages, such as JAGS (Plummer, 2003). We provide a concrete example of how these models can be applied using the stop-signal task (Logan, 1994). We constructed five increasingly complex models, constructing hierarchy across conditions, ROIs, and subjects. We then compare these models in terms of fit, parameter constraint, and generalizability. For these data, our results suggest that while subject and condition constraints are important for both fit and generalization, region of

interest constraints did not substantially improve performance. Finally, we conclude with a discussion on how these models can be used to make theoretical claims. In the stop-signal task, we found evidence of diminished activation in many key ROIs following a stop-signal, from condition level hyperparameters. Additionally, we found that individual differences appear to be integral to this task. We hope to demonstrate that hierarchical Bayesian models are feasible and useful tools in analyzing fMRI data that can lead to further theoretical development in understanding cognitive processes.

Topic Area: METHODS: Neuroimaging

C106 Influence of genetic relatedness on fMRI activation pattern similarity during the HCP working memory task

Joset A. Etzel¹, Maria Z. Gehred¹, Arpana Agrawal¹, Todd S. Braver¹; ¹Washington University in St. Louis

Previous studies have investigated genetic influences on fMRI activity patterns with twin designs, but have not typically considered task context effects. Here we leverage the large sample and family structure of the Human Connectome Project (HCP) dataset to examine individual differences and genetic influences on activation pattern similarity during the Working Memory (N-back) task, specifically contrasting load-based coding (0-back, 2-back) against the coding of picture category (Face, Place), in two ROIs: the FrontoParietal and Visual Communities defined by the Gordon parcellation. HCP participants were chosen to form 105 MZ (monozygotic) twin pairs, 78 DZ (dizygotic) twin pairs, 99 non-twin sibling pairs, and 100 unrelated pairs. The sixteen condition-wise correlations of the pairs' activation patterns were computed for each Community, with Load and Category coding quantified from the resulting similarity matrices. As expected, there was strong regional specificity: Load was selectively encoded in FrontoParietal, and Category in Visual. Likewise, there was a strong influence of genetic relatedness (MZ > DZ and siblings > unrelated), but only for Load in FrontoParietal and Category in Visual. In unrelated people, similarity was greater in Visual than FrontoParietal, suggesting its organization may exhibit more inter-individual consistency. Strikingly, higher Load quantification scores predicted better task behavioral performance (d'), but only in related individuals, supporting their functional importance. These results suggest that robust genetic influences can be detected in fMRI activity patterns, but that task context critically determines their anatomical locus. Additionally, they highlight the power of pattern similarity analyses for detecting key frontoparietal cortex coding features.

Topic Area: METHODS: Neuroimaging

C107 Structural brain network topologies associate with aspects of value-based decision-making

Cristina Bañuelos¹, Alexis Porter¹, Kirk I Erickson^{2,3}, Timothy Verstynen^{1,3}; ¹Carnegie Mellon University, ²University of Pittsburgh School of Medicine, ³Center for the Neural Basis of Cognition, Carnegie Mellon University and University of Pittsburgh

Value-based decision-making relies on the communication across disparate brain networks. Given the scale of the networks involved in adaptive decision-making, variability in how they communicate should impact behavior; however, precisely how the topological pattern of structural connectivity of individual brain networks influences individual differences in decision-making remains unclear. Using diffusion MRI we constructed structural brain connectivity networks in a sample of community dwelling adults (N=124). We used standard graph theoretic measures to characterize the topology of the networks in each individual and correlated individual differences in these topology measures with differences in the Iowa Gambling Task (IGT). A principal components regression approach revealed that individual differences in brain network topology associated with differences in each participant's sensitivity to high frequency rewards, but did not predict differences in optimal

decision-making. These findings show that aspects of structural brain network organization can constrain how information is used in value-based decision-making.

Topic Area: METHODS: Neuroimaging

C108 Adaptive Design Optimization of Real-time fMRI Experiments using a Joint Modeling Framework

Giwon Bahg¹, Per Sederberg², Jay Myung¹, Xiangrui Li¹, Mark Pitt¹, Zhong-Lin Lu¹, Brandon Turner¹; ¹The Ohio State University, ²University of Virginia

Efficient data collection is one of the most important goals to be pursued in cognitive neuroimaging studies due to the exceptionally high cost of data acquisition. Many static (e.g., Buračas & Boynton, 2002; Wager & Nichols, 2003) and adaptive (Lorenz et al., 2016) design optimization methods have been developed to ameliorate the cost of data collection by searching stimulus sequences that maximize information obtained within a limited amount of data. However, most of the previous methods are limited in answering questions about neural mechanisms that produce behavioral responses because they are in general bounded within the localization-based paradigm or general linear modeling framework. Moreover, none of the previous methods exploit neural and behavioral data simultaneously, which is a significant loss of information in investigating the connection between brain and behavior. As one possible solution, we discuss how a joint modeling framework (Turner et al., 2013) can incorporate neural and behavioral data together for adaptively optimizing experimental designs of cognitive-model-based fMRI experiments. In detail, we demonstrate the implementation of Adaptive Design Optimization (ADO; Cavagnaro, Myung, Pitt, & Kujala, 2010) in real-time fMRI experiments for estimating parameters of a simple visual psychophysics model (i.e., the Naka-Rushton equation and a Thurstonian decision model) as a proof-of-concept. The result shows that (1) ADO estimates the target function with higher accuracy than randomized experimental designs, and (2) the performance of ADO is reliable across subjects and sessions when the quality of neural data is guaranteed (e.g., a reasonable size of the mask, less head motions).

Topic Area: METHODS: Neuroimaging

C109 Short-term meditation training increases inter-network connections in the triple networks

Winston Fu Zun Yang¹, Yiyuan Tang^{1,2}; ¹Department of Psychological Sciences, Texas Tech University, ²Center for Advanced Study in the Behavioral Sciences, Stanford University

Research has shown that mindfulness meditation improves certain cognitive functions via changes in specific regions of the brain. However, little is known about the functional networks involved in this change. The current study aims to investigate the inter-relationship between default mode network (DMN), central executive network (CEN) and salience network (SN) following meditation. We hypothesized that inter-network connectivity between the triple networks will increase after short-term meditation. A total of 21 healthy young adults underwent 10 hours of Integrative Body-Mind Training (IBMT). Resting-state functional magnetic resonance imaging (rsfMRI) scans were taken before and after the training. rsfMRI images were preprocessed using DPARSFA. Difference between pre-IBMT and post-IBMT z-transformed connectivity maps was computed. Several graph metrics, including global efficiency, cost, cost-efficiency, and betweenness centrality were analysed. Results revealed increased inter-network connectivity between the DMN and CEN, and DMN and SN, and decreased intra-network connectivity within the DMN, CEN and SN ($p < 0.05$). While there was no change in global efficiency or cost, the cost-efficiency of the triple networks increased ($p < 0.05$). Betweenness-centrality changes suggest greater connections in the right anterior insula, right retrosplenial cortex, and right and left ventral intraparietal

sulcus. Short-term meditation increases inter-network communication in the triple networks. The findings likely reflect changes in cognitive processes, such as self-detachment, and more effortless attention with meditation practices. These findings may provide support for short-term meditation as a potential mental training, and highlights the neural impact of meditation at various topological levels.

Topic Area: OTHER

C110 Defining Sensory Subtypes in Young Children with Autism or Typical Development Using Loudness-Dependent Auditory ERPs

Patrick Dwyer¹, Xiaodong Wang¹, Rosanna De Meo-Monteil¹, Fushing Hsieh¹, Clifford Saron¹, Susan M. Rivera¹; ¹UC Davis

Sensory processing in autism is heterogeneous. However, previous studies defining sensory subtypes in autism have relied on questionnaires, and few have attempted to define sensory subtypes in typical development (TD). The present study used auditory ERP responses to explore sensory subtypes in autism and TD. 61-channel EEG data from 213 toddlers between 2.5 and 4 years (132 autism, 81 TD) were recorded. Participants heard tones varying in loudness (50, 60, 70 and 80 dB) while watching a quiet movie. The global field power (GFP) was used as an index of neural response strength, and an 85% peak latency time window was defined for each intensity separately (~80-150 ms). Each participant's GFP values in each loudness condition at each timepoint were then normalized and clustered using Ward's method. Four clusters were identified. One, characterized by strong 70 dB responses, had a disproportionate number of participants with autism (53 autism, 18 TD; $p = .004$). Interestingly, participants with autism in this cluster had higher cognitive abilities on the Mullen Scales of Early Learning. Another cluster (32 autism, 31 TD) was characterized by strong 60 dB responses; participants with autism in this cluster showed more typical sensory behaviours on the Short Sensory Profile. The other clusters included participants with unusually strong 80 dB (24 autism, 17 TD) and 50 dB (23 autism, 15 TD) responses, respectively. These results reveal significant heterogeneity in the loudness-dependent patterns of sensory processing in autism and TD, revealing both overlap between, and separation of, diagnostic groups across clusters.

Topic Area: PERCEPTION & ACTION: Audition

C111 Evoked activity plays a very substantial role in the cortical tracking of natural speech.

Edmund Lalor^{1,2}; ¹University of Rochester, ²Trinity College Dublin

How the human brain parses and processes continuous speech remains unknown. Recent progress on this topic has been made with the realization that low frequency cortical activity tracks the dynamics of natural speech. This has led to a prominent theory positing that intrinsic oscillations in cortex reset their phase so as to be optimally aligned with the rhythms of the speech input. However, evidence for this theory is lacking. An arguably more parsimonious explanation of cortical speech tracking is that speech stimuli evoke consistent transient responses in brain activity. This idea underpins analyses using encoding models to describe how speech dynamics affect neural data. In this study we examine both mechanisms – phase reset of intrinsic oscillations and transient evoked responses – using a combination of EEG data analysis and computational simulations. First, we show that EEG collected from 6 subjects exposed to multiple repetitions of the same 40s speech stimulus can be viewed as being consistent with generation by both phase-reset and transient evoked activity. Next, we simulate EEG using both phase-reset and evoked models and show that only the latter is consistent with the real EEG results. Finally, we show that this evoked model explains a substantial percentage of the explainable variance in real EEG data. These analyses suggest that transient evoked responses exist in real EEG data, that their existence cannot

be explained by the phase reset of intrinsic oscillations, and that, on their own, they can explain much of the EEG tracking of natural speech.

Topic Area: PERCEPTION & ACTION: Audition

C112 Neural Correlates of Familiarity in Music Listening: A Systematic Review and a Neuroimaging Meta-Analysis

Carina Freitas^{1,2}, Enrica Manzato³, Alessandra Burini³, Margot J. Talyor^{1,4,5,6}, Jason P. Lerch^{6,7,8}, Evdokia Anagnostou^{1,2,6,9}; ¹Faculty of Medicine, Institute of Medical Science, University of Toronto, Toronto, ON, Canada, ²Bloorview Research Institute, Holland Bloorview Kids Rehabilitation Hospital, Toronto, ON, Canada, ³Sant'Anna School of Advanced Studies, Pisa, Italy, ⁴Department of Diagnostic Imaging, Hospital for Sick Children, Toronto, ON, Canada, ⁵Department of Psychology, University of Toronto, Toronto, ON, Canada, ⁶Neuroscience & Mental Health Program, Hospital for Sick Children Research Institute, Toronto, ON, Canada, ⁷Mouse Imaging Centre, Hospital for Sick Children, Toronto, ON, Canada, ⁸Department of Medical Biophysics, University of Toronto, Toronto, ON, Canada, ⁹Department of Pediatrics, University of Toronto, Toronto, ON, Canada

Familiarity in music has been reported as an important factor modulating emotional and hedonic responses in the brain. Familiarity and repetition may increase the liking of a piece of music, thus inducing positive emotions. Neuroimaging studies have focused on identifying the brain regions involved in the processing of familiar and unfamiliar musical stimuli. However, the use of different modalities and experimental designs has led to discrepant results and it is not clear which areas of the brain are most reliably engaged when listening to familiar and unfamiliar musical excerpts. In the present study, we conducted a systematic review from three databases (Medline, PsychINFO, and Embase) using relevant keywords. Of the 704 titles identified, 23 neuroimaging studies met our inclusion criteria for the systematic review. After removing studies providing insufficient information or contrasts, 11 studies (involving 212 participants) qualified for the meta-analysis using the activation likelihood estimation (ALE) approach. Our results did not find significant peak activations consistently across included studies. Using a less conservative approach ($p < 0.001$, uncorrected for multiple comparisons) we found that the left superior frontal gyrus, the ventral lateral (VL) nucleus of the left thalamus, and the left medial surface of the superior frontal gyrus had the highest likelihood of being activated by familiar music. On the other hand, the left insula, and the right anterior cingulate cortex had the highest likelihood of being activated by unfamiliar music. Music familiarity had a motor pattern of activation which could reflect an audio-motor synchronization to the rhythm.

Topic Area: PERCEPTION & ACTION: Audition

C113 Neural dynamics of human auditory perception across space and time

Matthew Lowe¹, Yalda Mohsenzadeh¹, Benjamin Lahner¹, Santani Teng^{1,2}, Ian Charest³, Aude Oliva¹; ¹Massachusetts Institute of Technology, ²Smith-Kettlewell Eye Research Institute, ³University of Birmingham

Neuroimaging methods such as functional magnetic resonance imaging (fMRI) and magnetoencephalography (MEG) have afforded insight into the spatial and temporal mechanisms governing human audition, separately. Yet we still lack fundamental knowledge of simultaneously where and when auditory representations emerge in the human brain. Comparing data across different imaging modalities, however, can provide an integrated account of perception across space and time. Here we demonstrate how the processing of sounds from various sources unfolds across space and time in the human brain. Participants ($n = 15$) listened to 80 real-world sounds while we acquired MEG and fMRI data in independent sessions. First, by applying multivariate pattern classification to MEG, we illuminate the rapid emergence of individual sound identity beginning within 80 ms of sound onset. Second, using

representational similarity analysis we correlate whole-brain MEG and fMRI data to reveal the temporal dynamics of sound processing in the human brain. Refining this analysis, we examine independently-localized regions of interest in occipital, temporal, and frontal cortex to map their distinctive spatiotemporal dynamics. Our results reveal hierarchical organization of sound processing emerging with neuronal activation in primary auditory cortex and spreading rapidly across a distributed neural network within the first few hundred milliseconds of audition. Together, these findings elucidate the differential temporal dynamics for representations of individual sounds and provide an integrated account of auditory processing across space and time in the human brain.

Topic Area: PERCEPTION & ACTION: Audition

C114 Speech in noise versus simulated cochlear implant (CI) speech: Assessing co-activation between temporal and frontal cortices during an event-related, speech perception task

Jessica Defenderfer¹, Mark Hedrick¹, Patrick Plyler¹, Sobanawartiny Wijekumar², Aaron Buss³; ¹University of Tennessee Health Science Center, ²University of Stirling, UK, ³University of Tennessee, Knoxville

The cortical hemodynamic response undergoes significant changes during challenging listening conditions, often recruiting and co-activating with additional brain regions beyond those recruited during favorable listening conditions. Expanding upon our previous findings (Defenderfer et al., 2017), the current study uses functional near infrared spectroscopy (fNIRS) to assess frontotemporal activation during a speech perception task. Normal-hearing adults were instructed to listen to sentences and repeat aloud what they heard. Responses were scored for accuracy. Signal quality was reduced by vocoding (simulated CI speech) or adding background noise. Sentences in quiet were used as baseline comparison. Performance in degraded conditions averaged around 50% correct across subjects, allowing for balanced comparison between correct and incorrect trials. A custom headpiece (thirteen 30mm channels and one 10mm channel) measured activation over the left frontal and temporal lobes. ANOVA results from image-based analyses (Wijekumar et al., 2017) revealed significant interaction effects between perception accuracy and type of degraded speech. The middle temporal gyrus (MTG) and inferior frontal gyrus (IFG) demonstrated greater activation in response to correctly perceived trials (across both noise and vocoded trials) versus incorrect trials. However, a cluster spanning pars opercularis and aSTG exhibited a 3-way interaction: when noise was added to sentences in quiet, an increase in activation is observed, possibly as a compensatory mechanism. Yet, when vocoded sentences are degraded further by adding noise, activation demonstrates a clear decrease. These results reveal a potential disadvantage for CI users who may not have access to recruited frontotemporal activation when speech perception is challenging.

Topic Area: PERCEPTION & ACTION: Audition

C115 Testing the neural entrainment hypothesis by dissociating periodic stimulation from temporal predictions.

Luca Iemi¹, Charles E. Schroeder^{1,2}, Saskia Haegens^{1,3}; ¹Department of Neurological Surgery, Columbia University College of Physicians and Surgeons, New York, NY 10032, USA, ²Cognitive Neuroscience and Schizophrenia Program, Nathan Kline Institute, Orangeburg, New York 10962, ³Centre for Cognitive Neuroimaging, Donders Institute for Brain, Cognition and Behaviour, Radboud University Nijmegen, Nijmegen, 6500 HB, the Netherlands

An influential hypothesis proposes that periodic streams of sensory stimuli may result in an adjustment/alignment of ongoing neural oscillations, such that the oscillatory phase with high excitability coincides with the occurrence of task-relevant sensory targets. This phenomenon, referred to as neural

entrainment, is considered an important mechanism through which the brain instantiates temporal predictions and supports active perception. Here, we tested this hypothesis in a series of experiments using psychophysics, magnetoencephalography (MEG), and electrocorticography (ECoG) in human subjects. We used an experimental paradigm that specifically dissociates periodicity of sensory stimulation (thought to drive neural entrainment) from temporal predictions (which do not require periodicity). We found that, compared to aperiodic streams with equal temporal prediction, periodic streams with a frequency of 1.6 Hz were followed by increased phase-alignment of broad-band low-frequency oscillations, and by faster reaction times in subsequent target discrimination. These initial results do not appear to support the hypothesis of neural entrainment as it is currently formulated in the literature. Rather they fit with the ideas that: 1) that periodic cue streams lead to a general phase reset, rather than frequency-specific neural entrainment of ongoing oscillations, and 2) they benefit reaction times, rather than the precision of sensory processing.

Topic Area: PERCEPTION & ACTION: Audition

C116 Audiovisual Associations: The role of auditory stimulus properties in predicting visual image choice

Keith McCarthy¹, Kaya G. Mondry¹, Ferrinne Spector¹; ¹Edgewood College

Most perceptual experiences involve multiple senses, yet we often think of sensory experience as domain specific. Understanding how stimulus properties are associated across sensory domains can help to understand the cognitive structure and neural architecture of perceptual processing and integration. The purpose of this research is to examine associations between visual and audio domains through the development and experimental implementation of an audio stimulus set for use in multisensory research. The sound data set consists of 64 sound stimuli, each created to manipulate a single property of sound (pitch, volume, ascension, tempo, continuity), with each sound property represented across four musical instruments to capture differences in timbre. We examined audiovisual associations by playing a sound stimulus coincident with a forced choice between one congruent and one random visual image. Each visual stimulus was created to manipulate different visual features including roundedness, numerosity, continuity, movement and growth of shapes and lines. Sound features were categorized as congruent with properties of visual stimuli (e.g., sound articulation and line continuity) based on unpublished audiovisual integration data from our lab as well as consistent findings from the audiovisual literature. Initial results (N = 40) suggest that congruent images are chosen more than can be expected to due to chance in the sound categories of volume, tempo, low pitch, and ascension (all $p < .001$). These results support the idea of reliable and predictable translation of stimulus properties across sensory domains which can be utilized to understand the perceptual processes underlying multisensory integration.

Topic Area: PERCEPTION & ACTION: Multisensory

C117 Double-Blind Study of Visual Imagery in Grapheme-Color Synesthesia

EunSeon Ahn¹, David Brang¹; ¹University of Michigan

Synesthesia is an atypical perceptual phenomenon that has been associated with generalized differences in other cognitive and perceptual domains. Given similarities in the qualitative nature of synesthetic experiences to visual imagery perceptions, several studies have sought to examine whether synesthetes demonstrate increased visual imagery abilities. Using subjective imagery questionnaires, some studies have identified superior imaging abilities in synesthetes, while others have not. However, because most research on synesthesia uses un-blinded group membership prior to data collection, such methods for studying group differences may be prone to

participant and experimenter biases (e.g., a motivated synesthete may rate themselves as having stronger visual imagery abilities due to their own bias and perceived experimenter expectations). To address this issue, we demonstrate the feasibility of double-blind designs in synesthesia research, applied here to examine differences in subjectively reported levels of imagery usage and intensity. Prior to identifying synesthetes' and non-synesthetes' group membership (in order to eliminate the potential for bias), subjects completed two common measures of visual imagery experiences. Using this approach, we replicated findings of greater visual imagery usage in synesthetes on the Spontaneous Use of Imagery Scale (SUIS) measure, but not of enhanced imagery abilities on the standardized Vividness of Visual Imagery Questionnaire (VVIQ) measure. The present study strengthens prior evidence that synesthesia is associated with heightened visual imagery and demonstrates the utility of double-blind designs in order to limit biases and promote further replicability of other findings in research on synesthesia.

Topic Area: PERCEPTION & ACTION: Multisensory

C118 Lesion-symptom mapping analysis of interdependence of motor and language systems

Analia Arevalo¹, Guilherme Lepski^{1,2}, Timothy Herron³, Nina Dronkers^{3,4}, Juliana Baldo³; ¹University of Sao Paulo School of Medicine, Brazil, ²University of Tuebingen, Germany, ³VA Northern California Health Care System, ⁴University of California, Berkeley

According to "embodiment theory", the cortical sensorimotor regions responsible for action execution also underlie action observation, planning, and mental imagery as well as the processing of action-related words. Strict interpretations of these theories contend that the same regions are recruited when 1) executing actions, 2) observing actions, and 3) processing action-related words. However, previous studies have been criticized for not testing all these dimensions using the same stimuli, which would make results more compelling. In the current study, we analyzed behavioral data from 49 single, left hemisphere stroke patients on the Porch Index of Communicative Ability (PICA), which tests object and action comprehension through auditory, verbal, pantomime, gesture and writing modalities with the same stimuli. We used univariate and multivariate lesion-symptom mapping (LSM) to identify brain regions associated with performance across these different modalities. Fusiform gyrus, middle/inferior temporal and middle/inferior occipital cortices were associated with all task categories, while angular gyrus and superior parietal cortex were specifically associated with predominantly motor tasks (copying, pantomime and gesturing) or involving single-word processing (production or comprehension). Finally, word tasks also involved superior temporal cortex. These data corroborate previous findings from our group suggesting that processing action-associated information recruits a broad network of left hemisphere regions not limited to premotor cortex, and contradict the notion that all three dimensions of an embodied network recruit the same set of cortical regions. A clearer map of the key regions involved in sensorimotor processing across task modalities should better inform future clinical interventions.

Topic Area: PERCEPTION & ACTION: Multisensory

C119 Music perception as a multisensory experience

Simon Lacey¹, James Nguyen¹, K. Sathian¹; ¹Penn State College of Medicine

The crossmodal correspondence between auditory pitch and visuo-spatial elevation (in which high- and low-pitched tones are associated with high and low spatial elevation respectively) has been proposed as the basis for Western musical notation. One implication of this is that music perception may not be exclusively auditory. Here, we investigated how music perception was influenced by concurrent visual stimuli. Participants listened to unfamiliar five-note musical phrases with four kinds of pitch contour (rising, falling, rising-

falling, or falling-rising) that were accompanied by incidental visual contours that were either congruent (e.g., auditory rising/visual rising) or incongruent (e.g., auditory rising/visual falling) and judged whether the final note of the musical phrase was higher or lower in pitch than the first. Response times for the auditory judgment were significantly slower for incongruent compared to congruent trials, i.e. there was a congruency effect, even though the visual contours were incidental to the auditory task. Accuracy tended to be lower for incongruent than congruent trials. These results suggest that music perception, although generally regarded as an auditory experience, may actually be multisensory in nature.

Topic Area: PERCEPTION & ACTION: Multisensory

C120 Neurobiology of self-agency during reality monitoring and speech monitoring

Karuna Subramaniam¹, Leighton Hinkley¹, Hardik Kothare¹, Danielle Mizuiri¹, John Houde¹, Srikantan Nagarajan¹; ¹University of California San Francisco

Self-agency is the experience of being the agent of one's own actions. Reality monitoring (RM) involves distinguishing self-generated from externally-derived information. Self-agency, a necessary component of RM, is thought to depend on making reliable predictions about the expected outcomes of one's own actions. This self-prediction ability is also critical for monitoring our actions, particularly during speaking where we continually compare what we hear while we speak with what we expect to hear. We test a novel cognitive model underlying self-agency by investigating whether higher-level self-agency judgments during RM are driven by lower-level self-predictions during speech monitoring (SM) in healthy controls (HC). During RM, HC showed strongest neural activity during encoding and retrieval of self-generated information in medial prefrontal cortex (mPFC), which correlated with accurate self-agency judgments (i.e., identification of self-generated information). During SM, we altered auditory feedback so that subjects listened to a perturbed version of their own speech. When HC heard these auditory perturbations while speaking, they made corrective responses, indicating that they judged the perturbations as speech output errors. Self-agency judgments and mPFC activity during RM correlated with smaller corrective responses during SM. Thus, the more subjects relied on their self-predictions about their speech outcome, the less they relied on external perturbed auditory feedback. This resulted in smaller corrective responses and enhanced self-agency during RM, driven by subjects' reliance on their self-predictions. These results provide support for a unitary process of self-agency mediated by mPFC activity, and driven by reliably predicting the outcomes of one's own self-generated actions.

Topic Area: PERCEPTION & ACTION: Multisensory

C121 Spatiotemporal information conveyed by crossmodal phase-reset: An electrocortigraphy approach

John Plass¹, EunSeon Ahn¹, Aleksandra Sherman², Vernon Towle³, William Stacey¹, Vibhangini Wasade⁴, James Tao³, Shasha Wu³, Naoum Issa³, Marcia Grabowecy⁵, Satoru Suzuki⁵, David Brang¹; ¹University of Michigan, ²Occidental College, ³University of Chicago, ⁴Henry Ford Hospital, ⁵Northwestern University

Sounds can facilitate visual perception by placing visual cortex in a high-excitability state before visual signals arrive. However, the auditory source, visual cortical target, and spatiotemporal specificity of the crossmodal signals conveyed through this mechanism remain unclear. To address these questions, we examined visual cortex's responses to amplitude-modulated (AM) sounds and lateralized noise-bursts using intracranial electrocortigraphy (ECoG) in epilepsy patients. Both stimulus types evoked widespread phase-resetting throughout visual cortex, with maximal activity in pericalcarine (putative V1/V2) and lateral occipito-temporal cortex (potentially

V5/hMT+). To identify the level of hierarchical coding at which auditory information is transmitted to visual cortex, we compared crossmodal responses to AM sounds to typical responses observed at different levels of the auditory hierarchy. Visual cortex displayed transient onset and offset responses, but no entrainment to AM sounds, suggesting that visual cortex does not receive temporally fine-grained stimulus dynamics encoded by auditory midbrain/thalamus but, rather, a temporally segmented representation of auditory events that emerges only in auditory cortex. To assess the spatial specificity of these effects, we compared visual cortical responses to contralateral and ipsilateral sounds. Sites throughout visual cortex exhibited a contralateral bias, but no hemifield-specific responses, indicating modest but significant crossmodal spatiotopy. Altogether, these results are consistent with a model in which visual cortex inherits the properties of auditory cortex's responses to sounds through direct cortico-cortico connections. These crossmodal interactions may facilitate perception by time-locking visual computations to spatiotemporally coincident auditory events.

Topic Area: PERCEPTION & ACTION: Multisensory

C122 Visual optimization of auditory stream segregation in a 'cocktail party'

Niti Jaha¹, Antoine Shahin¹; ¹University of California, Davis

Lip-reading enhances comprehension in cluttered acoustical environments. We hypothesized that visual context aids in speech comprehension in a 'cocktail party' by strengthening encoding of acoustic representations of the visually-attended speech stream as opposed to the ignored stream. In an audiovisual (AV) task, EEG was acquired as participants watched and listened to videos of a speaker uttering a sentence while also listening to a concurrent sentence by a speaker of an opposite gender. A key manipulation was that each audio sentence had a 200-ms segment replaced by white noise. To assess their comprehension, subjects were required to transcribe the visually-attended sentence every few trials. In an auditory-only task, subjects listened to the same speech streams as in the AV task, except that the videos were of a static picture of a speaker of either gender. Subjects directed their listening to the voice of the gender of the speaker in the video. We found that the N1 auditory evoked potential to white noise onsets was significantly inhibited for the visually-attended stream compared to those of the auditorily-attended and visually-unattended streams. These results emphasize that visual context aids in streamlining the complex auditory scene, partly by filling-in auditory representations of the visually-attended stream while inhibiting auditory representations of interfering cues, in turn heightening the perception of continuity and comprehension.

Topic Area: PERCEPTION & ACTION: Multisensory

C123 When speech disagrees with your reach, grasping with your right and left hands differ from each

Nicole A. van Rootselaar¹, Bailey Way¹, Claudia L.R. Gonzalez¹; ¹University of Lethbridge

Speech and manual action affect each other. For example, studies have shown that right hand grip aperture changes according to the words pronounced (i.e. saying "apple" produces a larger maximum grip aperture [MGA: greatest distance between the thumb and index finger] than saying "grape"). However, few studies have examined this in the context of lateralization. Speech, praxis (tool-use network), and skilled motor control are known to be lateralized to the left hemisphere of the brain. So, it would be reasonable to speculate that only right-handed actions would be affected by speech. To investigate this, we asked participants to use their right and left hands (in separate blocks) to grasp one of two pairs of small/large tools (bolt/wrench or screw/screwdriver) while they pronounced the name of the tool. No hand differences were found in these congruent trials. To further

investigate the effects of speech on right- and left-handed grasps we included incongruent trials in which participants named the opposite object from the one they grasped (i.e. say "bolt", grasp the wrench). Interestingly, speech affected grasping differently for each hand. When grasping the small items (pincer grasps) but pronouncing the name of the large items MGA increased in the right hand. When grasping the large items (power grasps) but naming the small items MGA decreased in the left hand. These findings demonstrate that speech affects both hands, and supports research indicating a right-hand preference for precision and left-hand preference for power grasps.

Topic Area: PERCEPTION & ACTION: Multisensory

C124 Anticipation shapes consciousness: The neural dynamics of temporal prediction in visual awareness

Mathieu Landry¹, Jason Da Silva Castanheira¹, Sylvain Baillet¹, Amir Raz^{1,2}; ¹McGill University, ²Chapman University

A growing body of research highlights the centrality of pre-stimulus processing in shaping conscious perception. Notably, this work emphasizes the role of alpha oscillations in the sensory region. Following this trend, we investigated whether anticipation would enhance visual awareness by modulating alpha patterns. Participants completed a target discrimination task which consisted of a temporal cueing task combined with a backward masking strategy while we recorded brain activity using 64-channel electroencephalography. For half of the trials, a predictive temporal cue allowed participants to reliably forecast when an otherwise unpredictable target event would occur. Participants provided an objective response by indicating the orientation of the Gabor target followed by a subjective judgment about its visibility. Our results confirm that heightened anticipation boosts task performance and visual awareness. We corroborated these effects at the neural level through event-related potentials as predictive cueing increased the amplitudes of the contingent negative variation and the late positivity, two neural components indexing anticipation and visual awareness, respectively. We used single-trial regression models over time-frequency decomposition of pre-stimulus onset to evaluate our hypothesis and test the interaction between cueing, objective performance, and subjective judgments. Contrary to our expectations about alpha patterns, our analysis shows that anticipation enhances task performance and visual awareness by modulating frontal beta and gamma oscillations. Our findings uncover some of the neural dynamics corresponding to the influence of heightened anticipation over visual awareness and extend the range of oscillatory patterns involved in the prediction of forthcoming sensory events.

Topic Area: PERCEPTION & ACTION: Vision

C125 Can Processing Of Face Trustworthiness Bypass Early Visual Cortex? A Transcranial Magnetic Stimulation Masking Study

Shanice E. W. Janssens^{1,2}, Alexander T. Sack^{1,2}, Sarah Jessen³, Tom A. De Graaf^{1,2}; ¹Maastricht University, Maastricht, The Netherlands, ²Maastricht Brain Imaging Centre, Maastricht, The Netherlands, ³University of Lübeck, Lübeck, Germany

As a social and cooperative species, we often need to judge whether or not to trust someone simply by evaluating their faces. It has been suggested that this face trustworthiness can be processed unconsciously. However, empirical data supporting the existence of a neural pathway for trustworthiness processing that bypasses early visual cortex (EVC), similar to unconscious emotion processing, is still missing. To investigate this, we applied double-pulse transcranial magnetic stimulation (TMS) to right EVC, at different stimulus onset asynchronies (SOAs: 50ms, 100ms, 150ms, as well as no-TMS) from faces perceived as trustworthy or not, and rotated clockwise or counterclockwise. Faces were presented in either left or right hemifield. On each trial, participants reported 1) face trustworthiness, 2) stimulus rotation,

and 3) subjective visibility of trustworthiness. Performance on each of these three tasks was analyzed in 2 (Hemifield) x 4 (TMS SOA) repeated measures ANOVAs and Bonferroni-corrected post-hoc tests. If trustworthiness judgments do not require intact EVC, trustworthiness judgments should be unaffected by TMS. In accordance with our hypotheses, specifically at 50ms and 100ms SOA and for left hemifield targets, right EVC TMS decreased subjective visibility ratings of trustworthiness and impaired rotation task performance ($p < 0.05$), but not forced-choice trustworthiness judgments. Our results are compatible with the hypothesis that EVC may not be necessary for trustworthiness judgments, even though it is required for conscious perception of trustworthiness. This is in agreement with the proposal that trustworthiness processing may occur outside of awareness, relying on extrastriate pathways, and further emphasizes its ecological relevance.

Topic Area: PERCEPTION & ACTION: Vision

C126 Development of an ERP-based Cognitive Assessment

Mayuko Takehara¹, Ryohei Hasegawa²; ¹University of Tsukuba, ²National Institute of Advanced Industrial Science and Technology

In Japan's ultra-aging society, over 55% of the old man over 85 years of age is suffering from dementia and there is serious problems related with unconscious the aging cognitive function. Our study aims to examine the development of an event related potentials(ERP)-based Cognitive Assessment. We conducted two experiments aimed at identifying the target. In the first experiment, we measured the ERP, when human participants viewed images of scenes (familiar/unfamiliar), shapes of countries, chicken, and right hand. We use 8directions($0^\circ, \pm 45^\circ, \pm 90^\circ, 180^\circ$) angle of all images except the scenes to tried to reveal the task difficulty in terms of reaction time. In the second experiment, we conducted the behavioral task using the same images of first experiment. The subjects reacted by pressing the keyboard when the target shows in front of their monitor. From these two types of tasks, we could find the task difficulty and the result of measuring ERP is more precisely than behavioral tasks. It is sometimes difficult to measuring the accurate cognitive ability by paper tests, or behavioral tasks for dementia patients and the physically handicapped. But our findings will help find the pre-dementia as a frailty and also help to training the cognitive ability for all people including dementia.

Topic Area: PERCEPTION & ACTION: Vision

C127 Embodied emotion correlates with personality traits- A study with somatosensory- evoked potentials

Vasiliki Meletaki¹, Beatriz Calvo-Merino¹, Irena Arslanova¹, Bettina Forster¹; ¹City, University of London

The present study aimed to link the neural correlates of embodiment with personality traits such as emotional wellbeing, ability to understand emotions (namely alexithymia) and interoception using a neural index of emotions. Participants were presented with stimuli of faces expressing happiness, anger, sadness and neutral, while measuring their electrophysiological activity. An embodiment index was calculated by measuring participants' somatosensory-evoked activity by tactually probing (105 ms. post-visual facial stimuli) the state of SCx during an emotion discrimination task while controlling for visual effects (Sel et al., 2014). Additionally, we measured participant's levels of depression and alexithymia (by means of Beck Depression Inventory and the Toronto Alexithymia Scale respectively). In the SEPs data, significant differences were found in amplitude between all four emotions (happiness, anger, sadness and neutral) over the somatosensory cortices between 100-120ms, following previous data on embodied emotion over somatosensory cortices (Sel et al., 2014). Interestingly, we also found significant correlation between depression scores and the SEPs amplitude of sad emotion (calculated by subtracting the amplitude of neutral condition from the emotion condition). These data provide

novel evidence for relating neural somatosensory activity directly linked to embodied emotions (and independent from carry over visual effects), to subjective measures and personality traits, such as depression.

Topic Area: PERCEPTION & ACTION: Vision

C128 Statistical expectations about target identity impact early orientation by interacting with the encoding of target location

Uri Hasson¹, Giuseppe Notaro¹; ¹The University of Trento

Humans easily learn environmental regularities to generate predictions and increase the efficiency of visual detection. They respond faster to items that appear in predictable locations, or whose identity-features are predictable. However, the interaction between predictions of object-location and object-identity is poorly understood, with extant knowledge being almost exclusively based on paradigms necessitating deliberative decisions about item features. These have suggested that functionally independent systems govern utilization of predictable location and identity information. However, recent neuroimaging work suggests that the potential to predict both location and identity produces a bottleneck, and here we examined whether this is evident in the earliest orientation stages. We measured saccade latencies (SL) during a saccade-to-target task, where targets were images that belonged to one of four semantic categories and could appear in one of four possible locations. There were four types of series where: 1) both location and identity were predictable; 2) both location and identity were not predictable; 3) only location was predictable; 4) only identity was predictable. Location-predictability speeded SL, but identity-predictability impacted SL well. First, the spread of the SL distribution increased for identity-predictable streams, consistent with models of memory retrieval. Second, in series where location was predictable, the (deleterious) impact of location-violation was significantly exacerbated when people could predict target-identity. We conclude that identity regularities are registered, impact the earliest stages of visual orientation, and interact with early processes for coding target-location. These findings are consistent with neuroimaging data suggesting interactions between dorsal and ventral streams in object processing.

Topic Area: PERCEPTION & ACTION: Vision

C129 A cognitive map of social network space

Douglas Miller¹, Seongmin Park¹, Hamed Nili², Erie Boorman¹; ¹Center for Mind and Brain, University of California, Davis, ²FMRIB, University of Oxford

Recent findings suggest the hippocampal-entorhinal (HPC-ERC) system may serve a general mechanism for navigating cognitive maps of non-spatial tasks. These demonstrations have used continuous task dimensions, whereas many everyday tasks involve decisions between abstract and discrete entities. Here, we test whether the human brain uses the same principles when making binary decisions about the rank of individuals in a social hierarchy. Participants learned the rank of people on two dimensions, popularity and competence, in two separate groups. Next, they learned the relative rank of select individuals ("hubs") in each group with the other group, creating a unique associative path between groups. Finally, they made inferences about the rank of novel pairs between the two groups. Behaviorally, reaction times for inferences depended on the within-group Euclidean distance from the hub in the 2-D social space. Neurally, during inferences, ERC and medial prefrontal cortex (mPFC) encode the within-group Euclidean distance between individuals and the latent hub. Our findings adopting the trial-by-trial fMRI suppression showed that the hippocampal activity was suppressed when the novel pair was followed by their relevant hub compared to other matched hubs, suggesting a neural representation of the retrieved hub. Finally, we demonstrate that a robust linear relationship with the representational dissimilarity in the HPC-ERC system with Euclidean distances between people in the 2-D social space. These results shed light on how abstract and discrete structures are

represented, navigated, and combined in the human brain, suggesting that general mechanisms in the HPC-ERC system are leveraged to navigate social networks.

Topic Area: THINKING: Decision making

C130 Age-related and individual differences in neural substrates of moral decision making

Ting-Yu Liu^{1,2}, Hsu-Wen Huang³, Chih-Mao Huang^{1,4}; ¹Department of Biological Science and Technology, National Chiao Tung University, Taiwan, ²Institute of Bioinformatics and Systems Biology, National Chiao Tung University, Taiwan, ³Department of Linguistics and Translation, City University of Hong Kong, Hong Kong, ⁴Cognitive Neuroscience Laboratory, Institute of Linguistics, Academia Sinica, Taiwan

Moral decision-making is the unconscious and deliberate decision-making process to evaluate moral situation in a given scenario or identify moral permissibility of individual's action. Several functional neuroimaging studies suggest a distributed network of frontal and parieto-temporal regions, including medial prefrontal cortex (mPFC), anterior cingulate cortex (ACC), and temporoparietal junction (TPJ) associated with moral cognition. In this functional magnetic resonance imaging (fMRI) study, we conducted a mixed block/event-related design to examine age-related and individual differences in neural substrates of moral decision making. Twenty-one young and forty-one healthy older participants were instructed to perform a modified version of moral evaluation task that make a good/bad evaluation of an intentional action after presenting a set of visual scene that depicts social interactions between individuals. A whole-brain analysis revealed that older adults exhibited neural activation in mPFC, ACC, and bilateral TPJ in which the brain regions have been associated with moral decision making. In addition, older adults showed greater and distributed activation in bilateral posterior parietal cortex, amygdala, and hippocampus, probably involving strategic retrieval processes of social decision making. These findings demonstrate age-related and individual variations in neural substrates related to moral cognition and social decision making.

Topic Area: THINKING: Decision making

C131 Behavioral and Neural Signatures of the Subjective Value of Pain and Exercise

Allison Shapiro¹, Gold Okafor², Viktoriya Babenko¹, Tom Bullock¹, Neil Dundon¹, Barry Giesbrecht¹, Scott T. Grafton¹; ¹University of California, Santa Barbara, ²University of California, Berkeley

Everyday choices entail consideration of costs inherent in pursuing potential rewards. Utility theory posits that the subjective value (SV) of a given choice option is its perceived utility, accounting for its positively- and negatively-valued attributes. Previous literature has surveyed neural representations of different types of costs including probabilistic risk, pain, cognitive effort and grip-force effort. We investigated deterministic choices with significant material consequences, including pain and cardiovascular exercise. We implemented two approach-avoidance tasks with mixed outcome offers of monetary rewards contingent on costs of either physical pain or cardiovascular exercise. Each participant underwent a pain thresholding procedure and a VO₂ max test to determine their maximum pain tolerance and maximum cardiovascular capacity, respectively. BOLD responses were recorded while they accepted or rejected offers, calibrated to those thresholds. We modeled decision behavior with logistic regression to estimate the SV of each offer and observed substantial individual differences in both subjective valuation and preference for bike vs. shock costs. Most participants accepted more pain offers than exercise offers, however the strength and shape of that bias varied between individuals. BOLD responses in regions associated with the pain matrix tracked pain costs better than exercise costs. The two types of costs also

differentially modulated neural responses to rewards and the SV of each offer in areas associated with valuation, including the ventromedial prefrontal cortex, dorsomedial prefrontal cortex, and the anterior insula. The results suggest that estimation of subjective value recruits disparate brain areas, contingent on the cost structure of the decision variables.

Topic Area: THINKING: Decision making

C132 Electrophysiological Activity Underlying Optimism Biases during Belief Updating

Ziqing Yao¹, Xiaoqing Hu^{1,2}; ¹Department of Psychology, The University of Hong Kong, Hong Kong, China, ²The State Key Laboratory of Brain and Cognitive Science, The University of Hong Kong, Hong Kong, China

When people are presented with better- and worse-than-expected probabilities regarding future adverse events such as cancer, car accidents, in debt, etc., people show asymmetrical belief updating: they will adjust their estimates more for desirable (better-than-expected) than for undesirable (worse-than-expected) events, known as optimism biases. In a pre-registered study, we investigated the electrophysiological activity that underlies such a valence-dependent, asymmetrical belief updating process. Moreover, we examined two aspects of the optimistic biases: a judgment bias and a memory bias. These two biases were assessed both immediately and after a 24-hour delay following the first session. We examined ERPs that are elicited by desirable and undesirable probabilities and focused our analyses on ERPs that are relevant with feedback processing, i.e., feedback-related negativity (FRN), and with memory encoding, i.e., late positive potential (LPP). Behaviorally, participants showed a robust effect in optimistic biases: not only their judgments integrated more desirable than undesirable probabilities, their memories were also better for desirable than for undesirable probabilities. ERP analyses revealed that such an optimistic bias was rooted in biased memory encoding processes: desirable feedback elicited significantly larger LPPs compared to undesirable feedback across frontal and parietal electrodes. Moreover, the differences of LPPs between desirable and undesirable feedbacks were positively correlated with the asymmetric belief updating. We also found a marginal significance effect regarding the FRN, such that undesirable feedback elicited larger FRN than desirable feedbacks. These results provide novel insights regarding the neurocognitive processes underlying motivated belief updating.

Topic Area: THINKING: Decision making

C133 Hexadirectional coding in human entorhinal cortex represents the trajectory through social networks during decision-making

Seongmin Park¹, Douglas Miller¹, Erie Boorman¹; ¹Center for Mind and Brain, University of California, Davis

Recent findings suggest the hippocampal-entorhinal (HPC-ERC) system may serve a general mechanism for representing and navigating cognitive maps of non-spatial tasks. These map-like representations can be used to guide flexible goal-directed behavior. However, it is unclear whether the HPC-ERC system uses the same organizational principles to map the dimensions of abstract and discrete problems. We, therefore, developed a novel task to test how human brains map non-spatial, discrete dimensions and use this representation to guide decision-making. Participants learned the relationship between 16 entrepreneurs in two independent ability dimensions by comparing two entrepreneurs' relative rank in a hierarchy. During fMRI participants were asked to choose the better of two partners for a given entrepreneur by comparing their joint 'growth potential (GP)'. The GP corresponded to the area drawn by the relative rank of two entrepreneurs in the 2-dimensional cognitive space. We found that the level of dissimilarity of HPC-ERC activity patterns increased with the Euclidean distance between entrepreneurs in the 2-D social network. Moreover, ERC and ventromedial

prefrontal cortex (vmPFC) encoded the difference in GP between the pairs, suggesting a role in guiding decision-making. Finally, we show that the HPC-ERC system and vmPFC display hexadirectional signals, which serve as a proxy measure for a grid-like code, representing the trajectories through the cognitive space. This grid-like signal is consistent across sessions acquired more than a week apart. Our findings suggest a general grid-like code in human ERC that is extended to encode trajectories in abstract and discrete problems that serve everyday decision-making.

Topic Area: THINKING: Decision making

C134 Hierarchical Reinforcement Learning enables flexible transfer in humans

Liyu Xia¹, Anne Collins¹; ¹University of California, Berkeley

Human intelligence relies on our ability to flexibly and efficiently generalize what we learned in the past to new contexts. Recent work proposed a theory for such transfer in the case of task-sets which are simple, one-step stimulus-action policies. However, real world behavior routinely requires more complex skills to be transferred. Hierarchical reinforcement learning's options framework provides a theoretical basis for such transfer. Options are abstract multi-step policies, assembled from simple actions and smaller options, that can represent meaningful reusable skills. In this study, we aim to test if humans can indeed learn and transfer options at multiple levels with a novel two-stage reinforcement learning protocol. Participants learned to choose the correct action in response to stimuli presented at two successive stages to receive reward in a trial. Crucially, we designed the contingencies leading to reward to provide participants opportunities to create options at multiple levels of complexity, and to transfer them in new contexts. Results from this experiment, together with two control experiments, showed patterns of learning, including transfer effects at multiple levels of policy complexity, that couldn't be explained by traditional flat reinforcement learning models. We compared four models and showed that only the option model can account for all the transfer effects. Our computational and behavioral results provide evidence for option learning and transfer, but also points to the possibility that option transfer can happen flexibly at multiple levels of hierarchy. This has implications for understanding how humans learn flexibly, explore efficiently, and generalize knowledge.

Topic Area: THINKING: Decision making

C135 Processing the non-occurrence of expected outcomes in deterministic and probabilistic reversal learning

Selim Habiby Alaoui¹, Alexandra Adam-Darqué¹, Armin Schnider¹; ¹Laboratory of Cognitive Neurorehabilitation, Division of Neurorehabilitation, Department of Clinical Neurosciences, University Hospital of Geneva and University of Geneva, Switzerland

Orbitofrontal reality filtering denotes a mechanism necessary to synchronize behavior and thought with ongoing reality. Its failure induces reality confusion with disorientation and confabulations (Schnider A. The Confabulating Mind. How the brain creates reality, 2nd ed. Oxford University Press, 2018). Its underlying signal seems to be similar to the one inducing behavioral extinction. While early animal studies documented orbitofrontal neurons responding specifically to the absence of expected rewards, more recent studies testing probabilistic reversal learning (RL) pinpointed neurons in the anterior cingulate responding to such events. Here, we tested the hypothesis that the electrophysiological response to the omission of expected outcomes depends on the need to adapt behavior, and hence on the type of RL. Twenty-eight healthy volunteers underwent high-density EEG while performing two RL tasks, in which they decided behind which one of two colored squares an item was hidden. In the deterministic task, absence indicated with 100% probability a need to switch on the next trial. In the probabilistic task (association 80%),

omission did not necessarily indicate a need to switch. In the deterministic task, 97% of choices were correct, in the probabilistic task, 81% of choices corresponded to the more likely outcome. The non-occurrence of expected outcomes evoked an early frontal positivity between 200-300ms in the deterministic task; in the probabilistic task, it evoked a late central positivity at 400-600ms. We propose that these differential responses to absent outcomes influence different types of behavioral adaptation: orbitofrontal reality filtering (deterministic context) or elaborate decision making (probabilistic context).

Topic Area: THINKING: Decision making

C136 The development of the variance discounting task to investigate the impulsivity with delay discounting task and probabilistic discounting task

Yu-Chi Lin¹, Nai-Shing Yen¹, Fan-Ying Liu¹, Yun-Fan Fang¹, Tsung-Han Yang¹, Chi Wang¹, Wen-Hsi Huang¹, Nai-Shing Yen; ¹National Chengchi University

Among the past decades, delay discounting task (DDT) was frequently used to investigate the impulsive choices by manipulating immediate or delayed rewards to individual. The discounting parameter derived from DDT (K) has often shown association with impulsivity-related personality (e.g. neuroticism, psychotocism) or behaviors (e.g. smoking, drinking, etc.). Similarly, probabilistic discounting task (PDT) was used to examine the impulsive choices by manipulating certain or probabilistic rewards. However, the effect of variance of reward is not yet examined clearly in PDT, in specific, the expected value (EV) was not controlled. To fill this gap, we designed a variance discounting task (VDT) to manipulate the variances of the probabilistic reward options while kept the EVs of certain and probabilistic options equal. Moreover, we deployed it with DDT (immediate vs 1, 2, 3 months rewards respectively) and PDT (100% vs 25%, 50%, 75% rewards respectively) in present study. All tasks took 6 trials for each condition to estimate the discounting parameter. In VDT, the first trial of each variance condition (100% vs 25%, 30%, 50%, 60%, 75% rewards respectively) always presented 2 EV-equal reward options. The values of the risky reward options were estimated and the discounting parameter were then derived. Twenty-eight young adults from Taiwan participated. The results showed that DDT had no significant correlations with PDT, VDT, and other personality scales. PDT and VDT were highly correlated with each other ($p \leq .001$), yet only VDT was correlated with the behavioral inhibition system (BIS) and the psychoticism of Eysenck personality scale-revised.

Topic Area: THINKING: Decision making

C137 The effects of age on neural reward responses in the monetary incentive delay task

Isha Dhingra¹, Sheng Zhang¹, Herta H. Chao^{1,2}, Simon Zhornitsky¹, Wuyi Wang¹, Thang Le¹, Chiang-shan Ray Li^{1,3}; ¹Yale University School of Medicine, ²VA Connecticut Healthcare System, ³Yale University Interdepartmental Neuroscience Program

Specific goals: To examine the effects of age on reward processing using a monetary incentive delay task (MIDT). Methods: Fifty-four healthy adults aged 22-74 years (30 men, 40±14y) performed a MIDT to win a dollar, cent, or no money. The response window was calibrated to 67% success. Blood Oxygenation Level Dependent (BOLD) images were pre-processed using SPM8 and an event-related design was used to model activities at the two task phases – anticipation and feedback – separately with general linear models. Whole brain linear regression was performed in group-level analysis with age as a regressor. Results: All imaging results were evaluated at voxel $p < 0.001$ and cluster $p < 0.05$ FWE. Ventral striatal (VS) and precuneus activation to reward anticipation decreased with age. VS, pre-supplementary motor area, insula and precuneus activation were inversely correlated with age during

anticipation of higher (dollar) vs. lower (cent) reward. Supramarginal gyrus, superior and inferior frontal gyrus showed higher activation with age during feedback of cent loss vs. no reward, and insula and dorsomedial prefrontal cortex (dmPFC) showed lower activation with age to feedback of dollar vs. cent win. Conclusions: Healthy adults show age-related differences in neural responses to reward processing. Older adults show reduced responses to monetary gain but heightened sensitivity to loss. These findings may help in characterizing the psychological and neural mechanisms of reward-related decision making during aging and have implications for understanding the effects of age on neuropsychiatric conditions that implicate dysfunctional reward processing.

Topic Area: THINKING: Decision making

C138 Predictive processing in changing environments in autism: Electrophysiological, pupillometric and behavioral assays

SEYDANUR TIKIR¹, MICHAEL J. CROSSE¹, SOPHIE MOLHOLM¹; ¹Albert Einstein College of Medicine

Autism Spectrum Condition (ASC) is a complex neurodevelopmental condition characterized by deficits in social communication, as well as restricted and repetitive behaviors. Several groups consider ASC a disorder of prediction, proposing a link between predictive impairments and insistence on sameness. In a volatile environment where contingencies fluctuate often and predictions are violated recurrently, neurotypical individuals opt for a low level of confidence (precision) in beliefs, and thus prediction errors are less surprising; whereas in a low volatility environment, one tends to be highly confident in their predictions, and get surprised when they are violated. Individuals with ASC are often bothered by trivial changes in everyday life, leading us to hypothesize that they are lacking a specific ability that is crucial in predictive processing: flexibly adjusting the confidence level of predictions according to volatility in the environment. To test this, we first trained adults with and without ASC to perform a sequential pattern recognition task, where shapes are presented in specific orders. We then presented conditions with varying levels of pattern violation and environmental volatility, while electroencephalography (EEG), behavioral responses and pupillometry were recorded. To understand whether the environmental volatility was accurately estimated in ASC, we measured changes in pupil dilation, which served as a proxy for surprise. Evoked response potentials (ERPs) and reaction times were analyzed to infer predictive processing mechanisms. Preliminary results indicate that our manipulation of volatility is effective. Ongoing analysis is directed at determining whether the data support the thesis that volatility estimation is impaired in ASC.

Topic Area: THINKING: Other

C139 If only I had chosen differently! EEG manifestations of comparison between received and alternative outcomes

Deborah Marciano¹, Sacha Bourgeois Gironde^{2,3}, Leon Y. Deouell¹; ¹The Hebrew University of Jerusalem, Israel, ²Institut d'Etude de la Cognition, France, ³Institut Jean-Nicod, École Normale Supérieure, France

Following a choice between uncertain options, the outcome of the unchosen (alternative) option influences the evaluation of the received outcome: the better the alternative outcome, the least satisfied individuals are with their outcome. The electrophysiological correlates of this outcome comparison process are unclear. Studies of outcome comparison focusing on the Feedback-Related Negativity (FRN) and the P3 have reached conflicting conclusions, and had methodological limitations. Presenting both outcomes simultaneously at different spatial locations did not ensure that participants paid attention to both stimuli on each trial; revealing the alternative outcome first may have created biased expectations regarding the received outcome (Marciano et al, 2018). To overcome these issues, we designed a novel

paradigm. In the Matrix Game, feedback regarding the outcomes of both the received and alternative options is conveyed through one stimulus only. Participants (N=24) saw a matrix with two columns (+/-) and two rows (+/-). They had to bet on Columns or Rows. A token then appeared in one cell of the matrix. If participants bet on Columns (Rows) and the token appeared in the + Column (Row), they won money. Otherwise, they lost money. We found that the P3 elicited by the token (but not the FRN) was significantly modulated by both the received and the alternative outcomes: positive received outcomes elicited larger P3 than negative received outcomes, while positive alternative outcomes elicited smaller P3 than negative alternative outcomes. The P3 thus appears to be sensitive to the comparison of outcomes in a way that parallels behavioral findings.

Topic Area: THINKING: Decision making

Poster Session D

Monday, March 25, 8:00–10:00 am, Pacific Concourse

D1 Does sound-shape correspondence modulate a neuronal signature of visual shape processing for attended shapes?

Erinda Morina¹, Hiu Mei Chow², Vivian M. Ciaramitaro¹; ¹University of Massachusetts Boston, ²University of British Columbia

Crossmodal correspondences highlight naturally occurring associations across our senses. In the bouba/kiki effect, abstract shapes are associated with unrelated nonsense words, such that round shapes are matched to /bouba/ sounds and spiky shapes to /kiki/ sounds. Such associations have been found across cultures, languages, and across development. We used steady state evoked potentials (SSEPs) to examine how neural responses to a given visual feature depend on the auditory feature naturally associated with the visual feature. We hypothesized that neuronal responses to the same attended shape (e.g. spiky) would be enhanced for congruent (e.g. /ki/) vs incongruent (e.g. /ba/) sounds. Twenty-four subjects viewed one round and one spikey shape, each half-shape presented in a given visual hemifield. Visual shapes flickered at different frequencies (5.45, 7.5Hz) and were presented under one of three auditory conditions: no sound, /ba/ sound or /ki/ sound (3 Hz). Participants attended fixation to detect a color change, attended a given visual shape to detect a shape border thickening, or attended the auditory sound to detect a volume change. Signal-to-noise ratios were measured at the fundamental frequencies of visual stimulus presentation to quantify the strength of neural processing of visual shapes under different attention and crossmodal conditions. We found enhanced neuronal responses for a given attended shape when the unattended sound was congruent vs incongruent, but no difference in neural responses based on sound congruence when attention was directed to fixation and visual shapes were unattended, suggesting an influence of endogenous feature-based attention on crossmodal correspondence.

Topic Area: ATTENTION: Multisensory

D2 Rhythmic attentional sampling of visual and auditory objects is reflected in theta-modulated neural activity

Michael Plöchl¹, Ian Fiebelkorn², Sabine Kastner², Jonas Obleser¹; ¹University of Luebeck, Germany, ²Princeton University, NJ

Visual attention samples single objects rhythmically at ~8Hz. When two objects are attended simultaneously, these objects are sequentially sampled at ~4Hz and in counter-phase. However, whether similar attentional rhythms also exist in other modalities is still a matter of debate. Therefore, we adapted and extended an established paradigm to investigate potential visual and auditory attentional rhythms and their possible interactions on both a

behavioral (detection performance, N=33) and a neural level (EEG, N=18). After an attention reset towards one of two presented objects, our participants' detection performance alternated between target locations at a rate of ~4Hz during unimodal visual attention and at ~8Hz during unimodal auditory attention, possibly indicating that auditory stimulation was perceived as a single object with two different target locations. At occipital EEG electrodes ipsi- and contralateral to the visual attention reset event theta activity (4-8Hz) oscillated in counter-phase, which was also reflected in a corresponding modulation of alpha power. In both modalities we observed phase opposition between hit and miss trials at frontal channels: Detection performance was predicted by the 4Hz (visual) and 2-4Hz (auditory) phase of the alpha power envelope. Auditory hits and misses additionally displayed phase opposition at 8Hz. During bimodal attention the above-mentioned effects were reduced and did not become significant. Overall, we present behavioral and neural evidence for attentional theta rhythms in both the visual and auditory modality. The reduction of effects during bimodal attention furthermore suggests that these rhythms may interact on a supramodal level.

Topic Area: ATTENTION: Multisensory

D3 Supramodal and Modality-Specific Oscillatory Activity during Attention to Memory

Kristina C. Backer^{1,2,3}, Bernhard Ross^{2,3}, Guillaume Cheung², Claude Alain^{2,3}; ¹University of California, Merced, ²Rotman Research Institute at Baycrest Centre, ³University of Toronto

The ability to orient and sustain attention to a particular representation in short-term memory (STM) is a crucial cognitive function. Previous studies have demonstrated changes in the amplitude of alpha and beta oscillations when the attentional selection occurs among STM representations. However, it remains unclear whether the alpha and beta modulations are modality-specific or modality-general. We used magnetoencephalography (MEG) to investigate supramodal and modality-specific oscillatory activity during an attention-to-memory task. At the beginning of each trial, a memory array, comprising two abstract visual shapes and two complex tone sounds, was presented. Next, a visually-presented retro-cue indicated which memory representations should be attended (Auditory, Visual, or both (Uninformative cue)). Subsequently, one sound or picture was presented, and the participants decided if this stimulus was present in, or absent from, the memory array. Behaviorally, participants responded significantly faster on Auditory and Visual retro-cue trials than on Uninformative cue trials ($p < 0.001$). MEG data in the sensor-space were analyzed, time-locked to the retro-cue onset. The signal power of alpha and beta oscillations was estimated using a Hilbert transform on the bandpass-filtered data. The results revealed that stronger alpha/beta suppression over occipital sites occurred for both Auditory and Visual than Uninformative retro-cues. Only the informative cues elicited beta power suppression over parietal sites, suggesting a supramodal attentional control mechanism. Modality-specific alpha/beta modulations arose approximately one second after the retro-cue onset, indicating attentional selection of the cued memory representations. The results demonstrate that supramodal, followed by modality-specific, oscillatory dynamics underlie attention to memory.

Topic Area: ATTENTION: Multisensory

D4 Visual cortex activity varies with sound intensity: Electrophysiological evidence of inverse effectiveness

Spencer Mac Adams¹, Jessica Green¹; ¹University of South Carolina

Our lab has identified an ERP component that occurs over occipital scalp sites contralateral to a sound presented without an accompanying visual stimulus. Previously we determined that this novel ERP component, which we refer to as the rapid occipital auditory-evoked response (ROAR), begins 20ms following stimulus onset, is modulated by the location of the auditory stimulus,

and appears to be generated in primary visual cortex. Thus, the ROAR has the spatial and temporal properties to potentially reflect a mechanism by which early auditory and visual inputs are integrated within visual cortex. Here, our aim was to evaluate if the ROAR is modulated by sound intensity in a manner consistent with the inverse effectiveness principle of multisensory integration. To accomplish this, participants performed a simple auditory task while their brain activity was recorded using EEG. Participants were instructed to respond with a mouse click whenever they heard a centrally presented target tone, and to withhold a response to peripherally presented bursts of pink noise of varying sound intensities (55, 65, 75, or 85 dB). Sound intensity modulated the amplitudes of early lateralized occipital activity within 20-60ms of stimulus onset, displaying a pattern of inverse effectiveness between stimulus intensity and ERP amplitude, wherein as sound intensity increased ROAR amplitudes decreased. The ROAR occurs earlier than the initial inputs of visual information to visual cortex, is modulated by stimulus location, and displays a pattern of inverse effectiveness, suggesting that it reflects the activity of an audio-visual integration mechanism within primary visual cortex.

Topic Area: ATTENTION: Multisensory

D5 A neural assessment of reward-associated distraction upon sustained attention

Matthew D. Bachman¹, Madison N. Hunter¹, Scott A. Huettel¹, Marty G. Woldorff¹; ¹Duke University

Sustained attention can be interrupted by transient distractors, drawing attention away from a task and impeding performance (Demeter & Woldorff, 2016). Separate research on value-based attentional capture (VBAC) has shown how attention can be involuntarily drawn towards reward-associated objects. In this EEG study we investigated if imbuing transient distractors with value associations would lead to additional decrements of sustained attention. Participants first completed an oddball task aimed at inducing reward associations, where responses to lateralized targets of three different colors were tied to rewards of varying magnitude. These colored squares were then reintroduced as distractors in a sustained-attention rapid-serial-visual-presentation (RSVP) task. Participants viewed a central stream of characters changing at 6.7 Hz and responded to infrequent numbers. Occasionally one of the lateralized colored squares from the previous task would briefly reappear, but they were irrelevant to the RSVP task and would garner no reward. Sustained attention to the RSVP task was assessed using steady-state visual evoked potentials (SSVEPs). We hypothesized that these colored distractors would automatically draw attention away from the RSVP task, impeding performance and decreasing the SSVEP amplitude, and that the size of these effects would vary by the reward associations previously formed to each color. Although we did find a dip in the SSVEP in the response to the distractors, suggesting some attentional distraction, there was no differential effect of reward magnitude on either RSVP task performance or SSVEP amplitude. These results suggest that highly focused sustained spatial attention can overcome reward-related modulation of attentional capture.

Topic Area: ATTENTION: Nonspatial

D6 Behavioral Rhythms in Saliency-based Figure-ground Segregation

Ying Fan^{1,2,3,5}, Jianrong Jia^{4,5}, Huan Luo^{1,2,3}; ¹School of Psychological and Cognitive Sciences, Peking University, ²PKU-IDG/McGovern Institute for Brain Research, Peking University, ³Beijing Key Laboratory of Behavior and Mental Health, Peking University, ⁴Peking-Tsinghua Center for Life Sciences, Peking University, ⁵These authors contributed equally to the work

Foreground figures can be effortlessly separated from background based on saliency information. Recent studies have demonstrated that attention samples multiple foreground objects dynamically. However, it remains

unknown how figure and background, which are determined by bottom-up saliency information, are processed and coordinated in time. In the present study, participants were first presented with a display consisted of twelve discs, each of which had one of the three colors. Importantly, the number of discs associated with each of the three colors were one, three, and eight respectively. Using this manipulation, the colors related to fewer (1 or 3) and more discs (8) would serve as foreground and background features respectively. Next, after a variable delay (120:20:600 ms), an oriented bar having one of the three colors was presented, and participants were required to judge the orientation of the bar. The mean reaction time (RT) and accuracy across all stimulus-onset asynchronies (SOAs) showed no difference across the three conditions. Intriguingly, the RT time courses associated with the figure and background colors displayed different temporal profiles. Specifically, the behavioral traces for the foreground and background colors fluctuated at theta-band (3-5 Hz) and alpha-band rhythm (8-10 Hz) respectively, and the two foreground colors exhibited an alternation pattern. Moreover, the background-alpha power was related to the foreground-theta phase difference. Our results suggest a time-based figure-ground segregation, such that figures are processed via theta-band, and background is suppressed by alpha-band. The stronger the suppression of the background, the clearer separation between the two figures is.

Topic Area: ATTENTION: Nonspatial

D7 Characterizing the timecourse and mechanisms of the attentional selection of object representations in working memory

Charlie Giattino¹, Saikiran Gudla², Mariana Feingold¹, Marty Woldorff¹; ¹Duke University, ²University of Cincinnati

Attention can be directed externally to spatial locations, features, and objects in the environment, as well as internally to representations such as those in working memory (WM). Much recent work has focused on understanding the nature of such internal attention; yet, many of these studies have focused on attention to spatial locations or simple objects, rather than complex objects such as faces and scenes (e.g., houses). We sought to further characterize the timecourse and nature of internal object attention by recording EEG as subjects performed three different tasks designed to allow comparison of object-selective processing at multiple levels. To make these comparisons, we took advantage of EEG measures of object-selective processing, primarily the face-selective N170 ERP effect and its distinct scalp topography. We previously presented our findings using attentive object viewing (Task 1) to elucidate the timecourse of selective attention to external objects (Task 2). Here we focused on using both external attention tasks as object-selective templates to further characterize selective attention to, and WM maintenance of, internal object representations (Task 3). In Task 3, we used a delayed match-to-sample task with two samples on each trial, a face and a house, one of which was retroactively cued as relevant for that trial. We found that retro-cueing attention in this way led to a pattern of voltages highly similar to the external object attention tasks, starting at ~400 ms post-cue and lasting for several hundred milliseconds, giving insight into the timecourse of directing internal attention to the contents of WM.

Topic Area: ATTENTION: Nonspatial

D8 Learned Feature Distributions Predict Visual Search and Working Memory Precision

Phil Witkowski^{1,2}, Joy Geng^{1,2}; ¹University of California, Davis, ²Center for Mind and Brain, University of California, Davis

Previous research has established that attention operates by selectively enhancing sensory processing of task-relevant target features held in working memory. Much of this literature uses search displays in which the target is an exact match of cued features. However, real world visual search rarely

involves targets that are identical to our memory representations. The ability to deal with cue-to-target variability is a critical, but understudied aspect of visual attention. In these studies, we test the hypothesis that top-down attentional biases are sensitive to the reliability of target feature dimensions over time. In two experiments, subjects completed a visual search task where they saw a target cue composed of a certain motion direction and color, followed by a visual search display with multiple distractors. The target features changed from the cue, with one dimension drawn from a distribution narrowly centered over the cued feature (reliable dimension), while the other was broad (unreliable dimension). The results demonstrate that subjects learned the distributions of cue-to-target variability for the two dimensions and used that information to bias working memory and attentional selection: Reaction times and first saccades were better predicted by the similarity of the consistent feature than the inconsistent feature and the precision of working memory probe responses was greater for the consistent dimension. Moreover, the working memory precision predicted individual variation in search performance. Our results suggest that observers are sensitive to the learned reliability of individual features within a target and use this information adaptively to weight mechanisms of attentional selection.

Topic Area: ATTENTION: Nonspatial

D9 Neurophysiological Correlates of Trait Mindfulness

Ana Navarro Cebrian¹, Jessica Cooperman¹, Donna Wilcox¹, Ximena Mendez Schagar¹, Keisharely Perez¹; ¹Loyola University Maryland

Individuals who are more mindful in everyday tasks (trait mindfulness) demonstrate low anxiety and an increase in self-regulation of attention. However, the brain mechanisms underlying this psychological trait are still not fully understood. Individual alpha peak frequency (iAPF), the maximum alpha power value in the EEG frequency spectrum, is a type of brain activity that is stable over time that seems to be related to cognition in general, and to attention in particular. On the other hand, mindfulness meditation has been shown to improve attention. Based on these previous findings, in the current study we hypothesized that higher iAPF would be related to higher trait mindfulness scores. We tested this hypothesis on a group of undergraduate participants who filled both the Five Facet Mindfulness Questionnaire (FFMQ) and the Philadelphia Mindfulness Scale (PHLMS) and carried out two eyes-open resting state EEG sessions that allowed us to calculate the iAPF. Additionally, they completed two cognitive tasks (the STROOP test and the Flanker task) to measure attention and cognitive control. Our preliminary data (n = 9) show a positive correlation between trait mindfulness and iAPF, indicating that higher scores in the FFMQ covary with higher iAPF. Additionally, we observe a trending correlation between mindfulness and alpha-band phase synchrony, which has previously been associated with attentional control. In summary, our study suggests common neural substrates for trait mindfulness and attention. We hope that our findings can help future research towards developing more effective meditation treatments for people with an attention deficit.

Topic Area: ATTENTION: Nonspatial

D10 Object-based Attention Modulates EEG Alpha Activity

Sean Noah¹, Travis Powell¹, Natalia Khodayari¹, Diana Olivan¹, Mingzhou Ding², George R. Mangun¹; ¹University of California, Davis, Davis, CA, ²University of Florida, Gainesville, FL

Object-based attention is the selection of visual information from an object or object category. It may be deployed in anticipation of a task-relevant object or as a template during visual search. In this study, we investigated whether object-based attention modulates electroencephalographic (EEG) alpha-band

activity across the scalp, analogously to observed alpha modulations in spatial and feature-based attention experiments. If endogenous visual attention operates by a common mechanism throughout visual cortex, such alpha modulation should be observable whenever top-down attention exerts selective control over visual-cortical activity, regardless of what kind of visual information is selected. To test this hypothesis, we collected EEG data from 10 human participants, performing an anticipatory object-based attention task with three categories of objects: faces, places, and tools. These object categories were chosen on the basis of their differentiated specialized cortical regions. Although it is not possible using this method to unambiguously localize an alpha topography to a specific brain region, large changes in the underlying loci of alpha activity corresponding to effects in face, place, and tool regions would be expected to yield different patterns of alpha over the scalp. We observed reduced reaction time for valid compared to invalidly cued trials across all three object conditions, suggesting that our task produced the intended attention effect. Using a random cluster analysis over alpha power, we identified electrodes and time points that differed significantly between object conditions, suggesting that alpha topography is modulated by attention to specific categories of objects.

Topic Area: ATTENTION: Nonspatial

D11 Rhythmic sampling of orientation features in feature-based attention

Ce Mo^{1,2,3,4}, Junshi Lu^{1,3,4}, Bichan Wu¹, Huan Luo^{1,2,3}, Fang Fang^{1,2,3,4,5}; ¹School of Psychological and Cognitive Sciences, Peking University, ²Peking-Tsinghua Center for Life Sciences, Peking University, ³IDG/McGovern Institute for Brain Research, Peking University, ⁴Key Laboratory for Machine Perception (Ministry of Education), Peking University, ⁵Beijing Key Laboratory of Behavior and Mental Health, Peking University

One of the most intriguing hallmarks of spatial attention is its rhythmic nature. When multiple locations are attended, neural processing of information at these locations is boosted periodically. However, it remains unknown whether such a rhythmic sampling process also occurs when attention is directed to multiple non-spatial features. We addressed this question by reconstructing the temporal dynamics of feature representation using time-resolved inverted encoding model (IEM) applied on human MEG data. Subjects viewed two arrays of oriented (\pm ~45 degrees) gratings at random locations. A brief contrast increment (200ms) occurred with all gratings of one array to reset subjects' perceptual state. After resetting, the gratings remained on the screen for 1-1.25s before being replaced by a probe display comprising of the same number of gratings of one orientation that was approximately either parallel or perpendicular to the cue. Subjects indicated whether the orientation in the probe was clockwise or counterclockwise of its closest orientation in the stimulus display. We measured the representation intensity for each orientation at each time point. We found a common ~4 Hz rhythm in the representation intensity time courses of both orientations, which exhibited a consistent anti-phase relationship. Same findings were obtained using a time-resolved behavioral paradigm. Notably, these effects could be well characterized by a competition between the two neuronal groups selective to each feature respectively. Together, these results suggest that the two orientation features are rhythmically sampled in alternation in feature-based attention.

Topic Area: ATTENTION: Nonspatial

D12 Targeted brain stimulation to ameliorate vigilance in stroke: a combined tDCS-fMRI approach

Elena Olgiaiti^{1,2}, Ines Violante³, Lucia Li^{1,2}, Korina Li¹, Ara Faraj¹, Toby Sinclair¹, Jennifer Crow², Richard Wise⁴, Paresh Malhotra^{1,2}; ¹Imperial College London, ²Imperial College Healthcare NHS Trust, ³University of Surrey, ⁴Deceased

Most strokes affect widely-distributed cortical/subcortical brain networks, causing behavioural deficits. Vigilance impairments are common following right-hemispheric stroke, as right frontoparietal networks are critical in maintaining attention over time. Recent evidence suggested that prefrontal transcranial direct current stimulation (tDCS) improves vigilance in healthy adults. The aims of the present study are to investigate the effect of tDCS on vigilance and brain networks across the lifespan and following stroke, and to explore whether changes in network activity predict clinical response. tDCS (1mA, 10minutes) was delivered to the right dorsolateral prefrontal cortex via three circular electrodes (15mm diameter) positioned over F4, FP2 and F8. In a double-blind, sham-controlled, cross-over design study, 16 young and 8 older healthy adults, and 13 stroke survivors performed a vigilance task under real/sham tDCS. In a separate study, 20 young and 23 older healthy adults, and 13 stroke survivors received real/sham tDCS during Resting-fMRI. Targeted tDCS was well tolerated both alone and in combination with Resting-fMRI. tDCS improved vigilance in older adults, with no significant effect at the group mean level in young adults and stroke patients. However, individual patient trajectories were observed and are discussed in light of lesion anatomy. Using young controls as a model, we identified 5 brain networks of interest and compared functional connectivity with task performance with tDCS. We found a significant correlation between network strength and performance within the left attentional control network. The value of a biomarker approach in understanding the variable clinical response to tDCS is discussed.

Topic Area: ATTENTION: Nonspatial

D13 Human attentional capacity is predicted by spectral and anatomical patterns of large-scale synchronization

Satu Palva^{1,2}, Santeri Rouhinen^{1,3}, Felix Siebenhüner¹, J.Matias Palva^{1,2}; ¹Neuroscience Center, Helsinki Institute of Life Science, University of Helsinki, Finland, ²Centre for Cognitive Neuroscience, Institute of Neuroscience and Psychology, University of Glasgow, UK, ³BioMag laboratory, HUS Medical Imaging Centre, Finland

The capacity of visual attention determines how much visual information is perceived at once. This capacity can be investigated with multi-object tracking (MOT) tasks which have shown that attentional capacity varies greatly between individuals. The neuronal basis setting this capacity limit is poorly understood. Phase-synchronization of cortical oscillations coordinates neuronal communication within fronto-parietal attention network and between visual regions during endogenous visual attention. We tested a hypothesis that good attentional capacity would be related to stronger connectivity between attention-related cortical regions. We recorded cortical activity with magneto- and electroencephalography (M/EEG) during measurement of attentional capacity with MOT tasks and identified large-scale synchronized networks from source-reconstructed M/EEG data. All participants had attention-load dependent synchronization concurrently in many frequencies from theta to gamma-bands. The strength of this synchronization but also the frequency- and anatomical patterns of load-dependent networks dissociated participants with low- and high attentional capacity. Synchronization patterns in the beta- and gamma bands as well as the connectivity in fronto-parietal attention network were the most prominent predictors of attentional capacity. Cross-frequency interactions also coupled fast and slow oscillations specifically in high-capacity participants. These results suggest that good attentional capacity is predicted by efficient dynamic functional coupling within and across oscillatory networks.

Topic Area: ATTENTION: Other

D14 Human Frontal Cortex Modulates External and Internal Attention

Julia W. Y. Kam¹, Randolph F. Helfrich¹, Jack J. Lin², Anne-Kristin Solbakk^{3,4}, Tor Endestad³, Pal G. Larsson⁴, Robert T. Knight¹; ¹University of California – Berkeley, ²University of California – Irvine, ³University of Oslo, ⁴Oslo University Hospital

Prevailing theories of top-down control converge on the role of the frontal cortex in facilitating selective attention to behaviorally relevant external inputs. However, the neural architecture supporting sustained attention directed to either the external or internal environment is less well understood. To address this, we used intracranial EEG to characterize the spatiotemporal dynamics of external and internal attention during an auditory target detection task. Participants directed their attention externally to auditory tones and responded to infrequent target tones, or internally to their own thoughts while ignoring the tones. We compared high frequency band activity (HFA; 70-150Hz) in response to target and standard tones across the lateral, parietal and temporal cortices during external and internal attention. Increased HFA to target tones relative to standard tones, referred to as the target detection response, was present across all three cortices during both attention states. Notably, a larger percentage of frontal electrodes compared to temporal electrodes showed this target detection response during external attention. Direct comparisons between attention states revealed only the frontal cortex showed larger HFA response during external relative to internal attention, confirming that the frontal cortex was more sensitive to attentional modulations compared to other cortices. Taken together, these results provide evidence that the frontal cortex plays an important role in the top down control of attention to both the external and internal environments.

Topic Area: ATTENTION: Other

D15 Behavioural and genetic associations between internalising and externalising behaviours and executive function during adolescence

Georgina Donati¹, Emma Meaburn¹, Iroise Dumontheil¹; ¹Birkbeck College, University of London

Executive function (EF) refers to a set of cognitive processes necessary for goal-directed behaviours. Poor EF has been proposed as a risk factor for psychopathology. Cross-sectional studies in early development find associations between low inhibitory control (IC) and externalising behaviours, and between high IC and low cognitive flexibility and internalising behaviours. In adulthood EF deficits are present across mental health disorders and correlate with levels of anxiety in the general population. However, little is known about the direction of these associations or how they may influence vulnerability during adolescence, a time of changes in EF and emotional reactivity also marked by the onset of mental health issues. The Avon Longitudinal Study of Parents and Children dataset was used to investigate relationships between emotion and EF measures taken across adolescence. We first identified latent measures of IC, working memory (WM), internalising and externalising (N=5,838). Second, four genome-wide association studies were performed using these latent measures (N=4,611). Third, individual measures of the four phenotypes taken in early and late adolescence were entered in a longitudinal cross-lag panel design (N=1,404). While there was a consistent negative behavioural and genetic association between WM and externalising, WM and internalising were negatively associated behaviourally but showed a positive genetic association. Externalising and internalising in early adolescence were found to negatively predict WM in later adolescence, but not vice-versa. No association was found with IC. These results demonstrate significant and specific patterns of genetic and phenotypic associations between WM and externalising and internalising behaviours during adolescence.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D16 Brain Mechanisms for Processing Static and Dynamic Facial Expressions

Sing-Rong Sie¹, Shih-Tseng T. Huang^{1,2}, Yen-Ju Lu¹; ¹Department of Psychology, National Chung-Cheng University, Taiwan, ²Center for Research in Cognitive Science, National Chung-Cheng University, Taiwan

In the study, 25 college students (ages are between 20 and 25) participated and their functional magnetic resonance imaging (fMRI) data were collected when they watched static(images) and dynamic(videos) stimuli that included angry, fear, happy, neutral facial expressions, and non-human face objects. Participants were asked to view the stimuli presented at random sequence and pressed the bottom when they saw non-human face stimuli (i.e., objects). Analysis conducted by comparing each type of the facial expressions (including objects) to the neutral faces. Results found that for the static images, postcentral gyrus were more active when they were watching angry static face images, inferior temporal gyrus, superior parietal lobule, and inferior parietal lobule were active when watching static fear face images, hippocampus and thalamus were active when watching non-human objects. For the dynamic stimuli (videos), inferior parietal lobule and middle frontal gyrus were active when subjects watched happy face videos. And, precentral gyrus, calcarine sulcus, inferior parietal lobule, precentral gyrus, mid-cingulate cortex, supra-marginal gyrus, and insula were active when subjects viewing non-human face videos of objects. The results suggested differences in active brain areas in viewing static images versus dynamic videos. We further conducted analysis of autoencoder model by using the average of ICA components as the baseline and SVM personal model analysis. Results found the significant active brain regions in comparing each type of facial expressions with neutral faces of individual participants.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D17 Caffeine-induced physiological arousal impacts affective responses to ambiguity

Carlene Horner¹, Grace Giles^{1,2}, Caroline Davis^{1,2}, Benjamin Avanzato¹, Eric Anderson¹, Joseph Moran^{1,2}, Caroline Mahoney^{1,2}; ¹Tufts University, Center for Applied Brain and Cognitive Sciences, ²US Army Natick Soldier, Research, Development, and Engineering Center

Previous research has identified that stress manipulations heightening physiological and self-reported arousal play a critical role in interpreting social ambiguity. However, stress manipulations have not differentiated between cognitive, affective, and physiological aspects of arousal. The present study attempts to assess the extent to which caffeine-induced arousal influences interpretations of social ambiguity. Caffeine administrations allows for a selective manipulation of arousal, given that it reliably increases emotional and physiological arousal, but not affect. In a double-blind repeated measures design, sixty-four low to abstinent caffeine consumers categorized a series of surprised faces as either negative or positive after consuming a capsule of caffeine or placebo. Participants with a bias to interpret the faces positively in the absence of caffeine shifted to more negative interpretations following caffeine consumption. In contrast, participants with a bias to interpret the faces negatively in the absence of caffeine shifted toward more positive interpretations following caffeine consumption. The current findings suggest that the arousal component of stress manipulations may drive changes to interpreting social ambiguity.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D18 Distinct regions within the macaque face-selective system are differentially tuned to changes in head orientation and facial expression.

Jessica Taubert¹, Clarissa James¹, Shruti Japee¹, Aidan Murphy², Elissa Koele¹, Susheel Kumar¹, David A. Leopold², Leslie G. Ungerleider¹; ¹The

Laboratory of Brain and Cognition, NIMH, ²The Laboratory of Neuropsychology, NIMH

Faces are unique among objects because they convey multiple signals at once. These signals carry not only stable information (e.g. identity) but also transient information that often changes from one moment to the next (e.g. expression and head orientation). Here, we used fMRI-adaptation in rhesus macaques to determine the role of the face-selective patches in processing the expression and head orientation of a monkey avatar. The use of this avatar gave us unparalleled control of transient signals while stimulus identity remained constant. We scanned three subjects (*Macaca mulatta*) in a 4.7T Bruker scanner following an injection of monocrystalline iron oxide. During the experiment, the subjects fixated on blocks of images while we varied either: (1) the expression and head orientation of the avatar; (2) the expression but not head orientation; (3) the head orientation but not expression; or (4) held both constant. Based on the patterns of fMRI activity, we found that the face patches in the fundus (AF and MF) of the superior temporal sulcus (STS), as well as the amygdala, were more sensitive to changes in expression than to changes in head orientation. In contrast, the anterior lateral (AL) face patch was sensitive to changes in the orientation of the avatar's head but not expression. This dissociation augments existing theories claiming that the fundus of the STS is involved in processing expression while providing a new framework for understanding how the visual system simultaneously extracts independent, transient signals from a face.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D19 Does Face Identity Matter in the Face Flanker Task?

Victoria Ashley¹, Diane Swick^{1,2}; ¹VA Northern California Health Care System, ²University of California, Davis

The ability to ignore salient emotional distractors can play an important role in attention and emotion regulation. The face flanker task, an affective variant of the Eriksen flanker, requires participants to correctly identify the emotional expression on a central target face while ignoring the expressions of two (identical) flanking faces. At least one study examining the impact of face identity (same or different) on the face flanker task, found no differences (Mueller & Kuchinke, 2015). As part of a larger study, we tested 23 healthy controls (2 female, ages 26-54 years) on a face flanker task (anger, fear, neutral) using same and different face identities (64 individuals) with flanker faces preceding target faces by 200ms. Overall, participants showed an emotional interference effect, slower RTs ($p < .001$) and lower accuracy ($p < .001$) on emotional relative to neutral faces. Face identity analyses indicated a main RT effect of identity (slower when different, $p < .02$) and an interaction effect of identity and emotional expression (identity x target valence x flanker valence) ($p < .05$). Paired t-tests revealed that subjects were slower for neutral target faces with different identity neutral flanker faces relative to same ($p < .001$), and slower on fearful target faces with different identity neutral flankers relative to same ($p < .009$). Finally, interference effects (incongruent – congruent RTs) were larger for neutral faces ($p < .01$) and angry ($p < .03$) faces of the same identity, versus different. Our results suggest that face identity can interact with emotional expression in the emotional face flanker task, possibly affecting the ability to detect interference effects.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D20 Frontal Activities While Recognizing Microexpression: An fNIRS Study

Xunbing Shen¹, Gaojie Fan², Lei Chen¹, Huajie Sui¹; ¹Jiangxi University of Traditional Chinese Medicine, ²Miami University

Microexpression is a brief and subtle facial movement which usually lasts for 1/25 to 1/5 second. Many neuroimaging studies have investigated the

macroexpression recognition. However, to the best of our knowledge, few studies have investigated the brain activities while participants are recognizing spontaneous microexpression. The aim of the current study was to examine activity in the frontal area during the spontaneous microexpression recognition by using functional near-infrared spectroscopy (fNIRS). Nineteen right-handed university students performed a task of passively viewing microexpression videos (each video clip included a spontaneous microexpression and lasted for about 10s) and sandwiched expressions (one neutral expression followed by an emotional expression, then followed by a neutral expression from the same model). The videos of spontaneous microexpressions were selected from CASME II, and the sandwiched expressions were presented for 120 ms or 600 ms (two blocks), sandwiched in between two 5s presentations of the same expresser's neutral face. During the task, change of concentration in oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) at frontal regions was measured by a 74-channel NIRS instrument (LABNIRS, Shimadzu, Japan). NIRS-SPM is used for the analysis of NIRS signals. To seek the cortical loci responsible for the observed hemoglobin concentration changes, NIRS probe and channel locations were registered to the Montreal Neurological Institute (MNI) space. When viewing spontaneous microexpression as compared to sandwiched expressions, participants demonstrated higher levels of activation within the left PFC. The results suggested a left-hemisphere dominance of processing spontaneous microexpressions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D21 Perceived uncontrollability of life stress is associated with gray matter morphometry in youth

Alyssa Fassett-Carman¹, Harry Smolker², Hannah Snyder¹, Benjamin Hankin³, Marie Banich²; ¹Brandeis University, ²University of Colorado Boulder, ³University of Illinois Champagne Urbana

Animal studies consistently demonstrate gray matter (GM) morphometrical changes associated with stress. Human research shows similar effects, yet much of this research uses measures that confound stress frequency, appraisals, and individuals' reactions to the stress, and do not distinguish between types of stressors. Dependent (self-generated) and independent (fateful) stressors have differing behavioral outcomes, with dependent stressors being associated with stress generation and psychopathology (e.g., Conway, Hammen, & Brennan, 2012). Furthermore, appraisals of controllability of dependent stressors are associated with psychopathological stress outcomes in humans (Fassett-Carman, Hankin, & Snyder, 2018). We therefore tested whether appraisals of controllability were associated with GM morphometry outcomes, while distinguishing between dependent and independent stressors. We tested these associations in a community sample of youth ($n = 128$, ages 13-22). Uncontrollability appraisals of dependent stressors experienced in the past 6 months were associated with increased GM thickness in the frontoparietal control network, as well as gender-specific morphometry differences in mPFC and the amygdala. This research builds on learned helplessness literature and past stress appraisal research to highlight the importance of perceived control over life stress, in addition to demonstrating the importance of distinguishing between dependent and independent stressors.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D22 Reappraisal regulates the emotional arousal and increases the utilitarian choices

Wen-Hsi Huang¹, Nai-Shing Yen¹, I-Cheng Weng¹, Ning Tai¹; ¹National Chengchi University

In moral dilemmas studies, people often have to make a binary choice between two different courses of action: utilitarian or deontological. Traditional

view of moral decisions indicated that people relied on deliberative reasoning to make choices, in which the utilitarian choices are often implicated. But recent theories suggested that emotion is important to influence the moral decision-making, in which the deontological choices are implicated. Since moral dilemma often induces emotion in people, emotion regulation might be a key to influence how people make a decision between utilitarian and deontological choice. In present study, we aimed to examine the effect of two types of emotion regulation (reappraisal and distraction) while people confronted the moral dilemmas. Twenty-four young adult participants in Taiwan participated and were randomly assigned to reappraisal, distraction or control group, to explore their subjective emotional arousal and choices. There were two stages during the experiment. In the first stage, each group made a choice after reading the moral dilemma stories without any of the instruction to regulate emotion. In the second stage, besides control group, the reappraisal and the distraction group were instructed the strategy to regulate their emotion during reading the same moral dilemma stories. The results showed that participants using the reappraisal strategy significantly reduced their subjective emotional arousal, and chose more utilitarian choice (77.1%) than the control group (47.9%) ($p = .008$). However, although participants using the distraction strategy significantly reduced their subjective emotional arousal, they didn't chose more utilitarian choice (61.2%) than the control group.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D23 Rethinking affective vocalizations

Natalie Holz¹, Pauline Larrouy-Maestri¹, David Poeppel^{1,2}; ¹Max-Planck Institute for Empirical Aesthetics, Frankfurt, Germany, ²New York University, New York, New York, USA

Humans employ vocal information to sense and categorize affective states of others in everyday social interactions. The nature of this categorization process is debated, as is the informational or diagnostic content of such emotion expressions. Thorough investigation has remained difficult with existing stimulus sets, as they mainly rely on stereotypical expressions lacking ecological variability, or in the case of real-life expressions do not provide the possibility to systematically manipulate emotion intensity. Notably, little is known about the perceptual and acoustic properties of peak emotional states, oftentimes expressed through screams, which, featuring a set of acoustic cues distinct from speech and prosodic information, constitute valuable material to illuminate the mechanisms underlying vocal emotion perception. We describe a new corpus consisting of 480 human nonverbal vocalizations representing three positive emotions (achievement, surprise, and sexual pleasure) and three negative emotions (anger, fear, and physical pain), ranging from low to peak emotion intensity, produced by 10 female speakers. Database design and selection procedure were optimized to ensure the best possible naturalness of stimuli as well as to uphold within-category variability. Perceptual validation of the corpus was completed by three groups of participants ($n = 90$ in total) and includes data from a forced choice categorization task, an emotion rating task, ratings on the affect dimensions valence and arousal, along with authenticity ratings for each stimulus. Our results, building on a new ecologically valid corpus, challenge the notion of diagnostic acoustic representations and underscore the necessity to reassess conceptions of emotions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D24 Sisters' brains view a drama movie more similarly than friends' brains and friends' more similarly than acquaintances' brains

Gokce Ertas Yorulmaz¹, Mareike Bacha-Trams¹, Enrico Glerean¹, Elisa Ryyppö¹, Iiro P. Jääskeläinen^{*1,2}, Mikko Sams¹; ¹Brain and Mind Laboratory, Aalto University, Espoo, Finland, ²Advanced Magnetic Imaging (AMI) Centre, Aalto Neuroimaging, Aalto University, Espoo, Finland

Is the similarity in brain responses to a moral dilemma better explained by the subjects' relationship to each other, or by their perspectives viewing a movie? How similar are the sensory processings of the movie and the higher perceptual-cognitive functions between sisters, friends and acquaintances when their perspectives viewing the movie are the same or different? In this multi-factorial study conducted with 10 subject triplets of sisters, friends, and acquaintances, we have sought answers to these questions incorporating a 22-min movie stimulus (edited from "My Sister's Keeper", dir. Nick Cassavetes, 2009, Curmudgeon Films) in our fMRI study. Subject triplets were formed so that they had a sister pair, a friend of one sister, who is then an acquaintance of the other sister. Viewing the movie based on a character refusing to donate her kidney to her ill sister from the angle of the donor or the donee, knowing or not knowing the sisters are adopted, brain imaging data was collected from each subject through 4 different viewings. We have then analyzed similarities in information processing using voxel-wise inter-subject correlation (ISC). In prefrontal, posterior temporal, parietal, and occipital regions, relationship was found to be a significant factor to explain the activation similarities; and in posterior temporal, parietal and occipital regions, friends showed higher ISC compared to acquaintances. Our results suggest that similarity of brain activity during natural viewing co-occurs with both similar environmental factors when growing up (sisters) and in social bonding (friends).

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D25 The Effectiveness of Downward Counterfactual Thinking as an Emotion Regulation Strategy

Sarah Haurin¹, Natasha Parikh¹, Jason Zhang¹, Felipe De Brigard¹, Kevin LaBar¹; ¹Duke University

Remembering past events is a vital part of everyday life. However, recollection of negative personal memories sometimes requires emotion regulation, and an inability to do so is associated with disorders such as PTSD, anxiety, and depression. One naturalistic way to regulate negative memories is to create a downward counterfactual thought, or a worse version of the event, to put what occurred in a more positive light. However, the effectiveness of downward counterfactual thinking has not been compared to other cognitively-mediated regulation strategies in a lab setting. In this study, we were interested in comparing the regulatory effects of downward counterfactual thinking to temporal distancing, a cognitive reappraisal tactic with proven efficacy. Healthy participants recalled 45 regretful memories from the past five years and rated them on valence, arousal, regret, and detail. Two to six days later, they were asked to create a worse version of the memory, think of how they would feel about it 10 years from now, or passively recall it. A day later, participants rated the emotionality of each memory again. We found that counterfactual thinking and temporal distancing both positively increased valence and reduced arousal in response to regretful memories. However, counterfactual thinking was more effective than distancing in reducing regret for individuals who self-reported higher levels of anxiety. In addition, memories regulated through counterfactual thinking were accompanied by better source memory for the regulation manipulation used. These results prompt further study in the use of counterfactual thinking as a formalized, intentional emotion regulation technique.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D26 Unravelling neurocognitive processes underlying the suppression of unwanted emotional memories

Xuanyi Lin¹, Ziqing Yao¹, Xiaoqing Hu^{1,2}; ¹The University of Hong Kong, Hong Kong, China, ²The State Key Laboratory of Brain and Cognitive Science, The University of Hong Kong, Hong Kong, China

An ability in controlling unwanted emotional memories can benefit one's psychological well-being. Here we investigated the electrophysiological characteristics of direct suppression of emotional memories employing the Think/No-Think paradigm. We first presented participants with cue objects paired with target negative emotional scenes. The objects are embedded in the target scenes, thus establishing strong cue-target associations. Participants were later instructed to either retrieve (Think) or suppress the retrieval (No-Think) of memories of the target scenes, depending on the colour frames of the cue objects. Continuous EEGs were collected during this TNT phase. In Experiment 1 (n=36), we found that the left parietal episodic memory effect (i.e., positive potentials between 400-1000 milliseconds) was attenuated during the No-Think trials. Furthermore, Think trials elicited sustained negativity (800-1500 ms) over the right prefrontal cortex. We also found that the fronto-central N200 was stronger for No-Think than for Think trials. Aiming to replicate and to extend these findings, we ran Experiment 2 with a perceptual baseline condition (n=41). We successfully replicated the left parietal episodic memory effect as well as the right prefrontal effect. Furthermore, No-Think ERPs resembled ERPs elicited by perceptual baseline, providing strong evidence that people can successfully suppress the retrieval of unwanted emotional memories and down-regulate retrieval-related neural activities. Together, these results provide robust evidence that during emotional memory suppression, people can suppress and down-regulate retrieval-related neural activities at both parietal and prefrontal regions.

Topic Area: EMOTION & SOCIAL: Emotion-cognition interactions

D27 Beyond valence: differences in brain response to unpleasant and upsetting sounds.

Vaida Rimeikyte¹, Janis L. Whitlock¹, Adam K. Anderson¹; ¹Cornell University

Sounds often carry pertinent cues about our environment, which can elicit emotional reactions that help guide attention and behavior (e.g., hearing screeching tires may cause one to freeze out of fear). In addition to the affective information sounds carry about the imminent future, they can also have their own affective tone. An incessantly beeping truck may not alert of any danger yet, nevertheless, may cause severe irritation. In present study we compared the responses of 25 healthy young adults to unpleasant sounds as well as upsetting sounds from the International Affective Digital Sounds (IADS-2) database while they underwent fMRI scanning. Unpleasant sounds were rated as significantly more unpleasant than negative IADS. $M(\text{sound}) = 3.82$, $M(\text{IADS}) = 2.76$, $t(24) = 4.93$, $p < .001$. Despite this discrepancy on subjective displeasure ratings, no brain areas were found to be more active for unpleasant compared to negative IADS. In contrast, IADS elicited more robust brain activations in portions of Auditory cortex, bilateral Thalamus, bilateral Inferior Frontal Gyrus, pre Supplementary Motor Area (SMA), dorsomedial Prefrontal Cortex, bilateral Cerebellum, bilateral Caudate, bilateral Insula, and bilateral Amygdala. These differences persisted when modeling displeasure ratings separately. A conjunction analysis revealed that both unpleasant and upsetting sounds elicited activations in bilateral Auditory Cortex, Bilateral Superior and Inferior Parietal lobules, bilateral SMA, portions bilateral Cerebellum, left Putamen and mid Anterior Cingulate (BA24). These findings are in line with the research suggesting that certain aspects of affective processing may be evaluating the future value of information as opposed to its current affective tone.

Topic Area: EMOTION & SOCIAL: Emotional responding

D28 Functional Connectivity Associated With Intensity of Positive Affect

Lauren Goodes¹, Yush Kukreja², Jeffery Rouse M.D.², Jeremy D. Cohen Ph.D.¹; ¹Xavier University of Louisiana, New Orleans, LA, USA, ²Tulane University, New Orleans, LA, USA

While brain processing of affect valence has been characterized, the processing of affective intensity experience is less understood. Research has shown that the right hemisphere is responsible for processing negative emotions, while the left hemisphere is responsible for processing positive emotions. Additionally, the functional connectivity of positive and negative affect share implicated regions such as the medial prefrontal cortex, the anterior cingulate, visual cortex, and the cerebellum. The brain regions associated with emotion intensity processing is the ventral anterior cingulate cortex, inferior frontal gyrus, mid-insula, thalamus, superior temporal gyrus, hippocampus, and middle occipital gyrus. The current study examined what brain regions work together for positive affect intensity processing in 50 subjects (F=31; M=19) from the Nathan Kline Institute Rockland-Sample, ranging in age from 21-45 (M=31.8 SD=7.8), and completed the affect intensity measure questionnaire (AIM). The AIM captured the frequency of when the subject experiences positive and negative emotions and the intensity of that emotion. SPM12 and the CONN toolbox were used to preprocess subject brain data and conduct functional connectivity analyses, using the self-report scores in the AIM questionnaire for each subscale as a covariate across subjects. Results from this study indicate that there is increased functional connectivity between the left anterior superior temporal gyrus, left frontal operculum, and the left anterior insula during positive emotion intensity processing. The current data supports previous understanding of both positive emotional experience and intensity, while also adding new data concerning increased connectivity with increased positive emotional intensity.

Topic Area: EMOTION & SOCIAL: Emotional responding

D29 Neuroaesthetics: the emerging neuroscience of the nexus of art and philosophy, with implications for the economics of the visual arts

Martin Goldstein¹, Kelly Adams, Jonsara Ruth²; ¹Icahn School of Medicine at Mount Sinai, ²Parsons School of Design

Background: The trans-disciplinary field of neuroaesthetics has developed over the past decade, ambitiously attempting to bridge contemporary neuroscience and aesthetics. Efforts have focused on identifying neural mechanisms mediating the perception of fundamental features timelessly defining aesthetic value across artistic modalities. Potential import of neuroaesthetic studies is profound and impactful, with implications ranging from informing the neural underpinnings of aesthetics to the market valuation of art. For the purpose of this study, we focus on the neuroaesthetics of visual fine art. Methods: To inform paradigm development advancing this nascent field, we performed a metaanalysis of reported data via searching the National Library of Medicine using the term "neuroaesthetics". We then limited this search to solely visual-modality fine arts. Results: Ninety-three citations were initially identified. Restriction to visual modality-only yielded a subset of 33 publications. Of these, only 9 citations represented original empirical investigations. These studies range across functional neuroimaging, neuromodulatory, and neuroendocrinologic methodologies. Metaanalysis of these studies suggests a prefrontal, parietal, occipital neural network activated by complexly-layered cognitive-visual-emotional processes recruited during evaluation of visual art. Discussion: Neuroaesthetics is indeed a new field, with reports only first appearing in 2008. Neuroaesthetics' nascency is owing to the complexity of both the phenomenology of aesthetic experience and the challenge of probing its neural substrates. While a visual-evaluative neural network has been tentatively identified, significant theoretical development and methodologic refinement is required to meaningfully advance neuroaesthetics, including its application to determining socio-historical-independent features of visual art which inform sustainable artistic value.

Topic Area: EMOTION & SOCIAL: Emotional responding

D30 Orbitofrontal lesion patients show an implicit approach bias towards angry faces

Macià Buades-Rotger¹, Matthias Liebrand¹, Anne-Kristin Solbakk^{2,3}, Ingrid Funderud², Dorien Enter^{5,6,7}, Karin Roelofs^{5,6}, Ulrike M. Krämer¹; ¹University of Lübeck, Lübeck, Germany, ²University of Oslo, Oslo, Norway, ³Oslo University Hospital, Rikshospitalet, Oslo, Norway, ⁴Helgeland Hospital, Mosjøen, Norway, ⁵Radboud University Nijmegen, Nijmegen, The Netherlands, ⁶Donders Institute for Brain, Cognition and Behaviour, Nijmegen, The Netherlands, ⁷Leiden University, Leiden, The Netherlands

The mechanisms by which the orbitofrontal cortex (OFC) contributes to navigate the social world are uncertain. Indeed, while OFC lesions often lead to deficits in emotion recognition, this region is also critically involved in subjective value computation. Therefore, the OFC might not only code for the meaning of others' emotional expressions, but also for their motivational value. In order to test the latter assumption, we investigated whether OFC patients show differential approach and avoidance behavior to task-irrelevant emotional facial expressions. Twelve patients with focal OFC lesions, 3 patients with lateral prefrontal lesions (LPFC) as well as 31 age- and gender-matched healthy controls (HC) performed an implicit Approach-Avoidance Task (AAT) in which they either pushed or pulled a joystick depending on the color of an artificially tinted face. Importantly, the emotional expressions (angry, happy, or neutral), gaze (direct or averted), and gender of the faces varied orthogonally. We computed an approach-avoidance score as the latency difference between pushing a face away relative to pulling it close. Strikingly, OFC patients showed an implicit approach bias towards angry relative to both happy and neutral expressions, whereas HC and LPFC patients showed no such effect. Furthermore, the bias was stronger for patients with larger and more anterior lesions. OFC patients showed also signs of enhanced impulsivity, as they were generally faster and committed more errors than their counterparts. Our results indicate that the OFC is not merely involved in recognizing social threat, but in modulating approach and avoidance responses to these signals.

Topic Area: EMOTION & SOCIAL: Emotional responding

D31 'Working harder together': Distributed surges in activity & connectivity during task-switching.

Richard E. Daws¹, Eyal Soreq¹, Robert Leech², Peter Hellyer², Adam Hampshire¹; ¹The Computational, Cognitive & Clinical Neuroimaging Laboratory (C3NL), Division of Brain Sciences, Imperial College London, UK., ²Department of Neuroimaging, Institute of Psychiatry, Psychology and Neurosciences, King's College London, London, UK.

A recognised issue in cognitive neuroscience is the "one-to-many" & "many-to-one" mappings problem[1], i.e. individual brain regions activate for multiple distinct processes & individual processes co-activate distributed networks of regions. The Multiple Demands Cortex (MDC)[2], is a set of fronto-parietal regions that co-activate for many seemingly distinct cognitive processes[3]. Together, this suggests that it is the way that brain regions communicate within dynamic networks that allows for a set of regions to perform either reasoning or memory processing, for example. Key questions remain around how the brain self-organises transitions between task states. Previous work has identified frontal polar cortices as putative 'switching modules'[4]. Here, we use fMRI & a custom self-ordered switching (SOS) paradigm to examine regional activity and dynamic Functional Connectivity (dFC)[5] during task-switching. Task-switching was associated with robust switch costs to reaction time (~0.9s, SD=0.5), widespread increases in regional activation and broadband shifts in dFC, with decreases between cerebellar and fronto-parietal regions and increases between medial and lateral frontal cortices. In contrast to modular perspectives, these results support the notion that distributed mechanisms[6] support executive processes, such as task-switching. Future work could use causal modelling to investigate whether state transitions result from specific, localisable, drivers or emerge via highly

distributed mechanisms. 1. Lorenz, R., et al. 2017. *TICS*. 2. Fedorenko, E., et al., 2013. *PNAS*. 3. Hampshire, A., et al. 2012. *Neuron*. 4. Ramnani, N. & Owen, A. M. 2004. *Nat Rev Neurosci*. 5. McLaren, D., et al. 2012. *Neuroimage*. 6. Cole, M., et al. 2013. *Nature Neuroscience*.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D32 Adolescent Intermittent Ethanol Impairs Behavioral Flexibility in a Rat Foraging Task

Nancy Y.A. Sey¹, Alexander Gomez-A¹, Aric C. Madayag², Charlotte A. Boettiger¹, Donita L. Robinson¹; ¹University of North Carolina at Chapel Hill, ²Marquette University, Milwaukee, WI

Increasing evidence supports the hypothesis that binge levels of alcohol exposure during adolescence are particularly harmful to the brain, producing physiological and behavioral effects that can persist into adulthood. In human and animal model studies, exposure to alcohol has been shown to correlate with deficits in behavioral flexibility. The present study determined whether adolescent intermittent ethanol (AIE) similarly impaired action selection in a stimulus-response task using a foraging response. Rats were exposed to ethanol during adolescence (5 g/kg/day, 2 days on/2days off, P25 – 55) then left to grow to adulthood. Next, they learned to dig for a food reward buried in one of two media and cued with one of two odors. AIE and control rats both learned to discriminate between olfactory cues, but AIE rats were impaired when reversing that learned association (first reversal). However, AIE rats were faster to reinstate the original odor discrimination rule (second reversal), suggesting perseverative behavior. Additionally, we performed a set-shift test where rats were cued with media rather than odor. Both groups learned to set-shift; however, control rats were slower. The findings of this study are consistent with studies of people with substance abuse disorder, who learn new stimulus-response associations similarly to control subjects, but make more perseverative errors when attempting to replace a stimulus-response association.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D33 EEG correlates of working memory gating: link to reinforcement learning?

Rachel Rac-Lubashevsky¹, Yoav Kessler², Michael Frank³; ¹Brown University, ²Ben-Gurion University of the Negev, ³Brown University

Computational models of frontostriatal circuitry propose that the content of working memory (WM) is controlled through a selective gating mechanism which is modifiable by reinforcement learning. Information in WM is robustly maintained when the gate is closed; opening the gate enables updating. In the present study, a variant of the n-back task, the reference-back was used to learn about the mechanisms that underlie WM updating and gating in humans. The reference-back is composed of two trial-types: comparison trials, which require the maintenance of an item in WM, and reference trials, which require updating of this item. Switching between the two trial-types requires gating. EEG recordings were used to examine how the control functions involved in gating are mapped to different oscillatory activity. During gate-closing a relative increase in theta power was observed over mid-frontal electrodes. This midfrontal theta response is a signature of cognitive control (Cavanagh & Frank; 2014) that is proposed here to reflect reactive updating conflict that is solved by closing the gate to suppress updating irrelevant information. Conversely, during preparation time for gate-opening, a relative increase in posterior delta power was observed. These findings are reminiscent of reinforcement learning studies where posterior delta and midfrontal theta power were correlated with negative and positive and prediction errors, respectively (Cavanagh, 2015; Cavanagh, Frank, Klein, & Allen, 2010). We propose that these analogous findings are suggestive of models and data in

which WM gating strategies are learned by positive and negative prediction errors.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D34 Exploring non-linguistic codeswitching in bilingual aphasia

Lesley Peng¹, Mitchell Peck¹, Teresa Gray¹; ¹San Francisco State University

Bilinguals control two languages. This skill may transfer to a cognitive benefit, yet the relationship between these two processes is unclear. Because bilingual persons with aphasia (BPWA) may present with language control and cognitive control deficits, we aim to examine the performance of bilingual healthy adults (BHA) and BPWA on a cued color-shape switching task. Preliminary data have been collected from 3 Spanish-English BHA and 3 Spanish-English BPWA matched on age and education. We project to recruit 10 BHA and 10 BPWA. Participants completed one non-linguistic task requiring task-switching between color and shape within bivalent conditions that elicit inhibition of the non-target domain. The experimental structure was a sandwich design: two single blocks, three mixed blocks, two single blocks. Single blocks include single trials. Mixed blocks include non-switch and switch trials. Switching-costs (higher accuracy/faster response time [RT] on non-switch vs switch trials in the mixed block) that tap transient control mechanisms and mixing-costs (higher accuracy/faster RTs on single trials in single block vs non-switch trials in the mixed block) that tap global sustained control mechanisms were examined. All reported results are significant at $p < .05$. Separate paired samples t-tests were performed for each group to evaluate the switching-cost and mixing-cost on accuracy and RT for color and shape conditions. BHA results: for RT color switching-cost, non-switch trials were significantly faster than switch trials. BPWA results: for RT color mixing-cost, single trials were significantly faster than non-switch trials. Results suggest a dissociation between how BHA and BPWA manage non-linguistic control.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D35 Global Functional Network Modularity Facilitates Responding in Threat-Valenced Spatial Cueing

Marisa Ross¹, Josh Cisler¹; ¹University of Wisconsin-Madison

Preferential orienting to threatening stimuli is a common phenotype of posttraumatic stress disorder (PTSD) and is potentially mediated by functional brain organization. In fact, research suggests that increased brain network modularity (Q), a metric of brain network integration and segregation, may facilitate orienting to basic cues, which may be disadvantageous in PTSD. This study investigated the interaction of neural network organization with spatial orienting in the context of threatening images. Here, 72 subjects (61 with PTSD, 11 healthy controls) underwent resting-state functional MRI (rs-fMRI) and completed a version of the Posner spatial cueing task (SCT) where the target was preceded by a threatening- or neutral-valenced image. rs-fMRI data were analyzed using a graph-network approach, where modularity was maximized using Louvain community detection. SCT data were modeled using a mixed linear effects model to gauge the effects of Q, PTSD diagnosis, validity and valence of the cue on reaction times during the task. We found a validity x Q x group interaction, which indicated quicker reaction times on incongruent trials for women with more globally modular brains. Interestingly, this effect appears to be driven by the control group, indicating a facilitating effect of modularity in healthy women that is not present in the PTSD group. These results suggest a mechanism for facilitation of spatial orienting that is present in healthy adults but with a less clear function in PTSD. This finding suggests a need for further exploration of the effect of brain network modularity in PTSD populations.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D36 Isolating Attentional Mechanisms Behind Stereotype Threat Effects: Knocking Out Proactive Attention

Alice Kathmandu¹, Geoffrey L. Cohen², Bruce McCandliss³; ¹Stanford University, ²Stanford University, ³Stanford University

A multitude of studies document robust performance changes associated with activating a gender stereotype on math. Such studies lack an explanation in terms of cognitive mechanisms. Here, we isolate components of proactive attention by leveraging a predictable vs. unpredictable task-switch test (Rogers & Monsell, 1995) to more specifically isolate the nature of the cognitive cost of experiencing a gender stereotype being activated in the context of math and number. College women (N = 92) in an elite Chinese university participated in a 2 (stereotype vs. control) by 2 (predictable vs. unpredictable Response-Stimulus Interval) between-subject experiment. Women in the control (no-threat) group showed a significant reduction in switch cost for the predictable, relative to the unpredictable condition, suggesting a successful execution of preparatory control functions when the timing is predictable. By stark contrast, for women in the stereotype threat group, switch cost for the predictable timing condition was significantly exacerbated, suggesting that stereotype threat may rob them of the opportunity to engage in preparatory control. In addition, we identified college major as a boundary condition to this effect: humanities majors were most affected by the stereotype threat of their math abilities, whereas STEM majors were apparently immune to such effects. These findings shed light on the cognitive mechanism underlying one of social psychology's most cited effects, and highlight the need to use brain imaging tools to further isolate preparatory processes from execution processes.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D37 The effect of partial sleep deprivation on cognitive control functioning: The SLEEPIC study

Ingvild Saksvik-Lehouillier¹, Simen Berg Saksvik^{1,2}, Håvard Karlsen¹, Eva Langvik¹, Torhild Anita Sørengaard¹, Alexander Olsen^{1,2}; ¹Norwegian University of Science and Technology, ²St. Olavs Hospital, Trondheim University Hospital

Cognitive control functions are crucial for human goal-directed regulation of thoughts, actions and emotions. We examined how cognitive control was affected by partial sleep loss. 59 healthy individuals aged 18-35 was included in a 11-day study protocol. Participants slept at home, and sleep patterns were observed using actigraphs and sleep diaries. After maintaining habitual sleep for seven days, the participants were asked to sleep two hours less than their average sleep duration, the last three nights of the study protocol. A Not-X continuous performance test was performed at 9am (+/-90mins) at day 1, 4, 7 (habitual sleep), 9 and 11 (short sleep). Response speed and accuracy was recorded. Response speed decreased significantly; from time 1 to time 3 (habitual sleep) as well as between the habitual and short sleep period. The number of commission errors decreased significantly from time 1 to time 3 (habitual sleep), but then increased significantly from time 2 and 3 (habitual sleep) to time 4 and 5 (short sleep). There were no differences in number of omission errors. In conclusion, partial sleep deprivation leads to decreased response speed, but more commission errors, indicating that individuals become more impulsive after a period of short sleep.

Topic Area: EXECUTIVE PROCESSES: Goal maintenance & switching

D38 Disrupted executive control in schizophrenia: neural mechanisms revealed by event-related potentials and frontal midline theta oscillations

Xiangfei Hong^{1,2}, Wei Li¹, Jiangling Jiang¹, Hongyan Wang¹, Jiaqi Wang³, Jianan Wang³, Wenzheng Wang¹, Jianhua Sheng¹, Jijun Wang¹, Chunbo Li¹; ¹Shanghai Mental Health Center, Shanghai Jiao Tong University School of Medicine, Shanghai, China, ²J. Crayton Pruitt Family Department of Biomedical Engineering, University of Florida, Gainesville, FL, USA, ³School of Biomedical Engineering and Med-X Research Institute, Shanghai Jiao Tong University, Shanghai, China

Deficits in executive control have been widely regarded as one of the hallmark cognitive characteristics in schizophrenia. In this study, we recorded 64-channel scalp electroencephalography (EEG) from 30 schizophrenia patients (SZs; 17 women; mean age: 30.4 years) and 31 healthy control subjects (HCs; 17 women; mean age: 29.1 years) while performing a combined flanker-Go/NoGo task. We investigated the neural mechanisms of two core components in executive control, i.e., conflict suppression and response inhibition, by examining event-related potentials (ERPs) and frontal midline theta (FM θ) oscillations. We found that SZs showed significantly lower behavioral accuracy than HCs, but only in incongruent and NoGo task conditions. We also found that SZs showed decreased amplitudes of conflict-related N2 component and inhibition-related P3 component than HCs. Furthermore, although both HCs and SZs showed increased FM θ under incongruent and NoGo conditions, the magnitudes of such FM θ modulation were significantly reduced in SZs than that in HCs. In the HC group, we observed a positive correlation between FM θ and behavioral accuracy in the incongruent condition, but not in the NoGo condition. While in the SZ group, this correlation was observed in the NoGo condition, but not in the incongruent condition. The amplitudes of N2 and P3 components, however, were not correlated with behavioral accuracy in either group. Taken together, our results suggested an underlying neural mechanism consisting of impaired N2, P3 and FM θ for executive control deficits in SZs, and that the role of FM θ in SZs might vary according to the type of executive control required.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

D39 How does Stopping an Action Affect Action-Relevant Representations?

Atsushi Kikumoto¹, Tesufuai Sameshima¹, Ulrich Mayr¹; ¹University of Oregon

Stopping the execution of a planned, or initiated action is an important and well-studied control function. Yet, it is an open question what happens to the different representations that are relevant for the stopped action. Does stopping only affect the response representation, or also the associated task set, or the response-triggering stimulus code? The current EEG study combines the stop-signal paradigm with a task in which subjects were cued to execute simple action on the basis of three different, abstract S-R rules. In the first two experiments, the stop signal timing was fixed, at 100 ms after (Exp 1, n= 25) or 200 ms before (Exp 2, n= 25) stimulus onset. For Experiment 3 (n=36), an adaptive staircase procedure adjusted the stop-signal to allow a 50% stopping rate. Using the time-frequency EEG signal, we decoded orthogonal, task-relevant dimensions (cues, rules, stimuli, and responses) on a timepoint-by-timepoint basis. Results showed that stopping led to suppressed decoding accuracy for responses first, then for rules, and finally for the stimulus representation. Experiment 3 confirmed that this cascade of suppression effects was present only when stopping was successful. Additionally, stronger rule representation before the stop signal increased the likelihood of stopping failures. In principle, successful stopping could be achieved by simply inhibiting the response code. Yet, our results show that the strength of the rule representation is both an important target of the response-suppression process and a key determinant of its success.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

D40 Human intracranial recordings during a stroop task reveal parallel conflict processing across widespread frontal and insular cortices

Colin Hoy¹, Kris Anderson², Vitoria Piai³, Jack Lin⁴, Robert Knight¹; ¹University of California, Berkeley, ²Kernel, Venice, CA, ³Radboud University Medical Center, Donders Institute for Brain, Cognition, & Behavior, Nijmegen, Netherlands, ⁴University of California, Irvine

Classical theories of conflict processing posit serial computations in which medial prefrontal cortex (MPFC) detects conflict before recruiting lateral prefrontal cortex (LPFC) to resolve the conflict and execute the correct response. Despite many EEG and fMRI and a few intracranial studies in humans, the spatiotemporal dynamics and relationships between MPFC, LPFC, and related regions including orbitofrontal cortex (OFC) and the insula (INS) during conflict processing remain poorly defined. We utilized the spatiotemporal resolution of intracranial recordings in epilepsy patients (n = 14) performing a verbal color-word Stroop task to describe the local activity profiles of MPFC, LPFC, OFC, and INS. Data preprocessing included removing epileptic and excessively noisy channels and epochs, bipolar referencing, and band-stop filtering line noise. The data were then filtered to 70-150 Hz to isolate high frequency activity (HFA) known to correspond to local population activity. Although MPFC, LPFC, OFC, and INS had similar proportions of sites with conflict sensitive HFA (sliding window ANOVA, cluster-based permutations, p < 0.05 FDR corrected), onsets and time courses of conflict effects were highly variable within these regions. Examination of the onsets and time courses of conflict effects reveals parallel conflict processing across widely distributed functional networks, rather than a serial processing hierarchy of homogeneous anatomical regions. In sum, these findings emphasize heterogeneous functions within classical prefrontal control regions, contributions of non-classical regions such as OFC and the insula, and coordination of distributed networks in conflict processing.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

D41 Onsets of pre-SMA predict successful stopping in a stop-signal task

Hsin-Ju Lee^{1,2}, Fa-Hsuan Lin^{3,4}, Wen-Jui Kuo²; ¹National Taiwan University, Taipei, Taiwan, ²National Yang-Ming University, Taipei, Taiwan, ³University of Toronto, Toronto, ON, Canada, ⁴Aalto University, Espoo, Finland

Functional MRI (fMRI) can detect hundred-millisecond differences of evoked response onsets. In this study, we exploited a fast fMRI technique with a 10 Hz sampling rate for a whole-brain coverage to explore how our brain implements action inhibition in a stop-signal task. In the task, participants are asked to make a motor response as fast as possible, and occasionally, a stop-signal appears to call for stopping the intended motor response. By combining a stop-signal task and the fast fMRI, we would like to characterize the temporal characteristics of brain areas important for stop-signal processing. 18 participants took part in the experiment. To index BOLD response onset, the time to reach 50% of the maximal BOLD activity in response to stop-signals was estimated, i.e., the time-to-half (TTH). A wealth of imaging studies found activations in the pre-supplementary motor area (pre-SMA) and right posterior inferior frontal gyrus (rPIFG) closely associated with stop-signal processing, suggesting their prominent roles for stopping actions. TTHs of successful stopping (SST) and unsuccessful stopping (USST) in these two ROIs were analyzed. ROI analysis indicated only in the pre-SMA, the TTHs were shorter for SST than for USST. Note that, in a stop-signal task with a tracking procedure to adjust the stop signal delay, the participants were not able to predict the appearance of a stop-signal. Therefore, our findings suggested that when activities of the pre-SMA can respond faster to a stop-signal, i.e., the

shorter the BOLD onset at the moment, the participants can inhibit an action more accurately.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

D42 Parkinson's Disease and susceptibility to distraction from task-irrelevant auditory and visual oddballs

Rachel C. Cole¹, Arun Singh¹, Arturo Espinoza¹, Nandakumar S. Narayanan¹; ¹University of Iowa

Humans react to novelty, even when it is irrelevant to the task at hand. This process can be studied by inserting novel (oddball) stimuli into a central task. When participants encounter novel stimuli during a forced-choice reaction time task, they experience slower reaction times and more errors. Parkinson's disease (PD) is a neurodegenerative disease which involves motor symptoms as well as cognitive impairments, specifically worsened cognitive control. We hypothesized that novelty processing and susceptibility to distraction would be affected in PD. We tested this idea using a cross-modal distractor task in which participants (37 PD patients and 39 healthy older adults) responded to a central arrow. The arrow was preceded by two cues, a tone and a colored shape. On each trial, the cues were either both standard and more errors. Parkinson's disease (PD) is a neurodegenerative disease which involves motor symptoms as well as cognitive impairments, specifically worsened cognitive control. We hypothesized that novelty processing and susceptibility to distraction would be affected in PD. We tested this idea using a cross-modal distractor task in which participants (37 PD patients and 39 healthy older adults) responded to a central arrow. The arrow was preceded by two cues, a tone and a colored shape. On each trial, the cues were either both standard and the other was an oddball (the visual stimulus was a novel shape and color or the auditory stimulus was a novel birdcall). Overall, we found a main effect of group such that PD patients were slower than healthy adults. Interestingly, healthy adults demonstrated task-irrelevant novelty-related slowing with visual oddballs, whereas PD patients had slowing with auditory oddballs. We also examined mid-frontal theta activity in EEG during the task, and based on pilot work, we expect to find in this sample that mid-frontal theta activity is attenuated in PD patients compared to control when novel stimuli appear. Our results help elucidate the mechanism by which humans maintain attention and respond to novelty.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

D43 Decoding the content of the focus of attention in a working memory task: Electrophysiological evidence for refreshing

Evie Vergauwe¹, Mason Price², Kim Uittenhove¹, Nelson Cowan³, Jeffrey D. Johnson³; ¹University of Geneva, ²University of Nebraska Medical Center, ³University of Missouri

Cognitive models of working memory have proposed attentional refreshing as a central maintenance mechanism (e.g., Barrouillet & Camos, 2015; Cowan, 1992; Raye et al., 2007). Most evidence for this mechanism comes from studies using complex span tasks in which processing phases are interleaved between the to-be-remembered memory items. In particular, it has been shown that recall performance decreases as a function of the proportion of time available for refreshing. According to the Time-Based Resource-Sharing model (Barrouillet & Camos, 2015), as soon as attention is no longer captured by the processing task, it switches to the memory task and refreshing is assumed to reactivate the to-be-remembered information by bringing the items back into the focus of attention. While the observations of a negative relation between recall performance and time available for refreshing is consistent with the idea of spontaneous refreshing, direct evidence is currently lacking. The current study used multivariate pattern analysis (MVPA) of EEG to decode the content of the focus of attention during those periods of time during which spontaneous refreshing is assumed to take place. The main findings indicate that participants dynamically shift attention back and forth between the memory list items (letters) and the visuo-spatial processing task, suggesting spontaneous refreshing of the memory materials in between processing items.

Topic Area: EXECUTIVE PROCESSES: Working memory

D44 Deficits in Executive Function persist years after mild traumatic brain injury

Hector Arciniega¹, Marian E. Berryhill¹; ¹University of Nevada, Reno

Mild traumatic brain injury (mTBI), or concussion accounts for 85% of all TBIs. After several weeks of rehabilitation individuals return to activities of daily living and there is an assumption that cognitive status returns to premorbid levels. However, this assumption has not been carefully examined. Given the heterogeneity of mTBI, it could be challenging to identify consistent impairments at the group level. Executive functions, such as working memory (WM) can reveal persistent deficits because they are dependent on the success of earlier processing stages (e.g., perception, attention). WM's dependence on frontoparietal networks, supported by the superior longitudinal fasciculus make it a commonly damaged tract in general. Previous work identified a significant visual WM deficit in undergraduates with a history of mTBI using change detection tasks at a set size of 3 and a maintenance delay of 900 ms. Here, we extend our observations in three important ways to evaluate the generalizability of WM deficits. First, we employed another task, the n-back task, in addition to change detection. Second, we probed visual, spatial and verbal WM. Finally, to investigate attention deficits in WM we included a retro-cue task. Undergraduates with a history of mTBI (>4 years since injury) performed significantly worse than their neurotypical colleagues across WM tasks and retro-cue. These data begin to draw the boundary between likely-impaired executive functions, such as WM and attentional shifting ability, as shown in the retro-cue task. Importantly, they replicate and extend the findings that chronic mTBI can be associated with lasting cognitive changes.

Topic Area: EXECUTIVE PROCESSES: Working memory

D45 Does irrelevant speech suppress subvocal rehearsal?

Lisa Payne¹, Christina Labows², Morgan Purcell²; ¹Rutgers University, ²Swarthmore College

The irrelevant speech effect is a reliable decrease in accuracy of serial recall when background speech is played during silent verbal rehearsal of words. fMRI and PET studies have shown reduction in neural activity in brain regions associated with the articulatory store leading to the notion that irrelevant speech suppresses maintenance of task-relevant information. During selective attention, suppression of neural activity related to irrelevant stimuli is reflected by increased EEG alpha oscillations (8-14 Hz). If suppression of verbal rehearsal during irrelevant speech occurs via a similar mechanism, alpha oscillations should increase in left-lateralized frontotemporal areas of the brain associated with rehearsal. In this study, participants were presented a sequence of five words and instructed to subvocally rehearse these words until directed to recall the words out loud in order. Throughout retention, participants heard either white noise or irrelevant speech. Consistent with the irrelevant speech effect, participants were less accurate in recalling words when they heard irrelevant speech than when they heard white noise. In addition, alpha power was greater over left-lateralized frontotemporal regions associated with verbal rehearsal for trials with irrelevant speech compared to white noise. Thus, irrelevant speech may suppress subvocal rehearsal even when rehearsal is beneficial to the current task. Alternatively, the increased alpha activity may reflect the attempt to prevent irrelevant speech from intruding into the phonological loop. This finding also indicates that alpha oscillations reflect an inhibitory mechanism in areas beyond the sensory cortices.

Topic Area: EXECUTIVE PROCESSES: Working memory

D46 Evaluating the Optimal Timing of Transcranial Direct Current Stimulation to Augment Cognitive Training

Jacky Au¹, Seung Min Moon¹, Benjamin Katz², Tessa Abagis³, John Jonides³, Susanne M. Jaeggi¹; ¹University of California, Irvine, ²Virginia Tech, ³University of Michigan

Previous work from our lab has shown significant facilitation of working memory (WM) training performance over a 1-week period through the use of concurrent, or online, transcranial direct current stimulation (tDCS). We provided evidence that much of this facilitation occurred over the weekend (versus consecutive weekdays), and that these benefits persisted up to a year. We interpreted both the weekend and longitudinal effects to arise from spacing-dependent consolidation processes that interact with tDCS. The goal of the current study was to manipulate the timing of tDCS delivery (online: during WM training, offline: before or after WM training), compared to sham, in order to replicate and optimize these important effects. We recruited 82 college-aged participants, randomized into each of these four groups and matched on baseline WM ability, then repeated the same WM training procedure we used previously over a period of six consecutive days, with the exception of a weekend break. We found that online stimulation was superior to both offline conditions (p 's < .02), but curiously found no advantage over sham ($p=0.98$). Further analyses revealed baseline WM ability to be a significant moderator, with online tDCS outperforming all other conditions, including sham, among high baseline individuals, but all tDCS conditions underperforming relative to sham among low baseline individuals. We suggest that tDCS has a complex profile of effects that can either impair or facilitate performance depending on a number of factors, and discuss these differences in the context of previous studies, including our own, which sometimes report conflicting results.

Topic Area: EXECUTIVE PROCESSES: Working memory

D47 From cleats to cognition: Does playing soccer improve visuospatial working memory and physiological stress recovery?

Emily Burns¹, Princy Quadros-Mennella¹; ¹Neuroscience Program, Bay Path University, Longmeadow, MA

Working memory is a storage system where visuospatial information for goal-directed behavior is maintained. Participation in organized sports allows athletes to "practice" working memory. We aimed to determine if this practice on the field was transferable to working memory tasks off the field. Additionally, aerobic exercise enhances recovery from acute stress. Since athletes routinely engage in aerobic exercise through sports participation, we wondered if their recovery from acute stress would be faster compared to non-athletes. Female NCAA soccer players and non-athlete undergraduates completed a variation of the N-back task, which measures visuospatial working memory. Subjects had to remember how many trials ago (n-back) a single stimulus of position, or dual stimuli of position and color, occurred and their accuracy scores were recorded. Subjects then underwent acute cognitive stress by completing the Stroop task. Stress reactivity was measured using galvanic skin response (GSR). Time to return to baseline GSR was recorded. Two separate 2-way repeated measures ANOVA comparing athletes and non-athletes were conducted: (1) N-back task accuracy; (2) stress recovery. Soccer players have improved visuospatial working memory, as performance on the 2-back was significantly better than non-athletes. However, soccer players took longer to return to baseline upon completion of the Stroop task compared to non-athletes, likely because athletes' stress reactivity was much greater during the task than non-athletes. Our results suggest that playing sports could lead to transferable cognitive enhancements beyond the field. However, sports participation may produce unforeseen effects on stress recovery.

Topic Area: EXECUTIVE PROCESSES: Working memory

D48 Interaction between spatial attention and visual working memory from alpha oscillation and sustained potentials

Dongwei Li¹, Chenguang Zhao¹, Jialiang Guo¹, Bingkun Li¹, Qinyuan Chang¹, Yulong Ding², Yan Song¹; ¹Beijing Normal University, Beijing 100875, China, ²Sun Yat-Sen University, Guangzhou 510275, China

Selective attention helps us filter irrelevant information and allows limited relevant information into visual working memory for accomplishing the current task. We aimed to investigate the roles of alpha modulation and contralateral delay activity (CDA) during the retention of visual working memory. EEG signals were collected from 32 healthy adults while they performed a classical working memory task. We observed a sustained posterior CDA (351-1001ms) was presented and scaled with lateral working memory loads (one or two targets) but absent when the targets were presented across two visual hemifields. A strikingly same pattern emerged for modulations in the averaged alpha (8–12Hz) power (354-988ms). However, the alpha modulation in the early period of memory retention (354-600ms) was similar for lateral low- and high-load conditions, suggesting no difference in storage. In contrast, the alpha modulation was much larger in lateral high-load than low-load condition in the late period of memory retention (600-988ms). More importantly, the N2pc, a well-known electrophysiological index of attentional selection induced by the remembered targets in the following visual search task, showed the inverse gradations as compared with the late alpha modulation. Our results provide neurophysiological evidence for the dissociable roles of alpha oscillation and CDA during visual working memory, suggesting that CDA scales online maintaining of information but alpha oscillation reflects the allocation of visuospatial attentional resources and significantly influences the subsequent attentional selection of targets measured by N2pc.

Topic Area: EXECUTIVE PROCESSES: Working memory

D49 Interference on neural mechanisms for working memory maintenance

Julia C. Beck¹, Peter S. Whitehead¹, Marty G. Woldorff¹; ¹Duke University

We must often maintain information in working memory (WM) while attending to unrelated tasks and stimuli. However, the neural processes underlying WM maintenance in the face of attentional interruptions is relatively unexplored. Here, we used contralateral delay activity (CDA) – a sustained, posterior, negative-polarity ERP index of active maintenance of WM representations – to investigate the effect of visual and cognitive interruptions on such maintenance. Participants were presented with a lateralized array of colors and asked to maintain them in WM. During the delay period before the WM probe, in separate blocks, participants either attended and responded to a Flanker task stimulus, or ignored the stimulus. Behaviorally, high performance was observed on the Flanker task (93%) and on WM performance in Flanker-attended (85%) and Flanker-ignored (89%) conditions. We observed that the CDA was initially similar after WM array presentation, but terminated sooner prior to relevant Flanker stimuli, suggesting some WM withdrawal when expecting a cognitive task to perform. The Flanker stimulus disrupted the CDA in both conditions, but with interactions between lateralized sensory effects and the hemisphere of WM maintenance. Critically, the CDA never reinstated in the second delay period even following ignored Flanker stimuli, with an inverted, positive CDA (CDAp) following attended Flanker stimuli. We conclude that the CDAp resulted from the suppression of lateralized components of the Flanker stimuli while maintaining the fidelity of the WM representation. Moreover, high WM performance without reinstatement of the CDA suggests WM content can remain accurate without an active posterior CDA process.

Topic Area: EXECUTIVE PROCESSES: Working memory

D50 Persistent neural activity in parietal cortex tracks attractor dynamics in visual working memory

Qing Yu¹, Matthew Panichello², Bradley Postle¹, Timothy Buschman²; ¹University of Wisconsin-Madison, ²Princeton University

One important neural hallmark of working memory is persistent elevated delay-period activity in parietal cortex. In human fMRI, delay-period BOLD activity in parietal cortex increases monotonically with memory load and asymptotes at an individual's capacity. Previously, we have demonstrated the correlation between parietal delay-period activity and behavioral memory precision as a function of memory load. However, because memory precision can be influenced by a variety of factors, it remains unclear what cognitive processes underlie persistent activity in parietal cortex. Recent psychophysical work has shown attractor dynamics biases memory representations toward a few stable representations and reduces the effect of internal noise. Imprecision in memory thus reflects both drift towards stable attractor states and random diffusion. Here we asked whether delay-period BOLD activity in parietal cortex tracks the strength of attractor dynamics in working memory. We analyzed data from three different experiments in which participants performed delayed recall for motion direction or for line orientation, at different memory loads, during fMRI scanning. We modeled participants' behavior using a discrete attractor model, and calculated within-subject correlation between parietal delay-period activity and estimated sources of memory errors (drift and diffusion). We found that an increase in parietal activity was associated with increases in both diffusion and drift. Importantly, both parameters explained more variance in parietal delay-period activity than estimates of precision from classic mixture models. These results provide neural evidence for attractor dynamics as well as a new explanation for the function of parietal delay-period activity in working memory.

Topic Area: EXECUTIVE PROCESSES: Working memory

D51 The Neural Basis of Working Memory Load: Within vs. Between-Subjects Variation

Peeta Li¹, Todd Braver¹; ¹Washington University in St.Louis

Studies of working memory (WM) function have tended to either take a within-subject approach, focusing on effects of load manipulations, or a between-subjects approach, focusing on individual differences. This dichotomy extends to WM neuroimaging studies, often leading to discrepant findings, with WM load-based studies emphasizing lateral prefrontal cortex (PFC) effects, while individual-differences studies have pointed to the importance of non-PFC regions (e.g., parietal and anterior cingulate cortex). On purely statistical grounds such discrepancies may not be surprising, in that within-subject and individual difference effects depend on different sources of variation, and consequently are somewhat in tension. Here, we examined these issues more directly, leveraging the advantages of the large-sample Human Connectome Project dataset and a well-established cortical parcellation scheme (Gordon atlas) to conduct a whole-brain analysis of the N-back WM task in a well-powered and principled manner. This analysis revealed that a great many parcels (N=50), primarily located in frontoparietal regions, exhibited WM load-related (2-back > 0-back) activity increases of large effect size (Cohen's $d > 0.8$). Further, contrary to expectations, the cortical parcels showing the most robust individual differences relationship with behavioral indices of WM function, both in-scanner (N-back accuracy) and out-of-scanner (List Sorting), almost completely overlapped with those showing the largest load-related effect sizes, with prominent foci in lateral PFC. Together, these results demonstrate the advantages of addressing WM-related questions with large-sample datasets, and suggest that the effect size of WM load-related activity is a good predictor of individual differences-based brain-behavior relationships.

Topic Area: EXECUTIVE PROCESSES: Working memory

D52 Visual-Spatial Working Memory Deficits in an Adolescent with ADHD using ERP, MRI and Neuropsychological Data

Jennifer Schlak¹, Audreyana Jagger-Rickels¹, Sarah Vadnais¹, Hannah Travis¹, Zsafia Imre¹, Maria Stacy¹, Emily Caminiti¹, Genni Newsham¹, Michelle Y. Kibby¹; ¹Southern Illinois University-Carbondale

Despite visual-spatial working memory (VS-WM) deficits being common in ADHD, no studies were found that examined it as part of a comprehensive approach including ERP, MRI and neuropsychological data. Hence, this was the goal of our study using a case-study approach. VS-WM was examined with a 1-back ERP task that used a 4-square grid and a ball that 'bounced' between positions. Participants included a 16-year-old male with ADHD and a 14-year-old female control. Using 128-lead EGI nets, CZ, FZ, and right parietal electrodes were examined. The control achieved 97% accuracy, with a 666ms mean RT. The ADHD male displayed hastier performance (89% accuracy, with a 593 mean RT). The control's P2 had more evenly spread amplitudes across FZ, CZ, and right parietal leads (2.0 to 2.9). In contrast, the FZ amplitude was weak in ADHD (.3), with greater amplitudes posteriorly (5.8-8.0). On neuropsychological testing, the control attained a standard score of 125 on Children's Memory Scale (CMS) Picture Locations, a spatial span task, but the ADHD participant attained an 85. Further, the control scored 125 on CMS Sequences, a working memory task, but the ADHD participant scored 85. These differences corresponded with Geosource data from the 1-back. The control's peak activity was in the right pre-frontal area. In contrast, peak activity was in the right occipital area for ADHD. Further, on MRI those with ADHD displayed reduced right pre-frontal volume. Hence, brain activity, size, and neuropsychological data correspond in the two adolescents, for VS-WM and potential right prefrontal contributions.

Topic Area: EXECUTIVE PROCESSES: Working memory

D53 Association between maternal reading ability and fluency and child diffusion properties of language white matter tracts in pre-school age children

Rola Farah¹, Hagai Tzafir¹, Tzipi Horowitz-Kraus¹; ¹Technion- Israel Institute of Technology

Background: Early language exposure and shared parent-child reading, as assessed by maternal reading ability and fluency, has a tremendous impact on the child's future language abilities. The aim of the current study was to explore association of maternal reading ability and fluency on diffusion properties of language white matter tracts in their pre-school age children using diffusion tensor imaging (DTI). Methods: DTI data were acquired from fifteen girls (mean age: 3.83 ± 0.49 years). Effects of hemisphere and node on diffusion properties were measured at 99 points along white matter tracts related to language abilities. Maternal reading ability (TOWRE-SWE) and reading fluency (TOSREC) were assessed and associated with their children's diffusion measures and corrected for multiple comparisons. Results: Diffusion properties exhibited a significant variability along the length of the tracts with hemisphere and node effects. Fractional Anisotropy (FA) was significantly higher in the left Arcuate, Cingulum cingulate and Inferior longitudinal fasciculus while FA was significantly higher in the right Superior longitudinal fasciculus. No significant differences in mean diffusivity between the hemispheres were observed except from in the Uncinate fasciculus. Furthermore, significant positive correlations were found between maternal reading ability and FA in the left and right Arcuate fasciculus and between maternal reading fluency and FA in the right Uncinate. Conclusions: Our results suggest positive correlations between maternal reading ability and fluency scores and higher FA in their child's white matter tracts related to language, signifying the importance of maternal reading as a facilitator of the child's future language abilities.

Topic Area: LANGUAGE: Development & aging

D54 Bilinguals engage similar processes when verifying multiplication facts in each of their languages: ERPs evidence from children and adults

Vanessa Cerda¹, Nicole Wicha^{1,2}; ¹University of Texas at San Antonio, ²University of Texas Health San Antonio

Most bilinguals learn multiplication tables through verbal rehearsal in only one language, and typically prefer to do math using that language. Behavioral studies have shown that both bilingual children and bilingual adults are faster and more accurate at retrieving arithmetic facts in the language in which they learned them (LA+) than their other language (LA-). Consequently, models of math cognition theorize that math facts, like multiplication, are uniquely or differentially represented in one language, and a qualitatively different method is required to process math in the other language. However, these models are inconsistent with evidence from bilingual language research suggesting that bilingual lexicons are highly interconnected and interactive. We tested whether Spanish-English bilingual children and adults use qualitatively different processes for math fact verification across languages. We recorded event-related potentials (ERPs) as participants verified the correctness of spoken multiplication facts presented in LA+ or LA-. In children, incorrect solutions (2x4=9) elicited a larger negative-going ERP component, or N400, than correct solutions (2x4=8), reflecting differential access to semantic memory. This effect was present in both languages and implies that bilingual children engage similar strategies when verifying solutions in LA+ and LA-, contrary to math cognition models. Although adults showed modulations on a different ERP component (a target P300), the effect was again not qualitatively different across languages. Overall, our findings imply that a bilingual's sense of being able to process math in only one language may be due to differences across languages that are quantitative rather than qualitative in nature.

Topic Area: LANGUAGE: Development & aging

D55 Differential neuroplasticity of language systems in adult language acquisition

Kshipra Gurunandan¹, Manuel Carreiras^{1,2}, Pedro M. Paz-Alonso¹; ¹Basque Center on Cognition, Brain and Language, ²Ikerbasque - Basque Foundation for Science

Learning a new language in adulthood is an arduous enterprise met with varying degrees of success. Evidence suggests that adults typically do not achieve native-like proficiency in a new language due to age-related decreases in neural plasticity. Some aspects of language are easier to acquire than others, such as speech comprehension relative to verbal production or semantics in comparison with phonology, but it is unknown why this is the case. Here we present the results from two fMRI experiments aimed at investigating neural changes in reading, speech comprehension, and verbal production networks, induced by intensive language learning. Experiment I was cross-sectional, with 34 native Spanish adults who were either intermediate or advanced learners of Basque. Experiment II was longitudinal, with 50 sequential trilinguals speaking Spanish, Basque and English, half of whom underwent six months of intensive training in English. Inside the scanner, all participants performed high-level semantic reading, speech comprehension and verbal production tasks. Across both experiments, behavioral results revealed equal proficiency in the native language (L1) and differential in the other languages (L2/L3). Neuroimaging data revealed that increased L2/L3 proficiency was accompanied by (i) divergence in the functional engagement of native and non-native language networks, and (ii) different rates of change in the recruitment of language networks during reading, speech comprehension, and production. Our results indicate that language systems in adulthood exhibit different degrees of plasticity during the acquisition of a new language, with reading and speech comprehension networks showing greater change than production.

Topic Area: LANGUAGE: Development & aging

D56 Examining the role of Discrepant IQ and Reading Ability in left hemisphere Reading Network Activation

Rita Barakat^{1,2}, Stephen Gonzalez², Maya Rajan², Anisa Azad², Anthony Krafnick², Max Orozco², Hadley McGregor², Jason Zevin¹, Frank Manis¹, Kristi Clark^{1,2}; ¹University of Southern California Neuroscience Graduate Program and Psychology Program, ²Connectivity and Network Development Laboratory (CANDL) Group, Laboratory of Neuro Imaging and USC Mark and Mary Stevens Neuro Imaging and Informatics Institute

Dyslexia is a disorder characterized by an unexpected difficulty in reading, with a particular deficit in phonological processing. The presence and severity of the disorder is independent of an individual's IQ. However, there has been much debate as to whether individuals with a high IQ but average to below-average reading ability may show dyslexia-like activation patterns in the reading network. Using functional magnetic resonance imaging (fMRI), we examined activity in left-hemisphere reading network activation, and included IQ and reading ability measures as regressors of interest in our analyses. 71 right-handed, monolingual children (ages 8-12) participated in this study. IQ measures were obtained using the Wechsler Intelligence Scale for Children (WISC-IV), and reading ability was determined using the Woodcock-Johnson Test of Achievement (WJ-III). In addition to neuropsychological assessments administered outside the scanner, subjects completed Orthographic and Phonological word-processing tasks within the scanner, in which they were asked to make correct judgements based on either spelling (Orthographic task) or sound (Phonological task). Analysis of the behavioral results from the fMRI task data show that there were significant interactions between subject group and task, but no interactions between task and IQ. In addition, the fMRI data show similar patterns of activation between children with Dyslexia and discrepant readers, specifically on the Phonological task (thresholded to $p < 0.05$). From our data, we can conclude that there are similarities in the measured neural responses between discrepant readers and individuals with Dyslexia, though whether these differences generalize to other populations and tasks requires further exploration.

Topic Area: LANGUAGE: Development & aging

D57 Incorporating Strategy Training into Tablet-Based Anomia Therapy for People with Aphasia

Jeanne Gallée^{1,2}, Sofia Vallila-Rohter^{1,2}; ¹Harvard University, ²MGH Institute of Health Professions

Technology-based applications are being increasingly utilized in aphasia rehabilitation, however little is known about how individuals interact with these therapy applications. Interactive therapies allow individuals to complete language and cognitive rehabilitation tasks involving visual and auditory stimulus cues, as well as corrective feedback. Participants often undergo independent practice with tablet-based therapy, but their management of the provided feedback remains unknown. We examined the efficacy of a tablet-based treatment program for anomia probing whether strategy training influences how individuals with aphasia manage feedback and benefit from such therapies. Six individuals with aphasia were enrolled in one of two treatment paradigms: traditional or strategy therapy. For ten weeks, all participants received two hours of weekly in-house therapy using a tablet-based application with tasks targeting lexical and semantic activation. Participants were provided with iPads and were encouraged to work on therapy tasks for one hour a day at home. Based on the principle that repeated retrieval attempts may foster long-term naming gains (Middleton & Schwartz, 2016), the strategy training group was instructed to retrieve stimulus names, delay and limit cue use to maximize naming opportunities. We examined cue use, response latency, and accuracy through the course of therapy, comparing results across group and setting (in-house sessions vs. home logins).

Participants receiving strategy training made significant gains on untrained lexical items ($t[2] = -5.24, p = .04$), whereas the traditional group showed no improvement. Our work proposes a novel demonstration of how learning strategies that incorporate meta-awareness may improve therapy outcomes.

Topic Area: LANGUAGE: Development & aging

D58 Brain Activations of Categorical Tone Perception in Children with Specific Language Impairment

Huei-Mei Liu¹, Feng-Ming Tsao², Wei-Chin Hsu³, Li-Chun Kuo¹; ¹National Taiwan Normal University, ²National Taiwan University, ³National Taiwan University of Science and Technology

Individuals with Specific Language Impairment (SLI) are characterized by difficulties in understanding and/or producing language without obvious neurological deficits. The neural basis of underlying speech perception deficits have yet to be specified. The present study investigated the categorical speech perception deficits in children with SLI at behavioral and neural activation level. 22 school-age Mandarin-speaking students with SLI and 22 age-matched controls with typical development (TD) participated. The stimuli were a nine-point synthesized tone continuum of Mandarin /ba2/-/ba4/ syllables (tone 2&4). The identification and discrimination of lexical tones were used to examine the categorization performance. Within-category and across-category pairs with equal acoustic distances were selected to construct the two speech blocks in fMRI experiment. Compared to controls, individuals with SLI showed less accurate in discrimination and shallower categorization slope behaviorally. On the neural level, both groups showed activations in Wernicke's area (BA22), Heschl's gyrus (BA41, BA42), left prefrontal (BA6) and Insula, indicating the involvement of auditory and motor activations in speech perception. The between-group analysis showed when processing within-category speech, TD group exhibited greater activation than SLI group in left BA41, right BA42 and BA6, whereas the SLI group exhibited greater activation in left Insula. For across-category speech processing, SLI group exhibited greater activation than TD group in Broca's area (BA45), bilateral Temporal Pole (BA38), and left Insula. The correlation analysis showed associations between activation level (BOLD signal change in BA22, BA45, Insula) and speech categorization performance. The results provided the evidence for aberrant speech perception processing of individuals with SLI.

Topic Area: LANGUAGE: Other

D59 Neural characteristics of acoustic prosody during continuous real-life speech

Satu Saalasti^{1,2}, Enrico Glerean², Antti Suni¹, Jussi Alho², Juraj Simko¹, Iiro P. Jääskeläinen², Martti Vainio¹, Mikko Sams²; ¹University of Helsinki, ²Aalto University

When we exclaim "I told you so!" we mark the word "told" acoustically; this word is longer, pronounced with more effort, with higher pitch and different voice quality compared to the rest of the utterance. Prosody helps the listener to interpret the meaning of the utterance. Studying the neural processing of prosody during real-life speech has been hindered by lack of efficient analysis methods. The current study aims to quantify prosodic characteristics of speech based on a recently developed continuous wavelet transform (CWT) and explore the correlation between the prosodic signals and brain activity. A 3T functional magnetic resonance imaging (fMRI) was used to record brain activity of 29 female participants while they listened to an 8-minute narrative. The similarity of their brain activity was estimated by voxel-wise comparison of the BOLD signal time courses. A CWT based scale-space analysis was used to extract prosodic characteristics of the narrative, and the obtained wavelet timeseries were used as a regressor for the fMRI data to reveal how they map into the brain recordings. We found that acoustic-prosodic properties of speech aligned in a hierarchical fashion encompassing different linguistic

levels: phonemes, words, and utterances in the narrated speech. The model predicted brain activity in the medial temporal as well as superior fronto-lateral areas, in line with what is known about brain activity related to speech and language processing. Importantly, the automatically created model identified different levels of linguistic hierarchy, as different wavelet scales of the model elicited different brain activity.

Topic Area: LANGUAGE: Other

D60 Neural substrates of lexical embedding in Arabic speech processing

Sami Boudelaa^{1,2}, Francesca Carota^{2,3}, Mirjana Bozic², William Marslen-Wilson²; ¹United Arab Emirates University, Linguistics Department, PO. Box: 15551 Al Ain, UAE, ²University of Cambridge, Department of Psychology Downing St, Cambridge CB2 3EB, UK, ³Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525 XD Nijmegen, The Netherlands

Human languages exhibit extensive lexical embedding, with shorter words being onset-embedded in longer words (e.g., 'cap' in 'captain'). Previous behavioural and imaging research into Indo-European languages shows that speech sounds are continuously mapped onto lexical representations such that onset-embedded words are automatically activated (Marslen-Wilson 1987; Xhang & Samuel, 2015). Almost no research, however, has addressed the implications of onset-embeddedness for non-concatenative morphologies such as Arabic and Hebrew. Here we report an event-related fMRI study contrasting three categories of spoken Standard Arabic words in a passive listening paradigm with occasional 1-back memory tests. Category 1 consisted of non-concatenatively complex words like 'sarraba' leak out, made up of the root {srb}, the word pattern (WP) {-a- a-a}, with the onset-embedded pseudo-stem 'sarra' gladden (root {srr} and WP {-a-a-a}). Category 2 consisted of complex words with no embedded pseudo-stem (e.g., 'kaataba' correspond, root, {ktb} and WP {-aa-a-a}). Category 3 consisted of simple function words that had neither embedded stems, nor an underlying non-concatenative root and WP structure (e.g., 'naHnu' we). The results revealed strong bilateral STG and MTG activations for all stimulus categories, with LIFG activation detectable only for words with embedded stems at low statistical thresholds. This suggests that, at least under passive listening conditions, lexical embedding in Arabic does not strongly increase processing demands in bilateral temporal language areas, and that although lexical processing in Arabic operates on discontinuous morphemic elements, these are continuously mapped onto underlying representations.

Topic Area: LANGUAGE: Other

D61 Relevant Variables Affecting Training of Phonemic Awareness in Students with Dyslexia

Ethan Torpy¹, Rebekah Tozier², Kytja Voeller³; ¹Western Institute for Neurodevelopmental Studies & Interventions (WINSi)

Phonemes are the smallest meaningful sound units of spoken language. Phonemic awareness (PA) is the ability to identify speech sounds both in isolation and within spoken words. In the brain, phonemes are represented as invariant motor-articulatory gestures. Impaired phonemic awareness is a fundamental cognitive deficit in dyslexia, and training phonemic awareness is the gold standard for remediation. We have observed that even when training is delivered by experienced therapists in a consistent, formulaic manner, there is remarkable variability in the rate at which individuals achieve mastery. ("Mastery" = clear awareness of the invariant articulatory motor gesture, that is a solid mental representation of these motor gestures.) The goal of this study is to analyze the factors underlying this variability. Subjects (n=19), who had failed to learn in standard school programs, were assessed prior to PA treatment (IQ, receptive/expressive language, real/pseudoword reading, executive function, motor performance, praxis.) We examined the rates at

which these subjects (n=19) mastered the eight pairs of consonant phonemes. Average number of trials to mastery=651.9; range 98 to 2839. There was little correlation between age, IQ, gender, expressive/receptive language or educational exposure. Difficulty localizing and labelling oral anatomy and programming oral movements were identified as relevant factors in poor performance. However, if training was continued until mastery was achieved, clear gains in reading were evident.

Topic Area: LANGUAGE: Other

D62 Spontaneous speech synchronization predicts the engagement of a fronto-parietal network that supports word-learning and reflects individual differences

M Florencia Assaneo¹, Joan Orpella^{2,3}, Pablo Ripolles¹, Ruth de Diego Balaguer^{2,3}, David Poeppel^{1,4}; ¹Department of Psychology, New York University, ²Department of Cognition, Development and Educational Psychology, University of Barcelona, ³ICREA, Barcelona, ⁴Neuroscience Department, Max-Planck Institute for Empirical Aesthetics, Frankfurt

Recent work shows that speakers/listeners can be segregated into two groups according to differences in synchronization between produced and perceived speech; and that group membership predicts performance in word-form learning (Assaneo et al., forthcoming). Here we further explore the origin of this difference in learning. In a behavioral task, participants (previously categorized as low or high synchronizers; Assaneo et al., forthcoming) completed a statistical word-learning task under two conditions: (i) passive-listening and (ii) continuously whispering the syllable /ta/. The passive-listening condition replicated our previous result: high synchronizers were better word-learners than low synchronizers. However, there was no difference between groups in the whisper condition. While highs showed the previously described articulatory suppression effect (reduced learning when speech-motor areas are recruited for whispering; López-Barroso et al., 2011), lows performed equally across conditions. Next, we performed ICA on data from a different cohort undergoing fMRI during word-learning under the same conditions. As previously reported (López-Barroso et al., 2015), during the passive-listening condition, an audio-motor network is activated in both groups, and its activity positively correlates with learning. However, the groups differed in the engagement of a network comprising inferior-frontal, supplementary-motor, and superior-parietal areas, which is active for high synchronizers but not for low synchronizers. During the passive-listening condition, the interaction between the temporal dynamics of this additional network and the audio-motor network correlated with the learning benefit. In contrast, during the whispering condition, its activation predicted the degree of synchrony between the whispered speech and the external audio signal.

Topic Area: LANGUAGE: Other

D63 Changes in the neural representations of abstract science concepts after metaphoric reasoning

Vicky Tzuyin Lai¹, Nyssa Bulkes¹; ¹University of Arizona

The conceptual metaphor theory posits that abstract concepts can be understood via concrete concepts metaphorically. Does the cognitive-neural representation of an abstract concept vary depending on whether the concept is reasoned about metaphorically or literally? We approached this question in the context of science learning. Some behavioral evidence showed that the use of metaphors increases depth of thought (Baumer et al., 2013) and retention of learning (Schwartz et al., 2006). We used EEG to probe whether there are neural changes to the same concept taught metaphorically and literally. Twenty-three undergraduates participated in this 2-session study. Their science knowledge was assessed before and after the study. In both the pre-training and post-training EEG sessions, they read 80 science words and pseudowords. During off-line training, a tutor explained half of the concepts

metaphorically, and the other half, literally. The explanations were scripted and pre-tested to ensure aptness. We found that pseudowords, compared to words, elicited larger and more widespread N400s that typically index meaning activation, in both sessions, serving as a verification check. Critically, science words taught metaphorically elicited larger N400s than the same science words taught literally, but frontally distributed. Such frontal N400 effect has been found to index word concreteness (Barber et al. 2013). Further, the frontal N400 effect was positively correlated with science knowledge score improvement (weak $r=0.26$). We suggest that metaphoric reasoning enriches the abstract (science) concepts with concrete meaning instantiations. These instantiations may have strengthened the memory traces of the concept, which resulted in improved science knowledge.

Topic Area: LANGUAGE: Semantic

D64 Context matters: Brain activations to metaphor comprehension with and without meaningful context

Franziska Hartung¹, Eileen Cardillo¹, Stacey Humphries¹, Nathaniel Klooster^{1,2}, Anjan Chatterjee¹; ¹Penn Center for Neuroaesthetics, University of Pennsylvania, ²Moss Rehabilitation Institute

Metaphors are a special semantic case where part of the meaning of a base word is borrowed to express another target, often using concrete words to express abstract meaning. Previous research has shown that metaphors can activate sensory and motor brain regions that are linked to the meaning of the base word. As metaphors may also be more difficult to process than literal expressions, some evidence suggests that comprehending metaphors additionally activates areas involved in semantic selection and integration, executive function, and recruits additional right hemisphere resources. In this study, we tested the hypothesis that metaphors are processed differently when embedded in meaningful or in unhelpful contexts. Participants listened to short narrative and jargon contexts while undergoing functional MRI. In each of the contexts, one target sentence was presented that contained an action word used either literally (expressing motion) or metaphorically (expressing emotion). All metaphors were novel. Comparing activations to the target sentences revealed that metaphors are processed differently when contextualized by narratives as compared to jargon. Regardless of context however, metaphors activated an area in the right middle frontal gyrus. Metaphors compared to literal sentences in narrative contexts activate a wide bilateral network including inferior and middle frontal gyri, precuneus, temporal areas and posterior cingulate cortex, as well as left anterior insula and orbital gyrus whereas no additional activations were found for literal as compared to metaphoric sentences in narrative contexts. Our results show that context matters for metaphor processing and semantic selection.

Topic Area: LANGUAGE: Semantic

D65 Different neural networks for conceptual retrieval in sighted and blind

Roberto Bottini^{1,2}, Stefania Ferraro³, Anna Nigri³, Valeria Cuccarini³, Maria-Grazia Bruzzone³, Olivier Collignon^{1,4}; ¹University of Trento, Italy, ²International School for Advanced Studies (SISSA), Trieste, Italy, ³Neuroradiology Department, Fondazione IRCCS Istituto Neurologico Carlo Besta, Milan, Italy., ⁴University of Louvain (UCL), Louvain, Belgium

We investigated the experiential bases of knowledge by asking whether people that perceive the world in a different way also show a different neurobiology of concepts. We characterized the brain activity of early-blind and sighted individuals during a conceptual retrieval task in which participants rated the similarity between color and action concepts evoked by spoken words. Adaptation analysis showed that word-pairs referring to perceptually similar colors (e.g., red-orange) or actions (e.g., run-jump) led to repetition-suppression in occipital visual regions in the sighted, regions that are known

to encode visual features of objects and events, independently of their category. Early blind showed instead adaptation for similar concepts in language-related regions, but not in occipital cortices, as predicted by the absence of visual experience. Further analysis contrasting the two categories (color and action), independently of item similarity, activated category-sensitive regions in the pMTG (for actions) and the precuneus (for color) in both sighted and blind. These two regions, however, showed a different connectivity profile as a function of visual deprivation, increasing task-dependent connectivity with reorganized occipital regions in the early blind. Thus, occipital regions in the blind, albeit not encoding feature similarity, are however recruited during conceptual retrieval, working in concert with classic semantic hubs such as the precuneus and the lpMTG. Overall, our results show that visual deprivation changes the neural bases of conceptual retrieval, which is partially grounded in sensorimotor experience.

Topic Area: LANGUAGE: Semantic

D66 Neuronal correlates of label facilitated tactile perception

Tally McCormick Miller^{1,2}, Timo Torsten Schmidt¹, Felix Blankenburg^{1,2}, Friedemann Pulvermüller^{1,2}; ¹Freie Universität Berlin, ²Humboldt Universität zu Berlin

It is a long-standing question in neurolinguistics, to what extent language can have a causal effect on perception. A recent behavioural study reported that participants improved their discrimination ability of Braille-like tactile stimuli after one week of implicit association training with language stimuli being co-presented redundantly with the tactile stimuli. In that experiment subjects were exposed twice a day for 1h to the joint presentation of tactile stimuli presented to the fingertip and auditorily presented pseudowords. Their discrimination ability improved only for those tactile stimuli that were consistently paired with pseudowords, but not for those that were discordantly paired with different pseudowords. Thereby, a causal effect of verbal labels on tactile perception has been demonstrated under controlled laboratory conditions. This raises the question as to what the neuronal mechanisms underlying this implicit learning effect are. Here, we present fMRI data collected before and after the aforementioned behavioral learning to test for changes in brain connectivity as the underlying mechanism of the observed behavioral effects. The comparison of pre- and post-training revealed a language-driven increase in connectivity strength between auditory and secondary somatosensory cortex and the hippocampus as an association-learning related region.

Topic Area: LANGUAGE: Semantic

D67 Recruitment of visual cortex for language processing in blind individuals: A neurobiological model

Rosario Tomasello^{1,2}, Thomas Wennekers⁴, Max Garagnani^{1,3}, Friedemann Pulvermüller^{1,2}; ¹Brain Language Laboratory, Freie Universität Berlin, ²Berlin School of Mind and Brain, Humboldt Universität zu Berlin, ³Goldsmiths - University of London, ⁴Centre for Robotics and Neural Systems (CRNS), University of Plymouth

After sensory deprivation, the visual cortex is functionally recruited into non-visual cognitive language and semantic processing. Why this functional organization takes place and how its underlying mechanisms work at the neuronal circuit level is still unclear. Here, we use a biologically constrained network model implementing anatomical structure, neurophysiological function and connectivity of the fronto-tempo-occipital cortex to simulate word-meaning acquisition in visually deprived and undeprived ('healthy control') brains. Whereas in the 'undeprived' simulations only words denoting visual entities grew into the visual domain, the 'blind' models unexpectedly produced word-related neuronal circuits extending into visual cortex for all semantic categories (and especially for those carrying action-related meaning). Additionally, during word recognition, the blind model showed long-lasting

spiking neural activity compared to the sighted model, a sign for enhanced verbal working memory due to the additional neural recruitment. Three factors are crucial for explaining this deprivation-related growth: (i) changes in the network's activity balance brought about by the absence of uncorrelated sensory input, (ii) the connectivity structure of the network, and (iii) Hebbian correlation learning. By offering a neurobiological account for neural changes of language processing due to visual deprivation, our model bridges the gap between cellular-level mechanisms and system-level language function in blind humans.

Topic Area: LANGUAGE: Semantic

D68 Distributional Changes in P600 Variants as a Result of Natural Aging

Michelle Leckey¹, Kara D. Federmeier¹; ¹University of Illinois at Urbana-Champaign

Manipulations of syntactic processing difficulty are associated with a late, posterior positivity known as the P600. A similar positivity has been elicited to thematic role animacy violations and termed the "semantic P600". Previous research also points to similarities between the syntactic variant of the P600 and the P3b, a domain general component sensitive to saliency, task relevance and probability, factors that also modulate the syntactic P600. Current theorizing tends to assume the two language P600 effects are variants of the same underlying process, yet there is little empirical work testing that assumption. The goal of the present work was therefore to examine the relationship among the syntactic and semantic P600 and the P3b in the same subject populations. 24 young adults and 24 older adults completed three tasks that have each previously been seen to elicit one of these positivities of interest. All participants had no history of familial sinistrality. The P3b has been shown in many studies to manifest an age-related distributional change, such that it has a posterior distribution in young adults and shifts to include more frontal sites in older adults. We replicate that pattern. The syntactic P600 has also been found to show a similar age-related shift, which we also replicate. Notably, the semantic P600 (which has never been studied in older adults) did not show the same kind of age-related shift. This pattern suggests that the two P600s may be differentiable and that it is the syntactic variant that shares underlying mechanisms with the P3b.

Topic Area: LANGUAGE: Syntax

D69 Genetic topology of the language network

Roeland Hancock¹; ¹University of Connecticut

Genetic correlation (r_G) describes the proportion of covariance between two phenotypes attributable to shared genetic factors. r_G analysis was applied to functional activation (β) values from the narrative comprehension fMRI task (Binder 2011) of the preprocessed Human Connectome Project (HCP) young adult data (Barch et al., 2013). The twin-based sample was split into test and validation samples (approximately 120 monozygotic and 120 dizygotic pairs per split) to verify the reliability of clusters. Genetic correlations were estimated between each vertex within left inferior frontal cortex (IFC; including BA44, BA45, BA47 and FOP) and every other vertex in the left hemisphere using a bivariate additive-environmental model to obtain a measure of genetic similarity between each vertex in the IFC. The genetic similarity matrix was used to partition the IFC, resulting in 4 clusters. A cluster spanning BA44/45 largely reproduced current models of dorsal stream language architecture, with significant genetic correlation between IFG, posterior STS, perisylvian cortex and angular gyrus. A cluster spanning inferior BA45 and posterior BA47 was suggestive of a ventral language stream, having significant genetic correlations with middle temporal gyrus/TE2. These results provide novel confirmation of current understanding of language networks, showing that a broad dorsal/ventral stream distinction is also supported by genetic

differentiation of the two streams. In contrast, there was no evidence for genetic similarity between the IFC and the aTL. This suggests that aTL language functions may be mediated by genetic factors distinct from those that shape function in the majority of the language network.

Topic Area: LANGUAGE: Syntax

D70 Individual differences in electrophysiological correlates of non-native language comprehension

Sarah Grey¹, Annalise Caviasco¹, Kathryn Parker¹; ¹Fordham University

Increasing evidence shows that individuals systematically vary in whether they rely more on semantic or syntactic processes during language comprehension, as shown in variation in N400 and P600 ERP responses (e.g., Tanner & Van Hell, 2014; Kim, Oines, Miyake, 2018). These individual differences have been observed for late-learned non-native language (L2) comprehension (e.g., Grey, 2018; Tanner et al., 2013), but it is unclear whether or how this variability in neurocognitive language processes relates across different L2 structures. In this study, we examined individual differences in N400/P600 responses for different linguistic structures in English native speakers who learned French as a L2. During EEG/ERP acquisition, participants read correct sentences or sentences with errors in French verb aspect, verb tense, gender agreement, or semantics. ERP results indicated that participants showed N400s to semantics and gender agreement. Verb tense elicited what appeared to be a biphasic N400-P600 response whereas verb aspect elicited no significant ERP effects. Inspection of individual differences in ERP patterns using a Response Dominance Index (RDI; Grey, Tanner, & Van Hell, 2017; Tanner & Van Hell, 2014) revealed further details. For both semantics and gender agreement, individual variation was relatively low: most individuals showed N400s which suggests they were quite uniform in relying on lexical/semantic mechanisms to process these structures. For verb tense and aspect, variation was higher, with some individuals showing P600s and others showing N400s. These results have theoretical implications regarding the processing routes that individuals use for different linguistic structures during sentence comprehension in late-learned non-native languages.

Topic Area: LANGUAGE: Syntax

D71 Intra-operative stimulation of the left Frontal Aslant Tract disrupts sentence planning but does not affect articulation

Benjamin Chernoff¹, Max Sims², Susan Smith³, Webster Pilcher³, Bradford Mahon^{1,2,3}; ¹Carnegie Mellon University, ²University of Rochester, ³University of Rochester Medical Center

Sentence planning unfolds at multiple levels of processing, including planning of the message, syntagmatic and syntactic relations, and positioning of morphophonological elements. Patients with damage to a recently discovered white matter pathway in the brain, the left Frontal Aslant Tract (FAT), exhibit impaired sentence production and dysfluent speech, in the absence of impairments to semantic processing, lexical access, articulation, or non-speech motor function. We propose that the left FAT is a key pathway for integrating syntagmatic and positional-level planning during sentence production. We refer to this as the 'Syntagmatic Constraints On Positional Elements' (SCOPE) hypothesis. A core prediction made by the SCOPE hypothesis is that disruption of the FAT should specifically disrupt sentence production at phrasal boundaries, with no impairment for articulation. We test this prediction by measuring sentence production latencies in a patient undergoing direct electrical stimulation (DES) mapping of the frontal aslant tract during an awake craniotomy to remove a left hemisphere brain tumor. The patient produced cued sentences such as 'The red square is above the yellow circle', and we measured the intra-word and inter-word durations as a function of electrical stimulation of the tract. We found that stimulation

significantly prolonged inter-word pauses before the start of the noun phrases and at the verb, but not within phrase. Stimulation of the FAT had no effect on articulation time. These results provide initial support for the SCOPE hypothesis, and motivate novel directions for future research to explore the functions of this recently discovered component of the language system.

Topic Area: LANGUAGE: Syntax

D72 Sentence processing in pars opercularis adapts rapidly with short-term experience

Kelly Sharer¹, Malathi Thothathiri¹; ¹The George Washington University

How do comprehenders adapt to variation in the language environment? We investigated the neural substrates of exposure-based adaptation in garden-path sentence comprehension, which might require ambiguity resolution using cognitive control. We hypothesized that this adaptation could be sub-served by frontal regions linked to both sentence comprehension and cognitive control—the anterior cingulate cortex (ACC) and the left pars opercularis (ParsOp). Participants underwent three runs of functional neuroimaging (fMRI). In Run1, they read equal numbers of unambiguous and ambiguous main verb (MV) and relative clause (RC) sentences. Within individual-level functional regions of interest (ROIs. All Sentences>Baseline (false-font)), a structure-and-conflict-specific ambiguity effect for garden-path-inducing RC [t(27)=2.45, p<.05], but not default MV structures, was seen only in ParsOp. In Run2, we investigated adaptation in this region following exposure to unambiguous and ambiguous RC sentences. As expected, the first half of Run2 showed a significant RC ambiguity effect [t(27)=4.09, p<.001]. Consistent with adaptation, this effect diminished in the second half [t(27)=1.24, p>.2]. Our hypothesis that the extent of adaptation could vary based on individuals' cognitive control abilities was also supported [Pearson Skipped r=0.534238 CI=(0.308404 0.752808)]. Those who performed poorly in Stroop showed higher ambiguity effects in the second half, reflecting poorer adaptation. Finally, Run3 tested whether adaptation was verb-specific or generalized. There was no structure-and-conflict-specific ambiguity effect for verbs trained in Run2 but there was a marginally significant effect for untrained verbs [F(1,27)=3.63, p=.07], suggesting some verb-specificity. These results suggest that pars opercularis plays an important role in adapting language comprehension via cognitive control.

Topic Area: LANGUAGE: Syntax

D73 The role of speaker identity on listeners' processing of foreign-accented and native-accented speech

Carla Fernandez¹, Janet van Hell¹; ¹The Pennsylvania State University

Neurocognitive and behavioral research has shown that listening to foreign-accented speech is more effortful than listening to native-accented speech. A question that remained largely unexplored is how a speaker's facial features affect listeners' comprehension of foreign-accented speech. In an Event-Related Potentials (ERP) study, we examined the processing of congruent and incongruent facial cues and auditory signals. Twenty monolingual listeners (who were inexperienced with foreign-accented speech) listened to Chinese-accented and American-accented English sentences, preceded by an Asian face or a Caucasian face. To further examine how face-accent congruency or incongruency impacted semantic and syntactic processing, sentences contained semantic anomalies or pronoun violations, or contained no errors. Semantic violations elicited typical N400 effects in the congruent Caucasian face/American-accented English and Asian face/Chinese-accented English conditions, but no effect in the incongruent Asian face/American-accented English condition and a late N400 in the incongruent Caucasian face/Chinese-accented English condition. Pronoun violations elicited an Nref in the two congruent conditions (Caucasian face/American-accented English and Asian face/Chinese-accented English); these Nref effects were attenuated in the

incongruent conditions (Asian face/American-accented English and Caucasian-face/Chinese-accented English). These findings indicate that facial cues play an important role in activating certain stereotypes regarding a speaker (in line with the reverse linguistic stereotyping account; e.g., Kang & Rubin, 2009) and can affect the processing of both native and foreign-accented speech, depending on whether or not facial cues match listeners' expectations of a speaker's accent. Taken together, these findings provide a more in-depth understanding of the role that visual cues play in language processing.

Topic Area: LANGUAGE: Syntax

D74 A Rodent Model of Memory Facilitation by Stimulation of Cortical-Hippocampal Networks

Schnaude Dorizan¹, Craig Weiss¹, Joel Voss¹, John Disterhoff¹; ¹Northwestern University

Dysfunction of the cortical-hippocampal network has been implicated in memory disorders such as mild cognitive impairment and Alzheimer's disease. This network supports episodic memory and stimulation of cortical network regions using noninvasive TMS in humans can increase functional connectivity among distributed network regions and improve episodic memory accuracy. Although increased excitability has a putative role in such changes, neurobiological mechanisms remain uncertain. We have therefore developed a rat model of cortical-hippocampal network stimulation in order to better identify relevant mechanisms. The retrosplenial cortex (RSC) is a cortical region that is part of the cortical-hippocampal network with robust connectivity to the hippocampal subiculum. In a group of rats, stimulating macroelectrodes were implanted in the RSC and recording macroelectrodes were implanted in the subiculum. We hypothesized that theta-patterned stimulation of RSC will increase effective connectivity between RSC and subiculum by potentiating the relevant connections, with effective connectivity increases producing enhancements of hippocampus-dependent memory. Preliminary findings indicate that regimens of theta-burst stimulation to RSC increased magnitude of population activity in subiculum evoked by RSC stimulation, which is a measure of directed effective connectivity between these regions. The preliminary findings suggest that patterned stimulation of cortical access points of the cortical-hippocampal network can generate potentiation of network connections. Cumulative effects of multiple consecutive stimulation sessions on hippocampal-dependent trace-eyeblink conditioning will also be discussed and will be related to corresponding effects on network effective connectivity. We anticipate that these findings will help advance understanding of neurobiological mechanisms for network-level neuroplasticity generated by cortical electrical stimulation.

Topic Area: LONG-TERM MEMORY: Episodic

D75 Age-related changes in repetition suppression of neural activity during emotional future imagination

Aleea Devitt¹, Preston Thakral¹, Karl Szpunar², Donna Rose Addis³, Daniel Schacter¹; ¹Harvard University, ²University of Illinois at Chicago, ³Rotman Research Institute

Age-related reductions in episodic memory are accompanied by an impaired ability to imagine episodic future events. Neuroimaging findings show that aging is associated with reduced recruitment of a common core network when remembering the past and imagining the future. While recent work has focused on linking regions within the core network to specific components of imagined events, much still remains unknown about how age-related changes in episodic imagination are related to the functions of specific core network areas. In the current study we examine age-related changes in the neural underpinnings of emotional future imagination. We used a repetition suppression paradigm, where we modulated the emotional valence and

frequency of imagined events to evoke emotion-specific repetition related reductions in neural activity. Younger and older adults imagined positive, negative and neutral future events either twice or five times over the course of the experiment. Preliminary data (N=14, $p < .001$ uncorrected) suggest that a) overall, older adults showed greater repetition suppression effects than younger adults in regions involved in mental imagery, including the precuneus and occipital cortex; and b) age differences emerged for negative imagination specifically, with older adults showing a greater repetition suppression effect than younger adults in the temporal pole. Previous work has shown that older adults exhibit a positivity bias in future imagination; the current experiment suggests that this might be in part due to increased semantic processing of negative future thoughts with age.

Topic Area: LONG-TERM MEMORY: Episodic

D76 Behavioral and electrophysiological correlates of the memory search process during continuous recognition

John E. Scofield¹, Mason H. Price², Angelica Flores³, Edgar C. Merkle¹, Jeffrey D. Johnson¹; ¹University of Missouri, ²University of Nebraska Medical Center, ³Universidad de las Américas Puebla

Studies employing either continuous recognition or judgments of recency have demonstrated that response times (RTs) increase sub-linearly with increasing cue-target lag, suggesting that memory search sometimes operates sequentially along a compressed timeline. Less is understood however about whether and how this thorough search process might be abandoned when memories increase in strength. Here, we tested such a situation by acquiring EEG during a continuous recognition task in which items were repeated up to three times and did so across a range of lags lasting from about five seconds to one minute. Analysis of the RTs and multivariate pattern analysis (MVPA) of the EEG data identified graded effects according to the repetition manipulation. Bayesian multilevel modeling also indicated that RTs increased in a logarithmic manner with increasing lag, supporting the notion of a backwards self-terminating search along a compressed representation of time. Moreover, modeling revealed interactions between lag and repetition for both the behavioral and neural measures. These results provide converging forms of evidence that the sequential search process can be rapidly abandoned, making way for alternative, and possibly threshold-based means of making recognition judgments. Together, the findings suggest that even simple tasks can reveal the rapid dynamics by which we switch between distinct forms of neurocognitive processes that support memory retrieval.

Topic Area: LONG-TERM MEMORY: Episodic

D77 Competition Induces Exaggeration in Color Memory

Yufei Zhao¹, Avi. J. H. Chanals², Brice. A. Kuhl¹; ¹University of Oregon, ²New York University

Neural differentiation is thought to be an adaptive strategy for reducing interference between similar memories (Duncan and Schlichting, 2018). Recent fMRI research indicates that differentiation not only drives neural representations of competing memories apart, but ultimately causes representations of competing memories to become less similar than representations of unrelated memories (Chanals et al., 2017; Favila et al., 2016). However, it is unknown if this exaggeration in neural representations corresponds to an exaggeration in the features of events that are actually remembered. Here we tested for competition-induced exaggeration in color memory for objects. In our study, object pairs were generated where the only difference between the two objects in each pair was a 24° difference in color. Each object was associated with a unique face. Participants (n = 31) learned the face-object associations across multiple learning runs that included study rounds and associative memory tests. After 14 study-test runs, participants completed a color memory test during which they recalled the color for each

object using a color wheel. Successful face-object learning (during the study-test rounds) was associated with significant exaggeration in color memory (during the final test). Namely, for subjects that learned the face-object associations, the remembered distance between the paired objects on the color wheel was farther apart than veridical. Our results indicate that exaggeration of memory features plays an adaptive role in reducing competition. We consider the relationship between these behavioral findings and neural differentiation in a preliminary fMRI study.

Topic Area: LONG-TERM MEMORY: Episodic

D78 Concept generalization in young and older adults

Caitlin Bowman¹, Dagmar Zeithamova¹; ¹University of Oregon

Healthy memory function allows individuals to both remember specific past experiences and link across experiences to form generalized knowledge. While age deficits in memory specificity are well established, less is known about how healthy aging affects memory generalization. Concept generalization provides a useful domain to evaluate age effects in memory generalization because formal categorization models can probe the nature of representations underlying generalization judgments. Exemplar models posit that categories are represented by their individual category examples, whereas prototype models posit that categories are represented as the category average (prototype) abstracted across experiences. We hypothesized that concept generalization may be preserved in older adults when concepts are represented by abstract prototypes rather than memory for specific exemplars. While undergoing fMRI, young and older subjects learned to classify cartoon animals into two categories and generalized the category to new examples. Behavioral results showed no age differences in classifying new items that were close to category prototypes, but reduced accuracy in older adults for items further from the prototype. Behavioral fit of category models showed that both young and older adults tended to rely on prototype rather than exemplar representations. To identify brain systems supporting concept generalization, we fit predictors generated by the prototype and exemplar models to fMRI data. We found predominantly neural prototype correlates in both age groups, matching behavior. These results shed light on types of memory representations that older adults may use to maintain memory performance.

Topic Area: LONG-TERM MEMORY: Episodic

D79 Damage to temporoparietal regions disrupts autobiographical memory – evidence from neurodegenerative disorders

Siddharth Ramanan^{1,2,3}, David Foxe^{1,2,3}, John Hodges^{1,3,4}, Olivier Piguet^{1,2,3}, Muireann Irish^{1,2,3}; ¹The University of Sydney, Brain and Mind Centre, Sydney, NSW, Australia, ²The University of Sydney, School of Psychology, Sydney, NSW, Australia, ³Australian Research Council Centre of Excellence in Cognition and its Disorders, NSW, Australia, ⁴The University of Sydney, Central Clinical School, Sydney, NSW, Australia

Autobiographical memory permits the vivid recollection of personally experienced events, and hinges on interactions between the hippocampus and frontoparietal cortices. Parietal regions, in particular, are consistently implicated in functional imaging investigations of autobiographical retrieval, yet their exact contributions remain unclear. Here, we investigated a causal role for the inferior parietal cortex in autobiographical recall, using neurodegenerative disorders as lesion models. Ten patients with Logopenic Progressive Aphasia (LPA) – a rare neurodegenerative disorder characterised by early atrophy to the left inferior parietal cortex amidst relatively spared hippocampal integrity, were contrasted with 18 Alzheimer's disease (AD) patients, demonstrating significant hippocampal and parietal atrophy, and 16 healthy Controls. Participants completed the Autobiographical Interview - a measure examining free and probed recall of autobiographical memories from

four life epochs, and underwent structural brain imaging. Relative to Controls, the LPA group displayed marked deficits in free recall of autobiographical memories across all epochs. These impairments, however, were alleviated upon provision of structured probing. The AD group, by contrast, displayed global impairments across free and probed recall, relative to Controls. Voxel-based morphometry analyses of structural MRI data implicated left inferior parietal and temporal regions in autobiographical free recall impairments in LPA. By contrast, in AD, free and probed recall performance deficits correlated with atrophy of precuneus, posterior cingulate, and prefrontal regions. Our findings suggest the importance of regions beyond the hippocampus in modulating autobiographical memory retrieval, highlighting the need to consider parietal contributions in current theoretical frameworks of autobiographical memory.

Topic Area: LONG-TERM MEMORY: Episodic

D80 Examining immediate and long-term effects of sleep vs. sleep deprivation on emotional memory: Behavioral and electrophysiological evidence

Shengzi Zeng¹, Xuanyi Lin¹, Xiaoqing Hu^{1,2}; ¹The University of Hong Kong, Hong Kong, China, ²The State Key Lab of Brain and Cognitive Science, The University of Hong Kong, Hong Kong, China

To understand sleep's role in consolidating and maintaining emotional memories over time, the present study investigated the impact of sleep vs. sleep deprivation on emotional memory both immediately (i.e., 12-hours post-encoding) and after 60 hours (i.e., a delayed session). Furthermore, we recorded EEGs in the delayed recognition test to examine how sleep vs. sleep deprivation may influence the neural mechanisms of memory retrieval. Forty-five participants learned 120 IAPS pictures (60 negative and 60 neutral) and were randomly assigned to either sleep or sleep deprivation conditions. In the immediate recognition test, we observed a preferential consolidation of negative over neutral memories only among sleeping but not among sleep-deprived participants. However, over time negative memories were selectively preserved only in the sleep-deprived group, while they significantly declined in the sleep group. Thus, sleep deprivation disrupted consolidation processes of negative memories and prevented their natural decline over time. We also found that across time, negative pictures were rated less negatively only among sleeping participants, suggesting long-term benefits of sleep in attenuating negative emotional reactivity, compared to a preservation effect following sleep deprivation. Corroborating these behavioral results, ERP analysis focusing on the parietal old/new effect (300-800ms, 1000-2000ms) revealed that sleep-deprived participants showed a significantly stronger old vs. new parietal ERP effect during a sustained time window (300-2000 ms) than their sleeping counterparts. Since both groups showed equal memory accuracy at a behavioral level, these ERP results provide neural evidence that sleep-deprived participants may require sustained cognitive efforts to retrieve previous learned emotional materials.

Topic Area: LONG-TERM MEMORY: Episodic

D81 Hippocampal epileptic activity during sleep disrupts memory consolidation

Jessica Creery¹, David Brang², Mallika Patel¹, Vernon L. Towle³, James Tao³, Shasha Wu³, Ken A. Paller¹; ¹Northwestern University, ²University of Michigan, ³The University of Chicago

Memory consolidation may depend on temporal coordination among cortical slow-oscillations, sleep-spindles, and hippocampal-ripples during slow-wave sleep. This proposed mechanism may be dysfunctional in certain neurological groups. Some patients with epilepsy, for example, experience "accelerated long-term forgetting," in that forgetting becomes excessive only with some delay after initial learning. This pattern, with normal memory after shorter

delays, has been difficult to explain given conventional conceptions of memory. We propose that abnormal electrical activity in the hippocampus due to a seizure disorder could disrupt memory storage. Here, we analyzed relationships between seizure activity during sleep and memory consolidation. Our strategy was to use targeted memory reactivation (TMR) by presenting learning-associated sounds during sleep, with a within-subject design that avoided the interpretive challenges of comparing retention intervals with sleep versus wake. Patients diagnosed with temporal-lobe epilepsy performed a spatial memory task before and after nocturnal sleep. Five patients without seizure activity overnight remembered cued object-locations better in the morning compared to uncued object-locations (as do healthy individuals). In contrast, forgetting in four patients with seizure activity was increased for cued object-locations. Because memory was preferentially influenced for cued object-locations, rather than defective for all object-locations that had been learned, we suggest that overnight seizures specifically accelerated forgetting for exogenously reactivated memories. Given that this seizure activity was apparent unilaterally in the hippocampus, but not at the scalp, we speculate that this problem may impact patients with epilepsy even when standard scalp EEG recordings during sleep appear normal.

Topic Area: LONG-TERM MEMORY: Episodic

D82 Hippocampal reactivation predicts confidence in gist-based false memories

Surya Rajan Selvam¹, Ryan P. Coleman¹, William B. Corley¹, Mazura Ibragimova¹, Kathryn M. Mattingly¹, Nicholas C. Hindy¹; ¹University of Louisville

How are gist-based memories formed? For memories of episodic details, offline reactivation in the entorhinal cortex is predictive of subsequent memory (Staresina et al, 2013 PNAS). To examine the relationship between offline reactivation and gist formation, we combined the reactivation paradigm from Staresina and colleagues with a behavioral paradigm designed to induce false memories of non-presented gist words (Roediger and McDermott, 1995 JEP). During high-resolution fMRI, participants listened to lists of semantically related words that were each spoken in either a male or female voice. After every five lists, participants performed a simple number judgement task during a brief delay period followed by a recognition test with confidence ratings, which included words from the encoding phase mixed with the non-presented gist words and unrelated distractors. If a participant indicated that a word was "old", they were asked to rate their confidence in judging the gender of the voice in which the word was presented. We replicate previous findings of false memory effects, showing that participants were nearly as confident that gist words were previously presented as they were for presented words. Furthermore, using multivariate pattern analysis, we measured pattern reactivation of each preceding list during the delay period. Reactivation of a particular list in the hippocampus and entorhinal cortex during the delay predicted participants' confidence that the corresponding gist word had been presented. Findings link offline hippocampal reactivation to the formation of false memories, suggesting that gist information may be rapidly extracted in the hippocampus and entorhinal cortex after encoding.

Topic Area: LONG-TERM MEMORY: Episodic

D83 Identifying biomarkers to predict behavioral responses to stress in criterion shifting during recognition memory

Tyler Santander¹, Mary MacLean¹, Thomas Bullock¹, Alexander Boone¹, Jamie Raymer¹, Liann Jimmons¹, Alexander Stuber¹, Gold Okafor¹, Scott Grafton¹, Barry Giesbrecht¹, Michael Miller¹; ¹University of California, Santa Barbara

Successful recognition memory relies both on the ability to discriminate previously-studied items from novel stimuli and on the placement of an

appropriately-biased decision criterion. While it is well-established that there are vast individual differences in these factors, the present study sought to determine: 1) how they are modulated following acute exposure to stress; and 2) whether there are neurological, physiological, or hormonal variables that predict susceptibility/resilience to stress. Thirty healthy young adults performed a recognition memory and criterion shifting task following 90 seconds of exposure to a cold pressor task (CPT; here, dunking feet in ice water); warm water served as a control in a separate session. The study phase was performed prior to any stress induction, and testing occurred approximately one hour later (separated by other tasks beyond the scope of this analysis). We additionally collected electroencephalography (EEG), cardiography, and a number of salivary cortisol samples within-session: putative biomarkers included spectral measures of brain activity (e.g. frontal theta), heart rate variability (e.g. entropy), and cortisol dynamics (estimated as a latent growth function). A linear mixed model demonstrated that there were no significant effects of CPT exposure on discriminability. However, there was a significant effect on criterion placement, such that individuals became more extreme on average. These effects were further modulated by frontal theta and the rate of cortisol activity. Together, our results suggest that—while acute stress affects decisional processes in memory—there are a host of biological factors that may lead one to be more susceptible or resilient to CPT.

Topic Area: LONG-TERM MEMORY: Episodic

D84 Improving associative memory and inference via a shared spatial context

Jessica Robin¹, Nahid Iseyas^{1,2}, Keisha Joseph^{1,2}, Rosanna Olsen^{1,2}; ¹Rotman Research Institute, Baycrest, ²University of Toronto

Binding items in memory to form associations is a key feature of episodic memory, and is related to hippocampal function. Some theories suggest that spatial context plays a supportive role in episodic memory, providing a foundation for the formation of episodes and associations. Based on these models, we predicted that forming associations via a common spatial context compared to other non-contextual stimuli would result in improved memory for those relationships, as well as the indirect relationships between different items linked to a common context. Across three studies using eye-tracking and the associative inference paradigm, we compared memory and visual behaviours for associations including scenes compared to those between objects and faces. In Experiment 1, we compared object-object associations to object-scene associations and found better memory for associations including scenes, but also increased fixations to scenes compared to objects. In Experiment 2, we compared object-face associations to object-scene associations and found better memory for associations including scenes, despite equal or increased fixations to faces compared to scenes. In Experiment 3, we compared associations between non-pictorial object or scene words with images of objects. We found that the memory advantages for scenes were reduced when scene words were presented instead of images of scenes. Taken together, these results suggest that forming associations including scenes leads to stronger associative memories, but that this mnemonic advantage may be mediated by increased visual exploration and depend on viewing scene imagery.

Topic Area: LONG-TERM MEMORY: Episodic

D85 Network abnormalities rather than hippocampal atrophy predict remote memory impairment in hippocampal amnesia

Georgios P.D. Argyropoulos¹, Clare Loane^{1,2}, Adriana Roca-Fernandez¹, Carmen Lage-Martinez³, Christopher R. Butler¹; ¹University of Oxford, ²University College London, ³University Hospital Marqués de Valdecilla

Patients with hippocampal amnesia play a central role in memory neuroscience, but its neural underpinnings are hotly debated.

Characteristically, the foundations of remote memory are addressed by several frameworks that generate competing predictions on retrograde amnesia following hippocampal and extra-hippocampal damage. Given network-wide disruption following focal damage in other diseases, we hypothesized that hippocampal damage is followed by functional abnormalities in regions interacting with the hippocampus, and that those predict retrograde amnesia more reliably than hippocampal volumes. We assessed this hypothesis in a large cohort of patients (n = 36) with a previous history of autoimmune limbic encephalitis, a syndrome that typically causes focal hippocampal damage. We conducted neuropsychological assessment, structural MRI and resting-state fMRI to investigate the relationship of retrograde amnesia with structural and functional abnormalities. Patients showed anterograde amnesia and impaired remote autobiographical memory, in the face of spared remote personal semantic memory, executive, language, visuospatial and motor functions. Patients showed focal hippocampal atrophy within the medial temporal lobe, along with more subtle volume reduction in specific medial and lateral thalamic regions. Beyond structural abnormalities, patients also showed reduced resting-state hemodynamic activity in the precuneus. While scores for remote autobiographical memories correlated with hippocampal volumes, the effects of hippocampal atrophy were fully mediated by patients' correlative reduction in the resting-state hemodynamic activity in the precuneus. Our findings highlight the need to examine the occurrence of functional abnormalities in broader memory networks following focal hippocampal damage. Accounting for such abnormalities may help resolve inconsistencies in the literature.

Topic Area: LONG-TERM MEMORY: Episodic

D86 Population code for time on the scale of tens of minutes in mice hippocampus

Yue Liu¹, Sam Levy¹, William Mau¹, Marc Howard¹; ¹Boston University

To form episodic memory, the brain needs to make associations on a wide range of timescales. Decades of cognitive psychology research demonstrates that recency and contiguity effect exist on a wide range of timescales, from seconds to hours. If temporal effects across time scales have the same origin, then this implies that common neural substrates underlie timing for short and long timescales. Previous electrophysiological recording showed 'time cells' robustly activated at certain times after a salient stimulus over the scale of seconds. These time cells fire in sequence and tile the delay interval. It has not yet been demonstrated that sequences also extend over longer time scales necessary to provide a complete account of episodic memory. Here by analyzing two in vivo calcium imaging datasets with mice performing different tasks, we report in both experiments population of cells in hippocampus CA1 carrying information about elapsed time on the scale of tens of minutes. We show that the population dynamics for each session follow similar trajectories. This confirms that the population indeed code for time in a session rather than goes through random drift for each session. The same population of cells encodes elapsed time within a trial, on the scale of 10 seconds. These results together indicate that population neural dynamics in the brain encode temporal information on both short and long timescales. These findings suggest that a common memory store supports temporal effects in memory over a range of scales from seconds up to hours.

Topic Area: LONG-TERM MEMORY: Episodic

D87 Primary visual cortex activity is associated with confidence in memory for spatial locations

Michael Cohen¹, Larry Cheng¹, Ken Paller¹, Paul Reber¹; ¹Northwestern University

The role of early visual cortex in memory retrieval is controversial. Crick and Koch (1995) suggested that memory-related V1 activity is unconscious and

mainly reflects sensory characteristics. In contrast, low-level visual activation has been associated with conscious memory reactivation, particularly memory for spatial locations. Here, participants studied novel kaleidoscope images; two were presented on each trial, each in a different screen quadrant. A later memory test required participants to endorse images as either old or new, and in the former case to select the quadrant where it had initially appeared. Participants subsequently rated their confidence by selecting, for items judged as old, either: confident about item memory and its spatial location, confident item memory but guessing about location, or guessing on both. Between the first two categories, greater confidence in spatial location was associated with greater activity in primary visual cortex. Activity here tracked confidence in spatial location memory when those memories were accurate, and seemingly also when memory was inaccurate. The same early visual brain region was also activated during successful encoding. Thus, activity in primary visual cortex, during a confidence judgment made while the image is off-screen, appears to reflect the strength of stimulus reactivation. This visual signal seems to then contribute to subjective judgments of confidence in spatial location memory. Our result echoes findings showing a role for V1 in false memory for spatial location (Karanian & Slotnick, 2018), and supports the view that representations in V1 can directly influence conscious judgments.

Topic Area: LONG-TERM MEMORY: Episodic

D88 Reconstructing real-life event sequences with schema-based knowledge

Xinming Xu¹, Sze Chai Kwok^{1,2}; ¹East China Normal University, ²NYU Shanghai

Humans are able to reconstruct past event-sequences making use of schemas or causality without specific memory retrieval. While the hippocampus can support recall of specific event sequences, the posteromedial (PM) network is proposed to represent abstract knowledge about sequences and is found to represent real-world event schemas during narrative perception. However, it remains unclear whether PM regions would also support retrieval of event sequences with schema-based knowledge. In the current study, we examined the role of the PM regions in judging the temporal order of event sequences that could be uniquely resolved by schema-based knowledge versus by experienced sequence of events. Participants (n=24) watched a non-linearly narrated film with the chronological order and the narrated order of events dissociated. Then they were immediately tested on two order-judgment tasks using fMRI: judging either the chronological order or the narrated order of a pair of frames extracted from the film. In both tasks, half of the trials contained a congruent narrated/chronological order of the two frames whereas the other half did not. Participants performed above-chance in both tasks, with better performance in the chronological order task (mean=73%) than in the narrated order task (mean=64%). Critically, chronological order judgments were not biased by the narrated order, suggesting participants did not rely on the narrated order to perform the task. fMRI results showed that the PM regions (precuneus and angular gyrus) were preferentially engaged by schema-based chronological order judgments. These results provide novel insights into how event sequences could be retrieved using schema-based knowledge.

Topic Area: LONG-TERM MEMORY: Episodic

D89 Reviewing autobiographical memory cues promotes distinctive neural coding in older adults

Chris Martin¹, Rachel Newsome¹, Bryan Hong¹, Andrew Xia¹, Christopher Honey², Morgan Barense^{1,3}; ¹University of Toronto, ²Johns Hopkins University, ³Rotman Research Institute

Digital memory augmentation (DMA) is one promising approach to mitigating age-related memory decline. In DMA, portable devices are used to capture information about everyday episodes, making them available for later review.

Here, we developed a novel, smartphone-based DMA application that allowed older adults to create and review rich autobiographical memory cues, which were randomly assigned to one of two conditions: replayed or hidden. Over a two-week period, participants created an average of 67.83 autobiographical cues, approximately half of which were reviewed an average of 8.47 times each. Content in the hidden condition was never replayed. A behavioural cued-recall test and fMRI scanning was completed after a delay of one-week and again after a delay of three-months. We revealed a 30% boost in the number of event-specific autobiographical details retrieved in the replayed as compared to the hidden condition, while holding event significance, event frequency, and memory age constant. This effect persisted after a three-month delay. Replayed memories exhibited more distinct neural representations. A representational similarity analysis focused on the hippocampus revealed that voxel patterns of replayed memories were more dissimilar during retrieval than were voxel patterns of hidden memories. A whole-brain searchlight analysis revealed reliable differences in activity patterns between when retrieving hidden and replayed events within the core episodic memory network: posterior medial regions, angular gyrus, medial temporal, and ventromedial prefrontal cortex. Taken together, these findings indicate that reviewing rich autobiographical memory cues can boost retrieval of event-specific detail and promote orthogonal coding of pertinent information in the hippocampus.

Topic Area: LONG-TERM MEMORY: Episodic

D90 Semantic influences on episodic memory distortions

Alexa Tompary¹, Sharon L. Thompson-Schill¹; ¹University of Pennsylvania

Prior knowledge can facilitate or impair the formation of new episodic memories, depending on the consistency between old and new information. Although this phenomenon is well studied, past work rarely considers how the structure of semantic knowledge leads to variation in how it biases newly acquired information. We aim to quantify distortions in episodic memories due to prior knowledge by examining how differences in category membership bias new encoding. In experiments conducted on Amazon Mechanical Turk, participants (n=25) encoded and retrieved 70 image-location associations by dragging each image to its associated location. We used this continuous retrieval measure to disentangle biases driven by semantic knowledge from errors due to forgetting. Critically, the locations associated with each image were determined by similarity ratings generated by a separate cohort, such that members of the same category (e.g. birds) were located near each other. These ratings were also used to identify typical and atypical members of each category, which were assigned to random locations that were inconsistent with the similarity ratings. First, memory was more precise for image-location associations that were consistent with similarity ratings, relative to those that were inconsistent. Second, retrieval of typical category members was more biased towards the locations of their semantic neighbors, relative to retrieval of atypical members. Both effects replicated in a separate cohort (n=35) and were disrupted in control experiments where images' locations were not related to semantic ratings (n=43). Taken together, this suggests the structure of semantic knowledge can bias encoding of new memories.

Topic Area: LONG-TERM MEMORY: Episodic

D91 Targeted memory reactivation of competing memories during sleep induces forgetting

Bardur H Joensen¹, Sam C Berens¹, Scott A Cairney¹, M Gareth Gaskell¹, Aidan J Horner¹; ¹University of York

When two memories interfere at retrieval, repeated retrieval of one of the competing memories has been shown to disrupt retrieval for the other competing memory, leading to retrieval-induced forgetting. Although memory retrieval during wakefulness is thought to be distinct from reactivation processes in sleep, it has recently been shown that memory reactivation

during sleep can, under certain conditions, also lead to forgetting. Here we asked whether retrieval-induced forgetting can be seen for overlapping pairwise associations when repeatedly cued via targeted memory reactivation (TMR) during sleep. Participants learned several sets of overlapping pairwise associations (e.g., Hammer-Barack Obama, Hammer-Kitchen). The object (e.g., Hammer) was always the overlapping element. Following learning, participants retrieved the individual associations belonging to half of the overlapping sets prior to sleep, and all the associations following sleep. During sleep, we presented half of the learnt object words auditorily, assuming that presentation of the object word (e.g., Hammer) would induce retrieval and reactivation of the associated elements (e.g., Barack Obama, or Kitchen, or both). We show that TMR during sleep induces forgetting of the more weakly encoded overlapping pairwise associations. However, we also show that prior testing protects these memories from forgetting during sleep, consistent with a recent proposal that retrieval practice during wake can induce a rapid 'online' consolidation process that reduces competition between overlapping memories. Our findings suggest that TMR can produce a form of retrieval-induced forgetting during sleep, but prior retrieval during wakefulness can protect against such forgetting.

Topic Area: LONG-TERM MEMORY: Episodic

D92 Task-independent abstraction of episodic context in parietal cortices

Qun Ye¹, Emiliano Macaluso², Sze Chai Kwok^{1,3}; ¹East China Normal University, ²Lyon Neuroscience Research Center, ³NYU Shanghai

Computational and cognitive models suggest similarity in contextual features might serve as a substrate for linking events across time. However, the elucidation of neural similarity underlying episodic context has been constrained by individual tasks (e.g., free recall task), rather than by some overarching processes. Here we use multivariate decoding methods to investigate the extent to which common neural patterns characterize memory retrieval by decoding two types of episodic context across two different tasks: temporal order judgment (TOJ) and temporal duration estimation (TDE). Subjects watched TV-episode first, and after a break (Experiment 1: 4-minute short-retention delay, n = 26; Experiment 2: 24-hour long-retention delay, n = 19), completed the two tasks during fMRI. In the TOJ, subjects were presented with two frames of either same- or different-storylines from the episode, and required to choose the frame that happened earlier; in the TDE, the same subjects were required to indicate how far apart in time the two frames were: "very near", "near", "far", "very far". We trained a SVM classifier to classify the neural patterns associated with same- versus different-storylines in TOJ and applied this classifier to predict the episodic context on the neural data obtained from TDE, and vice versa. In both experiments, we observed significant between-tasks decoding of the episodic context (same- vs. different-storylines) in the precuneus, angular gyrus and posterior cingulate cortex. This study provides evidence for the existence of context-based neural representations irrespective of task/retention demands, demonstrating the role of the parietal cortices in supporting episodic context abstraction.

Topic Area: LONG-TERM MEMORY: Episodic

D93 The effect of a dual task manipulation on the neural correlates of recollection and post-retrieval monitoring in young and older adults

Erin D. Home^{1,2}, Marianne de Chastelaine^{1,2}, Michael D. Rugg^{1,2}; ¹University of Texas at Dallas, ²Center for Vital Longevity

We examined the fMRI correlates of recollection and post-retrieval monitoring in young and older adults (Ns = 28) during episodic retrieval under single and dual task conditions. The aim was to test the hypothesis that depleting resources available for retrieval monitoring would disproportionately impact older adults' memory performance and monitoring-related neural activity.

Participants completed an associative retrieval task (Intact/Rearranged/New responses to studied and new word pairs) in the MRI scanner while continuously hearing tones. In different test blocks they either ignored the tones (single task) or responded to occasional target tones (dual task). Young adults' associative memory performance did not differ by task condition, but older adults' performance was lower in the dual task condition, as predicted. Recollection-related BOLD activity in both groups was largely unaffected by the task manipulation and was not predictive of memory performance. In young adults, monitoring-related neural activity in lateral prefrontal and anterior cingulate cortex was attenuated in the dual relative to the single task condition. Monitoring effects in older adults were attenuated relative to young adults in the single task condition, and were not modulated by task demands. Regardless of age and task condition, the magnitude of these fMRI monitoring effects predicted associative memory performance, replicating and extending prior findings. We interpret the differential effects of the task manipulation on fMRI monitoring effects in the age groups as evidence that older adults' monitoring resources were depleted even in the single task condition, possibly due to the need to overcome distraction caused by the tones.

Topic Area: LONG-TERM MEMORY: Episodic

D94 Active Learning on Brain: Constructive, Motivational, Emotional, Goal-oriented and Self-Regulated Integrative Learning Theory

Kazuhisa Niki^{1,2}, Makoto Yururi³, Shoka Utsumi¹, Takayuki Iwano², Kie Fujiwara¹; ¹Ochanomizu Univ., ²National Institute of Advanced Industrial Science and Technology, ³Showa Woman's Univ.

We propose human Active Learning Theory based on Brain's learning mechanisms at the level of acts (= human intentional behavior). Really, we can account learning phenomena as dynamics between learning acts, teaching acts and learning environments, where intentional communication and intentional goals play important roles. An act is human intrinsic behavior that is realized using all brain functions including motivation, emotion, memory and cognitive executive function. Our Active Learning Theory focus on the roles of the default mode network that provides functions of memory, emotion and motivation; and furthermore, working memory on PFC-Parietal, where Parietal cortex interfaces with internal information, especially episodic memory. In this way, the goal-directed learning of learning acts can be explained as self-regulated learning. More importantly, constructive learning is realized when the intentional goal is achieved immediately after any conflicts are resolved. Our Active Learning Theory can consistently describe almost all characteristics and phenomena of active learning in a vivid manner from the viewpoint of brain cognitive neuroscience. [Background data from fMRI experiments] We would introduce a series of fMRI experiment of this constructive learning experience; we find significant activities in the hippocampus, amygdala, ACC, TPJ, and that the positive emotion accelerates this phenomenon with significantly increased activation of the amygdala, ACC, TPJ, while negative emotion activates the insula and suppresses constructive learning behavior. Social emotion is formed and evaluated by mPFC through experience, and expressed by the amygdala. We point out the importance of positive emotions and high motivation for constructive and active learning.

Topic Area: LONG-TERM MEMORY: Other

D95 Distortion of Memory Drawings for Real-World Scenes by the Presence of Incongruent Objects

Wan Kwok¹, Wilma Bainbridge¹, Christopher Baker¹; ¹Laboratory of Brain and Cognition, National Institute of Mental Health, National Institutes of Health

Previous work has found that visual memory has highly detailed and diagnostic features when evaluated by a free recall drawing task (Bainbridge et al., 2018). Drawings can thus be used to reveal the nature of

representations within memory. One question of interest is the effect of incongruent or schema-inconsistent objects on memory recall of a larger scene. Previous literature has shown mixed results on these effects. In this study, we investigate how content of visual memory changes based on the congruency of objects within scenes. 30 participants were eye-tracked while viewing 12 scenes, each containing a single congruent or incongruent object. For example, a pool scene contained either a congruent beach ball or an incongruent microscope. Following a distracting task, they were tested with the drawing task as well as recognition tests. Participants drew an average of 8.4 images from memory with 4.2 correct object/scene pairings, with no significant differences between incongruent and congruent scenes. Interestingly, participants made significantly more object/scene binding errors for incongruent scenes, errors not seen in our prior work. These errors were either objects remembered in isolation, or transposed into incorrect scenes. Differences were also found in eyetracking patterns and drawing stroke order for incongruent versus congruent scenes. Free recall drawings provide a powerful method of investigating nuanced visual memory recall effects created by the presence of incongruent objects.

Topic Area: LONG-TERM MEMORY: Other

D96 Making confident navigators better: Revealing the mechanisms of cognitive mapping through virtual reality interventions

Qiliang He¹, Timothy McNamara², Thackery Brown¹; ¹Georgia Institute of Technology, ²Vanderbilt University

Daily function depends on an ability to mentally map our environment. Environment visibility and complexity can increase this challenge. Path integration (PI) is theorized to contribute to cognitive map formation (CMF), but this relationship may be affected by other spatial learning cues and individuals' confidence in their directional abilities. We tested the causal relationship between PI and CMF, and whether this relationship is affected by self-reported directional ability, via targeted interventions reducing PI difficulty. Participants learned virtual towns under naturalistic conditions, or with either visibility (building translucency) increased, or the amount of visual information simplified. Participants then performed wayfinding and pointing tasks to probe CMF. Translucency uniquely improved CMF, supporting a causal role for PI in CMF. Interestingly, however, only participants with high self-reported sense of direction (SOD) showed this benefit, suggesting a unique link between this trait and individuals' tendencies to leverage additional spatial cues to reduce PI difficulty. Our findings provide important insight into the cognitive factors influencing the relationship between PI and CMF, the mechanistic link between SOD and PI, and interventions that can improve spatial learning.

Topic Area: LONG-TERM MEMORY: Other

D97 Musical prodigies exhibit better atonal melody recall and greater sensorimotor brain connectivity than equally trained musicians

Michael Weiss^{1,2}, Megha Sharda^{1,2}, Isabelle Peretz^{1,2}; ¹International Laboratory for Brain, Music, and Sound Research, ²University of Montreal

Musical prodigies are known anecdotally for having remarkable memory for music. The current study tests whether adolescents and adults who were prodigies continue to learn and remember melodies better than their musician peers, and whether their performance is limited to tonal music. We also tested whether individual differences in melody retrieval correlate with resting-state brain activity in sensorimotor learning networks that have previously been implicated in mental transformations of music. Participants include 12 prodigies (4 female, $M=25.6\pm 6.8$, range=13–33 years) who achieved prominence or won a major performance competition in childhood. The control group includes 11 musicians (5 female, $M=22.8\pm 7.0$, range=14–34 years) matched with prodigies in age, gender, IQ, onset of training, overall training, and practice. Participants completed a melody learning task on 2 consecutive

days, which involved hearing a melody and singing it back repeatedly (D1: 10 attempts; D2: 5 attempts) for each of 4 melodies (2 tonal, 2 atonal; each 28 notes). Results show a higher proportion of correctly recalled melodic contours for tonal over atonal melodies. Compared to musicians, prodigies' recall of atonal melodic contours improved from the first to the second day (i.e., group*tonality*day interaction). Across the sample, functional connectivity between parieto-frontal regions (right inferior parietal cortex, left dorsolateral prefrontal cortex) was significantly related to overall melodic contour retrieval (i.e., collapsed across tonality and day). Moreover, the magnitude of connectivity was greater in prodigies than controls. These findings support the notion that prodigies are better learners of music, perhaps due to differences in brain connectivity.

Topic Area: LONG-TERM MEMORY: Other

D98 The human dentate gyrus is critical for statistical learning and associative inference

Zorry Belchev^{1,2}, Hannah Marlatte^{1,2}, Asaf Gilboa^{1,2}; ¹University of Toronto, Department of Psychology, ²Rotman Research Institute at Baycrest

The hippocampus has long been implicated in learning indirect associations through associative inference (AI), and more recently has also been linked to statistical learning (SL), the implicit learning of environmental regularities. Both abilities require integration of information across time to form new associative structures, and are thought to critically depend on the CA1 subfield of the hippocampus. However, AI and SL are hypothesized to differ in that the hippocampal monosynaptic pathway (MSP; entorhinal cortex >> CA1) is thought to be sufficient for SL, independent from the trisynaptic pathway (TSP; entorhinal >> dentate gyrus (DG) >> CA3 >> CA1), but not sufficient for AI with few repeated exposures to the stimuli. We tested the pathway specificity of these abilities in patient BL with a rare selective lesion to the DG, which presumably interrupts the TSP but not the MSP. During AI, BL studied overlapping paired associates (AB, BC) and was tested on AB, BC (premise pairs) and inferred AC (indirect association). As predicted, BL performed significantly worse than matched controls on indirect associations despite being able to acquire the premise pairs. During SL participants passively viewed continuous sequences of pictures that contained an underlying structure of triplets and had to later recognize the repeated triplets. Contrary to our predictions, BL's focal DG lesion was sufficient to lead to chance performance on SL, suggesting the MSP is insufficient for SL. Together, these results implicate the DG in the extraction and binding of associations across events, in both explicit and implicit cross-event generalization.

Topic Area: LONG-TERM MEMORY: Other

D99 Interhemispheric premotor interaction during motor learning is modulated by practice conditions

Chien-Ho Lin¹, Ching-En Lin¹, Ho-Ching Yang¹, Shin-LeH Huang¹, Barbara Knowlton², Allan Wu², Ming-Chang Chiang¹; ¹National Yang-Ming University, Taiwan, ²UCLA

Interleaved practice (IP) of motor sequences is generally more difficult than repetitive practice (RP) but leads to better learning, a phenomenon known as the contextual interference (CI) effect. To identify effective functional connectivity underlying the CI effect, dynamic causal modeling (DCM) was applied to analyze fMRI data. On 2 consecutive days, 26 right-handed young adults practiced serial reaction time tasks with the non-dominant hand in an MR scanner. The tasks consisted of three distinct 4-element sequences arranged in either an interleaved (IP) or repetitive (RP) order separated by 2-4 weeks. Retention was evaluated on Day 5. 5 ROIs were selected for DCM: the premotor cortices (PM) and superior parietal lobules bilaterally, and right primary motor cortex. Functional connectivity between ROIs was decomposed into intrinsic connectivity and modulatory connectivity that could be modulated

by inputs (IP or RP here). The optimized connectivity model was obtained using a hierarchical approach based on the parametric empirical Bayes (PEB) method, which compared the full with all possible reduced models. We found that benefit of CI to learning, measured by IP-minus-RP difference in response time, was correlated with the stronger modulatory effects of IP on Day-2 functional connectivity from the left to right PM, but correlated with stronger modulatory effects of RP on connectivity from the right to left PM. These findings corroborate the left hemisphere dominance for the involvement of the premotor cortex in a more complex motor task in right-handed participants.

Topic Area: LONG-TERM MEMORY: Skill learning

D100 Motivation does not increase plateau performance with continued practice of the motor sequence task

Mollie Bayda¹, Olivia P. Manickas-Hill¹, Alexandra Morgan¹, Robert Stickgold^{1,2}; ¹Beth Israel Deaconess Medical Center, ²Harvard Medical School

A transient boost in performance after a short break from practice of the motor sequence task (MST)—a widely-used probe of explicitly instructed motor skill that involves repeatedly typing a sequence of digits—has been reported. This phenomenon has been proposed to represent early consolidation mechanisms or recovery from reactive inhibition (i.e., decrements in performance that build up with each trial over practice and dissipate with rest). However, it could also be explained by the monotonous nature of the MST simply leading to apathy, and thus deflated performance, with continued practice. To rule out this possibility, during 48 trials of continuous practice of the MST we offered increments in monetary reward per correctly typed sequence on trials 8, 12, 24, 36, and 48 to a motivation group compared with on trials 40, 44, and 48 to a no motivation group. This design allowed us to examine whether and how motivation affects performance dynamics over practice while equating possible effects by expectations of reward. We found that monetary incentive in the motivation group on trials 8, 12, 24, and 36 did not affect performance (all p 's > 0.25) and further that between-group performance dynamics around these trials did not differ ($p = 0.18$). These results suggest that increased performance during the "boost" window is not a result of decreased performance at the end of practice due to lack of motivation.

Topic Area: LONG-TERM MEMORY: Skill learning

D101 Revealing the neural basis of rest spacing effects in music sequence learning

Tyson Oyler¹, Dmitrii Paniukov², Ze Zhang³, Ekaterina Paniukov³, Carla Cash¹, Gregory Brookes¹, Changzhi Li¹, Tyler Davis¹; ¹Texas Tech University, ²University of Calgary, ³Independent

Many musicians have stressed the importance of practice, but can too much practice without rest periods be less effective? Previous studies have shown that taking an early rest period during motor sequence learning can improve performance relative to later rest. However, the neural mechanisms underlying these rest effects are currently unknown. One possibility is that formation of internal motor sequence representations is enhanced by early rest. The cerebellum is a key brain region for establishing motor sequence representations early in learning and thus we anticipated that early rest may enhance cerebellar processing relative to later rest. To test this hypothesis, we scanned 70 participants using an fMRI while they completed a music sequence learning task. Half of each group was given a rest period early in learning, while the other half were given a late rest period. Results from a test phase after both early and late groups rested, revealed that there was more activation in the striatum, thalamus, auditory, motor, and premotor cortices for correctly played versus incorrectly played sequences. In addition, greater activation was found in the cerebellum for experts who had an early rest period than the later rest period experts. This early vs late rest difference was and

not observed in novice musicians. The greater cerebellum activation for early rest in experts mirrors results from motor sequence learning and suggests that experts who received an early rest may have an advantage in terms of establishing representations of motor sequences early in learning.

Topic Area: LONG-TERM MEMORY: Skill learning

D102 A Network diffusion model for combining MEG and Diffusion MRI data

Chang Cai¹, Ashish Raj¹, Xihe Xie², Eva Palacios¹, Julia Owen³, Pratik Mukherjee¹, Srikantan Nagarajan¹; ¹Department of Radiology and Biomedical Imaging, University of California at San Francisco, CA, ²Department of Neuroscience, Weill Graduate School of Medicine, Weill Cornell Medicine, New York, NY, ³Department of Radiology, University of Washington, Seattle, WA

One of the most important questions in computational neuroscience is how the brain's structural wiring gives rise to its function and its patterns of activity. Although neural mass models that involve large coupled non-linear differential equations could capture these structure-function relationships, they are unwieldy, difficult to compute, and are only accessible via simulations. Here we present for the first time a linear and analytically accessible model that extends prior work on linear network diffusion modeling that was capable of predicting a subject's resting state BOLD functional connectivity matrix from their structural connectivity Laplacian matrix. The extended model incorporates all frequencies of oscillations, is fast and in a closed form, given by the eigen-modes of the graph Laplacian. Structural connectivity matrix was computed as the anatomical fiber connectivity between gray matter regions from diffusion tensor imaging data. Resting-state brain activity patterns were measured from magnetoencephalography (MEG) and subject to source reconstruction algorithm and the time-course of regions were estimated. We expand the graph diffusion model to incorporate local oscillations, and obtain closed form equations for each of the graph Laplacian's Eigen-modes. The model is able to recapitulate the general properties of the steady state frequency spectra of empirical MEG measurements of brain activity. We found that the spatial pattern predicted by the model for two frequency bands (delta and alpha), and indicates that the model is able to recapitulate substantially the empirical observed spatial patterns. Therefore, this novel structure-function model describes a principled framework for combining MEG/EEG and diffusion MRI data.

Topic Area: METHODS: Neuroimaging

D103 Assessing the relationship between reading ability and dyslexia: A Behavioral and fMRI study

Stephen Gonzalez^{1,2}, Rita Barakat^{2,3}, Maya Rajan^{2,4}, Kristi Clark^{1,2,3}; ¹University of Southern California Neuroimaging and Informatics Masters Program, ²Connectivity and Network Development Laboratory (CANDL) Groups, Laboratory of Neuro Imaging and USC Mark and Mary Stevens Neuro Imaging and Informatics Institute, ³University of Southern California Neuroscience Graduate Program, ⁴University of Southern California Psychology Program

Dyslexia is traditionally thought to be a product of a deficit in phonological processing. Other theories suggest a deficit in integration of phonological and orthographical processing streams. It has also been shown that areas participating in these processes show hypoactivity during phonological tasks, and that this pattern of activation is more strongly related to dyslexia as opposed to reading ability. Using functional magnetic resonance imaging, we examined key regions of the left hemisphere reading network that contribute to orthographic and phonological processing, as well as primary convergence points of these two streams, while including reading ability in our regression model. Participants were between ages 8-12, right-handed, and were

monolingual English speakers. We presented subjects with phonological and orthographical decision tasks which adapted to their performance over the course of each task. For each task, we assessed subject's performance by measuring the average difficulty level across all trials, as well as the frequency subjects switched difficulty level within a task (variability). Reading ability was measured using the Woodcock-Johnson Test of Achievement (WJ-III). Behavioral analysis revealed dyslexic subjects exhibited lower mean difficulty level, and higher variability on each task when compared to controls. Preliminary functional analysis for the phonological task highlighted differences in activation between groups in the superior temporal gyrus, a location shown to contribute to phonemic processing. These findings suggest a difference in phonological processing between dyslexic individuals and non-deficient controls. Further analysis is needed to determine the magnitude of these differences and if they are replicable across subject populations.

Topic Area: METHODS: Neuroimaging

D104 Deep learning classifiers of visual cortex activity can identify which moment of a video is represented by a single fMRI volume during naturalistic movie viewing

Matthew Johnson¹, Jacob Williams¹, Rafay Khan², Karl Kuntzleman¹; ¹University of Nebraska-Lincoln, ²University of Illinois at Urbana-Champaign

In this fMRI study, participants watched the same short video several times in separate scan runs. We then trained subject-specific deep learning models based on a visual cortex region of interest (using the DeLINEATE toolbox; <http://delineate.it>) to discriminate whether two fMRI volumes from different movie-viewing runs represented the same timepoint vs. two different timepoints. All training was performed only on data from the second half of each run. The trained deep-learning model was then applied to the held-out, independent first half of each run, comparing each timepoint of each run to each timepoint of each other run. We found that this model performed easily above chance at identifying whether two timepoints were the same or different. Furthermore, the likelihood of "same" judgments fell off with increasing temporal distance between the timepoints compared. This suggests that such classifiers can provide a useful and robust measure of neural pattern similarity, even for continuously varying brain activity without discrete epochs or events. Our method compared favorably to other similarity measures (Pearson correlation, Euclidean distance) while avoiding certain caveats of those measures and yielding a more interpretable numeric value. In a control analysis, we also compared each timepoint of each run of movie-viewing to each timepoint of each run of two resting-state scans. The control analysis did not find strong similarity between corresponding timepoints, confirming that effects observed among movie-viewing runs were due to sensory/cognitive activity evoked by the film, rather than alternative explanations such as scanner drift or time-on-task.

Topic Area: METHODS: Neuroimaging

D105 Evaluation of Neural Oscillation Burst Detection Algorithms

Sashaank Pasumarthi¹, Scott Cole¹, Andrew Washington¹, Bradley Voytek^{1,2}; ¹University of California, San Diego, ²Halicioğlu Data Science Institute

Emerging evidence regarding the functional role of neural oscillations suggests that oscillatory "bursts" may play a distinct role in neuronal computation and cognition. However most tools for detecting bursts remain untested against noisy, ground-truth simulated data, and no experiments have been done to assess inter-rater reliability for burst detection. That is, we lack a benchmark for what exactly qualifies as an oscillatory burst. To address this, we tested how eight human raters categorize bursts in neural time series data, including synthetic data, animal local field potential recordings, and invasive human electrocorticography and non-invasive electroencephalography. We also compared several burst detection algorithms to the human raters, and

assessed their performance against the ground-truth in synthetic data. By having human subjects label data with varying signal-to-noise levels, we were able to quantify the reliability and consistency of algorithmic and human-labeled burst detection. We found that an algorithm based on individual cycle features performed better than a standard dual amplitude threshold algorithm (Feingold et al., 2015, PNAS) at higher signal-to-noise levels. In addition, we calculated the balanced accuracy score, adjusted for chance, of each reviewer against the others to measure inter-rater reliability. The balanced accuracy score was consistently above zero, suggesting that there is some consensus among human raters, and that human-labeled burst detection is more reliable than chance. Further, we found that humans tended to agree with the algorithm labels of bursts in synthetic data, whereas the consensus between humans and algorithms was no better than random for the EEG data.

Topic Area: METHODS: Neuroimaging

D106 Fictional or Functional Connectivity? Validating and improving functional connectivity analyses for EEG

Anthony Herdman¹, Alex Moiseev²; ¹University of British Columbia, ²Simon Fraser University

Introduction: Source leakage is a major challenge for conducting functional connectivity (FC) analyses of EEG/MEG data. A signal from one brain region can "leak" into another brain region due to mathematical consequences of source-modeling procedures. This results in finding false connections. Validation papers even showed that non-zero lagged methods return a large number of false connections. So, we are left wondering which connections are "fictional" or "functional"? This study simulated EEG, with defined connectivities, in order to verify/validate the performances of different source-modeling methods for FC analyses. Methods: EEG was simulated to have specific connectivities among three or six source locations at four signal-to-noise ratios (0.2-0.5). Source waveforms were 5-6 Hz sinusoids time-locked across 80 trials with defined phase-locking values (PLV) of 0.3-0.7 and phase-lag indices (PLI) of 0.3-0.5. EEG was modeled using single-source (SPA, LCMV, eLORETA, MNE) and multi-source (MIA) inverse solutions to reconstruct source waveforms. Whole-brain connectivity maps were obtained using FC analyses (PLV and PLI) of source waveforms. Performances were determined for each inverse solution. Results: Single-source solutions had high false-positive rates (PLV=0.62-0.75; PLI=0.56-0.73); whereas multi-source had low (PLV=0.18; PLI=0.32) when true-positive rates=0.8. Thus, MIA had superior performances (PLV AUC=0.89; PLV AUC=0.84) over all single-source inverse solutions (PLV AUC=0.50-0.66; PLI AUC=0.56-0.71). Conclusion: Multi-source inverse solutions are a better choice for FC analyses than single-source methods because they perform better and yield fewer false connections regardless of using PLV or PLI measures. FC analysis pipelines should be verified using simulated data before wide-spread implementation with human EEG/MEG data.

Topic Area: METHODS: Neuroimaging

D107 Frequency specific neural oscillation abnormalities distinctly associated with amyloid-beta and tau in Alzheimer's disease

Kamalini Ranasinghe¹, Jungho Cha¹, Leighton Hinkley², Danielle Mizuir², Susanne Honma², Viktoriya Bourakova¹, William Jagust³, Bruce Miller¹, Gil Rabinovici¹, Keith Vossel^{1,4}, Srikantan Nagarajan²; ¹Memory and Aging Center, Department of Neurology, University of California San Francisco, ²Biomagnetic Imaging Laboratory, Department of Radiology and Biomedical Imaging, University of California San Francisco, ³Helen Wills Neuroscience Institute, UC Berkeley, Berkeley, ⁴N. Bud Grossman Center for Memory Research and Care, Institute for Translational Neuroscience, and Department of Neurology, University of Minnesota

Neurophysiological studies on animal models of Alzheimer's disease (AD) suggest that network dysfunction mediated by amyloid-beta and tau are characterized by abnormal neural oscillations. A better understanding of the neurophysiological manifestations in patients with AD will allow us to link the findings in AD mouse models to human condition and will bring us closer to moving therapeutic interventions from basic science to clinical trials. In this study, we used a multimodal imaging approach combining magnetoencephalographic imaging (MEGI) and Positron Emission Tomography (PET) with amyloid-beta (11C-PIB) and tau (18F-AV-1451) tracers to examine the specific associations between neurophysiological manifestations and the molecular biomarkers in patients with AD spectrum and age matched controls. Using MEGI we examined the global synchrony within delta-theta (2-8 Hz) and alpha (8-12 Hz) oscillations in AD patients (n=12) and investigated the spatial and functional correlations between neural synchronization deficits and amyloid and tau tracer uptake. We found that spatial patterns of abnormal alpha synchrony showed a strong regional association with tau tracer uptake while the spatial patterns of abnormal delta-theta synchrony showed strong regional associations to amyloid-beta uptake. Quantitatively, higher tau uptake significantly correlated with decreased neuronal synchrony whereas higher amyloid-beta uptake significantly correlated with enhanced neuronal synchrony. Unique associations of alpha and delta-theta neural synchronization to amyloid and tau depositions denote neurophysiological signatures of AD pathophysiology. Our results demonstrate that MEGI derived frequency-specific neurophysiological markers can be used as sensitive indices to gauge the degree of dysfunction associated with amyloid and tau depositions in AD.

Topic Area: METHODS: Neuroimaging

D108 Investigating individual variation in cognitive function through Mesoscale Individualized Neurodynamic (MINDy) models

Matthew F. Singh¹, ShiNung Ching¹, Todd S. Braver¹; ¹Washington University in St. Louis

It is widely thought that a critical aspect of individual variation in human cognition relates to how information is transferred between widely-distributed regions, in addition to within-region local computations. Although it is possible to robustly characterize individual differences in brain network functional connectivity (FC) in a data-driven manner, such approaches don't allow for the overt construction of mechanistic hypotheses. By contrast, generative biologically-plausible models do enable testing of mechanistic hypotheses, but to date these have not been individually constructed directly from functional data. In the current work, we bridge this gap with a novel method to fit high-resolution Mesoscale Individualized Neurodynamic (MINDy) models directly to fMRI data. The estimation procedure enables networks consisting of hundreds to thousands of nonlinear neural masses (parcels) to be fit individually for each subject, requiring only a minimum of 15 minutes worth of resting-state data. Model parameters are highly reliable across scanning sessions and robust to preprocessing choices. Ground-truth tests also indicate that recovered models are valid and robust to both additive measurement noise and hemodynamic uncertainty. The model mechanistically reveals sources of individual variation in brain networks that may be mis-estimated in standard resting-state FC approaches. The findings represent an advance on two fronts: generating spatially-detailed biophysically plausible models at the level of individual human brains which utilize a new measure of connectivity. Planned follow-up analyses will apply the model to examine how cognitive task states modify brain network dynamics and provide new metrics for characterizing cognitive individual differences.

Topic Area: METHODS: Neuroimaging

D109 Optimizing preprocessing and confound regression procedures for rapid single-trial multivoxel pattern analysis

Tyler Davis¹, Sean O'Bryan¹, Timothy Kelley¹; ¹Texas Tech University

Preprocessing and confound regression are key analysis steps for eliminating irrelevant or unwanted signals from fMRI data. However, the role that different processing steps and confound regressors play in data analysis can vary greatly across different analysis types, suggesting a "one-size-fits-all" processing stream for fMRI analyses is unlikely to be optimal. For example, motion artifact presents a critical confound in connectivity analysis by inducing correlations between brain regions, which makes controlling for it a necessity when trying to estimate true between region coupling. Contrastingly, in task-based analysis, unless correlated with task, motion primarily affects the error term. In the present study, we examine how common preprocessing and confound regression steps including spatial smoothing, high pass filtering, adjustment for motion artifact, and model-type [standard beta series models/least-squares all (LSA) or least squares single (LSS)] impact estimation of single-trial activation patterns for multivoxel pattern classification. Using face, scene, and object localizer data from several studies scanned in our lab, we find that choice of model (LSA or LSS) has the largest impact on prediction of image class, with LSA outperforming LSS. Inclusion of a temporal derivative decreased classification accuracy, likely due to decreasing design matrix efficiency from the increase in the number of task-related regressors. Surprisingly, effects of motion regression were small and inconsistent across studies, which may reflect the fact that the run-level error term after LSA/LSS extraction does not directly contribute to subsequent classification accuracy.

Topic Area: METHODS: Neuroimaging

D110 Univariate versus Multivariate Lesion Symptom Mapping Approaches

Juliana Baldo¹, Maria Ivanova^{1,2}, Brian Curran^{1,3}, Nina Dronkers^{1,2}, Timothy Herron¹; ¹VA Northern California Health Care System, ²University of California, Berkeley, ³University of California, San Francisco

In the current study, we addressed the recent criticism that voxel-based, univariate lesion symptom mapping (ULSM) methods are problematic due to vasculature-driven spatial correlations and limited statistical power. Our approach was to perform a fully-crossed set of simulations using 5 different ULSM methods and 8 different multivariate methods (MLSM) with 3 sets of real chronic-stage stroke lesion masks covering the left middle cerebral artery (MCA). We defined either 1, 2, or 0 (false positive) anatomical targets as driving the simulated behavior. ULSM and MLSM methods were compared with respect to accuracy and power using multiple metrics. Anatomical targets varied throughout the MCA and were of two different sizes. We tested the effects of varying the number of patients from 32 to 208, and used several different levels of behavioral noise in the simulations. We found that ULSM methods generally had the most power and highest accuracy for 1 anatomical target, while some MLSM methods performed best for the 2-target ("network") case. The simulations also provide guidance on the number of patients recommended for a specified power, plus guidance on how to interpret statistical images. As a real-world illustration, we applied the 5 ULSM and 8 MLSM methods to a real dataset to identify the critical brain regions associated with longitudinal language recovery in 48 left hemisphere stroke patients. There was partial agreement across methods of the critical role that left temporal cortex plays in aphasia recovery.

Topic Area: METHODS: Neuroimaging

D111 Investigating Pattern Separation in the Medial Temporal Lobe through the Parametric Manipulation of Item Similarity

Corey Loo^{1,2}, Bradley Buchsbaum^{1,2}; ¹University of Toronto, ²Baycrest Hospital

Pattern separation is a computational process that reduces the overlap between similar neural input patterns. In the context of memory encoding, computational models posit that the degree to which memories become separated varies as a function of their similarity. In an fMRI task, we investigated the parametric relationship between mnemonic similarity and neural activation in both the cortex and regions of the medial temporal lobe (MTL), including probabilistically defined hippocampal sub-regions. In a preliminary behavioral experiment, 90 pairs of similar images were separately assessed for their pairwise similarity using an aggregate measure based on discrimination accuracy, discrimination reaction time, and subjective similarity ratings. In encoding blocks of an fMRI task, participants were exposed to one of the images from each of the similar image pairs. In the following recognition memory phase, participants were presented with an image probe and were asked to indicate if the probe was old or new and then provide a confidence rating. We examined regions in the brain that were parametrically modulated by the degree of similarity between targets and similar lures. We found that in all of the MTL sub-regions examined, confidence rating was a strong and significant predictor of neural activity, whereas similarity was not significantly related to neural activity. These results suggest that MTL activity associated with pattern separation processes are more related to internal mnemonic state variables indexed by confidence ratings than to externally derived measures of stimulus similarity.

Topic Area: OTHER

D112 Early-life auditory experience modulates resting state functional connectivity networks: A functional near-infrared spectroscopy study

Bradley E. White¹, Lauren Berger¹, Clifton Langdon¹; ¹Gallaudet University

INTRODUCTION. Recent neuroimaging research with long-term hearing aid (HA) and cochlear implant (CI) users suggest that early-life auditory experience plays a paramount role in functional language processing (White & Langdon, 2018a-b; White, Kushalnagar, & Langdon, 2018). Here, we hypothesized that early, long-term auditory experience modulates resting-state functional connectivity (rsFC) networks, manifesting in lower inter-hemispheric connectivity for early-deaf compared to typical-hearing listeners. **METHODOLOGY.** Healthy, monolingual, English-speaking adults were enrolled: (A) listeners with typical hearing (TH; N=14), (B) CI users (N=4), (C) HA users (N=4), with CI/HA use starting at or before age 5. Participants completed a battery of language and cognitive assessments. Participants were also asked to relax and remain awake with their eyes closed while undergoing functional near-infrared spectroscopy (fNIRS). Data were collected from frontal and bilateral temporoparietal regions for 5 minutes (Geng et al., 2017). **RESULTS.** We observe rsFC differences across groups as a function of auditory experience. TH listeners have greater overall rsFC than HA and CI users, spanning frontal and bilateral temporoparietal regions. CI users exhibit connectivity primarily within frontal sites, while HA users exhibit left temporoparietal and frontal rsFC. **DISCUSSION.** Studies have shown that CI users exhibit lower inter-hemispheric connectivity than TH, aligning with our findings of reduced inter-hemispheric connectivity in both CI and HA users alike (McKay et al., 2016). Our findings suggest that the default-mode network is sensitive to variations in early-life auditory experience, and that modulations of this experience can result in differential engagement of neural sites during rest.

Topic Area: PERCEPTION & ACTION: Audition

D113 Hemispheric differences in parietal contributions to auditory beat perception

Shannon Proksch¹, Jessica Ross¹, John Iversen², Ramesh Balasubramanian¹; ¹University of California, Merced, University of California, San Diego

Previous research using continuous theta burst stimulation (cTBS) to down-regulate activity within areas of the dorsal auditory stream has shown a causal relationship between motor regions of the brain and musical beat perception (Ross et al 2018, J Cog Neuro). Specifically, cTBS of the left posterior parietal cortex (IPPC) interfered with accurate detection of shifts of beat-phase, but not absolute interval timing or tempo discrimination. In the present study, we examined whether the right PPC, which is implicated in many aspects of spatial cognition, is causally involved in beat-based musical timing. We compared the effect of downregulating the left and right PPC in 18 participants to discover hemispheric differences in beat-based musical timing perception. Three aspects of timing perception were investigated: 1) discrete interval timing, as well as two facets of relative beat-based musical timing—discrimination of 2) tempo and 3) shifts in phase. Participants are tested pre- and post- stimulation using a test of sub-second interval discrimination and the Adaptive Beat Alignment Test (A-BAT). Our data suggest a role for the left PPC, in detecting shifts in beat phase, but not tempo or interval discrimination. However, we did not find a strong effect of the right PPC in any aspects of beat timing function. We discuss the results in the context of hemispheric and functional differences across the parietal region of the human brain and the Action Simulation for Auditory Prediction (ASAP) hypothesis.

Topic Area: PERCEPTION & ACTION: Audition

D114 Multiple timescale sensitivity of EEG components to statistical features in unattended tone sequences

Tamar I Regev¹, Geffen Markusfeld¹, Israel Nelken¹, Leon Y Deouell¹; ¹The Hebrew University of Jerusalem

Everyday auditory stimuli, such as in music and speech, contain relevant statistical features in multiple timescales. We demonstrate sensitivity of ERP components to the distribution of auditory frequencies in an unattended tone sequence. In three EEG experiments, 81 participants (21, 27 and 33 in Experiments 1, 2 and 3, respectively) were instructed to ignore tone sequences while viewing a silent film. The sequences were comprised of five equiprobable notes. The notes were distributed across four octaves in Experiments 1 and 2, while in Experiment 3 this range varied between large, medium, and small (4, 2 or 1 octaves, respectively). We found that the amplitude of the N1 component - a negative EEG deflection peaking about 100 milliseconds after tone onset - was sensitive to the absolute distance between the current tone's frequency and the mean frequency of the tones in the sequence: The farther the tone's frequency from the mean, the larger the evoked N1 amplitude. In contrast, the P2 component - a positive deflection peaking about 200 milliseconds after tone onset - showed a temporally local sensitivity to the interval between the current and previous tones' frequencies, and a weaker sensitivity to the sequence mean frequency. These results were replicated across the 3 experiments. We propose a simple biophysical model of adapting neurons with wide frequency tuning curves and multiple adaptation time constants to explain these results. Our results give electrophysiological evidence for pre-attentive simultaneous monitoring of distributions of sound features at multiple timescales in the human auditory cortex.

Topic Area: PERCEPTION & ACTION: Audition

D115 Predictive signals in temporal and frontal cortex reflect sensitivity to regularities at different scales

Stefan Dürschmid^{1,2}, Christoph Reichert^{1,5}, Hermann Hinrichs^{1,2,4,5,6}, Hans-Jochen Heinze^{1,2,4,5,6}, Heidi Kirsch⁷, Robert T. Knight⁸, Leon Deouell⁹;
¹Department of Behavioral Neurology, Leibniz Institute for Neurobiology, Brenneckestr. 6, 39120 Magdeburg, Germany;; ²Department of Neurology, Otto-von-Guericke University, Leipziger Str. 44, 39120 Magdeburg, Germany;; ³Stereotactic Neurosurgery, Otto-von-Guericke University, Leipziger Str. 44, 39120 Magdeburg, Germany;; ⁴German Center for Neurodegenerative Diseases (DZNE), Leipziger Str. 44, 39120 Magdeburg;; ⁵Forschungscampus STIMULATE, Otto-von-Guericke University, Universitätsplatz 2, 39106 Magdeburg, ⁶CBBS - center of behavioral brain sciences, Otto-von-Guericke University, Universitätsplatz 2, 39106 Magdeburg, ⁷Department of Neurology, University of California, 400 Parnassus Avenue, San Francisco, CA 94122, ⁸Helen Wills Neuroscience Institute and Department of Psychology, University of California, Berkeley, CA 94720;; ⁹10 Edmond and Lily Safra Center for brain sciences and Department of Psychology, The Hebrew University of Jerusalem, Mount Scopus, Jerusalem 91904

Predictive coding (PC) theories posit that neural networks learn statistical regularities in the environment to compare top-down prediction signals with actual outcomes. In turn, prediction error (PE) signals, flow bottom-up, to modify the ensuing predictions. However, disentangling prediction from PE signals has been challenging. We compared patterns of human high frequency amplitude (HFA: 80-150Hz) in deviance detection using intracranial recordings from frontal and temporal cortices in patients implanted with subdural electrodes for clinical reasons. Patients listened to task-irrelevant sequences of repetitive tones including infrequent predictable or unpredictable pitch deviants. Critically, frontal HFA activity discriminated between fully predictable and unpredictable changes, responding only to unpredictable events. In contrast, temporal cortex responded as much to predictable and unpredictable deviations. These results provide direct evidence for dissociation between the temporal and frontal cortex in their sensitivity to regularities across time: while the temporal cortex is sensitive to the very recent history, the frontal cortex utilizes the longer range structure of the input. Moreover, we found that frontal cortex evinces prediction signals while anticipating deviants, that is, before deviants actually occur. HFA decreased prior to the onset of expected relative to unexpected deviants in the frontal cortex only, and its amplitude was sensitive to the increasing likelihood of deviants following longer trains of standards in the unpredictable condition. Critically, HFA pre-stimulus decrease was correlated with post-stimulus response to deviants within and across frontal but not temporal electrodes. These results provide direct evidence for frontal cortex signals predictive of the future, independent of PE signals.

Topic Area: PERCEPTION & ACTION: Audition

D116 Relationship between speech motor adaptation and relevance of auditory errors

Ayoub Daliri¹, Jonathan Dittman¹; ¹Arizona State University

To accurately produce speech, the central nervous system (CNS) predicts auditory consequences of its planned speech movements and compares its predictions with incoming auditory feedback. The CNS uses discrepancies between its predictions and incoming auditory information to modify its future output (adapt). While auditory errors are crucial for speech motor learning, not all perceived auditory errors are task-relevant. Therefore, the CNS needs to evaluate the relevance of perceived auditory errors. Here, we examined the relationship between relevance of auditory errors and extent of auditory-motor adaptation by systematically altering the relevance of auditory feedback. Participants (n=17) produced consonant-vowel-consonant words containing the vowel /e/ (e.g., "head") while their formant frequencies were shifted (80% shift) toward the vowel /æ/ and fed back to them in real-time. In one condition, auditory errors (i.e., received auditory feedback relative to planned production) depended on participants' productions, and thus were relevant—participants

could change their productions to reduce/change the perceived auditory errors. In another condition, auditory errors were pre-defined (regardless of the participant's productions), and thus were irrelevant—changes in participant's production did not result in change/reduction of the auditory errors. We found that participants adapted less and were less sensitive to auditory errors when the auditory errors were irrelevant. Additionally, we found that participants with smaller perceptual targets adapted more and had higher sensitivity to auditory errors. Together, our results highlight the intricate mechanisms—involving both perception and production systems—that the CNS uses to optimally integrate auditory errors for successful speech motor learning.

Topic Area: PERCEPTION & ACTION: Audition

D117 Morning brain: Real-world neural evidence that high school class times matter

Dana Bevilacqua¹, Suzanne Dikker¹, Saskia Haegens^{2,3}, Lu Wan⁴, Ido Davidesco¹, Lisa Kaggen¹, James McClintock, Kim Chaloner, Mingzhou Ding⁴, Tessa West¹, David Poeppel¹; ¹New York University, ²Columbia University Medical Center, ³Donders Institute for Brain, Cognition and Behaviour, ⁴University of Florida

Researchers, parents, and educators consistently observe a stark mismatch between biologically preferred and socially imposed sleep-wake hours in adolescents, fueling debate about high school start times. We contribute neural evidence to this debate with electroencephalogram (EEG) data from 22 high school students, collected during their regular classes, taught in the early morning, mid-morning, and afternoon. Students' baseline alpha brain activity decreased as the time of day progressed, consistent with adolescents being least attentive early in the morning. While students showed consistently worse performance and higher alpha power in the early morning classes, quiz scores and alpha levels in the afternoon varied by individual focus as well as class activity. Together, our findings demonstrate that class time is reflected in adolescents' brain state in a real world setting, and suggest that mid-morning may be the best time to learn.

Topic Area: PERCEPTION & ACTION: Development & aging

D118 Olfactory Recognition Memory in Non-Demented, Elderly Apolipoprotein E4 Carriers and Non-Carriers

Eleni Kapoulea¹, Claire Murphy^{1,2}; ¹San Diego State University, ²University of California, San Diego

Possessing the Apolipoprotein (ApoE) E4 allele is unequivocally the strongest known genetic risk factor for Alzheimer's disease. Neuronal areas responsible for memory processing are also associated with odor functioning. The present study investigates olfactory memory task performance during functional magnetic resonance imaging (fMRI) in non-demented ApoE E4 carriers and non-carriers. Participants were (N = 39) non-demented older adults, ranging in age from 64 to 88 years. Individuals with at least one E4 allele were classified as E4 carriers (n = 18) and individuals without the E4 allele (n = 21) were classified as non-carriers. Participants completed an fMRI and structural scan. Prior to the fMRI scan, participants were presented with 16 odors from the California Odor Learning Test (COLT). During the scan, participants were presented with labels of odors and asked to decide if the label was presented prior to the scan (target) or not (foil). Multiple regression analyses were performed to examine associations among E4 status, neuroimaging data, and task performance. There were no significant (p > .05) differences between groups in demographic variables. E4 carriers demonstrated significantly (p < .05) greater right hippocampal activation than non-carriers during false positives. When controlling for age, E4 status and its interaction with left entorhinal cortex thickness had significant (p < .05) effects on right hippocampal activation during false positives. Results suggest that ApoE E4

carriers require a greater cognitive expenditure to complete the task. Further, there may be aging trajectories associated with E4 status resulting in differential odor memory processing.

Topic Area: PERCEPTION & ACTION: Development & aging

D119 Sensorimotor contingency leads to developmental changes in the neural mechanisms supporting visual recognition

Sophia Vinci-boohar¹, Anastasia Nikoulina¹, Thomas W. James¹, Karin H. James¹; ¹Indiana University, Bloomington

Letter production leads to increases in functional connectivity among visual and motor brain systems as well as gains in visual letter recognition. We hypothesized that the coupling between hand movements and visual feedback during early learning stages would result in the emergence of visual-motor functional connectivity during perception and, further, that this connectivity would support gains in recognition. Twenty literate adults were trained on four sets of novel symbols over one week. Training conditions were designed to manipulate the contingency between the motor and visual experiences of a letter that occur during letter production: writing with ink, writing without ink, watching a handwritten symbol unfold, and watching a static handwritten symbol. Participants were presented with the training symbols during functional magnetic resonance (fMRI) scanning at three time points: one pre-training, one post-training, and one after a week-long no-training delay. Recognition was tested after each training session and after the third scan. We found that the contingency between visual and motor experiences during production changed the pattern of functional connectivity among visual, motor, and auditory brain systems and resulted in recognition gains at post-training. Recognition gains were maintained after the no-training delay, but the functional connections observed immediately after training returned to their pre-training baselines. Our results suggest that behaviors that couple sensory and motor systems result in temporary increases in functional connectivity that contribute to longer-lasting changes in the neural mechanisms supporting recognition.

Topic Area: PERCEPTION & ACTION: Development & aging

D120 Embedding beat in auditory streams suppresses auditory response: an MEG study

Yuanye Wang^{1,2,3}, Huan Luo^{1,2,3}; ¹School of Psychological and Cognitive Sciences, Peking University, ²PKU-IDG/McGovern Institute for Brain Research, Peking University, ³Beijing Key Laboratory of Behavior and Mental Health, Peking University

When listening to a piece of music, listeners would automatically tap their toes to beat – the perceived rhythm. Beat is the basic temporal structure of music and serves as a fundamental framework for synchronization of movements to audition. Previous studies have revealed that beat perception is a complex brain function involving temporally-precise communication between auditory regions and motor planning regions of the cortex. In the present study, we used magnetoencephalographic (MEG) recordings in combination with an adapted experiment paradigm (Benjamin Morillon and Sylvain Baillet, 2017) to investigate how beat information modulates and shapes the neuronal activities in time. In each trial, subjects were presented with 9 consecutive tones with different amplitude and frequencies, which were also temporally organized either in a periodic or an aperiodic manner. Using a time-resolved linear regression analysis on the MEG response for each tone stimuli, we estimated and separated brain response that was specifically modulated by amplitude, frequency, and beat. Our results (N=16) demonstrate that the sound amplitude showed a positive modulation on the auditory response, whereas the beat information exerted a negative influence at the latency of around 200 ms. Our findings suggest that the embedded rhythmic structure in auditory streams suppresses the neuronal response to sounds, consistent with

predictive coding model, given that rhythm enables us to extract temporal regularities and efficiently anticipate upcoming events.

Topic Area: PERCEPTION & ACTION: Audition

D121 Assessing Parietal Contributions to Abstract Numerosity with Steady State Visual Evoked Potentials (SSVEPs)

Peter J. Kohler¹, Anthony M. Norcia¹, Bruce McCandliss^{1,2}; ¹Department of Psychology, Stanford University, CA, ²Graduate School of Education, Stanford University, CA

Portable, high signal-to-noise EEG assays of cortical number sense would be an asset to educational neuroscience. Previous attempts to use SSVEPs to index parietal number computations, however, have only demonstrated effects over primary visual cortex. Here, we used slower stimulation rates and smaller quantities to segregate parietal number computations from early visual effects. 5-dot cloud arrays that changed in size, area, or density on each presentation formed a slow “carrier” frequency (3, 4.5, or 6 Hz). Periodic changes in numerosity (8-dot cloud), controlled for changes in perceptual features, formed an even slower “oddball” frequency (1 Hz, 0.75 Hz, or 0.5 Hz). Each carrier frequency induced SSVEPs with a midline occipital topography. In contrast, at each frequency explored, parietal topographies emerged for abstract numerosity changes, with oddball effects evident from 200 to 500 msec. In a second study, the numerical change was varied to be either supra- threshold (i.e. carrier = 8 dots, oddball = 5 dots) or below the threshold required for detecting numerosity changes (carrier = 8 dots, oddball = 9 dots), and we found robust parietal responses for the supra-threshold case only. A third study replicated the supra-threshold parietal oddball SSVEP effect across four distinct pairings of numerosity-contrast conditions. These findings support the use of SSVEP oddball paradigms as a bridging technology between fMRI studies of parietal computations of number and psychophysical studies, and may prove to be useful for creating a rapid, portable, “neurometric” approach to number sense within educational settings.

Topic Area: PERCEPTION & ACTION: Other

D122 Body representation distortions at a higher resolution: the role of the spatial acuity in length and width estimation of body parts.

Valeria Peviani^{1,2}, Lucia Melloni^{1,3}, Gabriella Bottini^{1,2,4,5}; ¹Department of Neuroscience, Max Planck Institute for Empirical Aesthetics, Grüneburgweg 14, 60322, Frankfurt am Main, Germany, ²Department of Brain and Behavioural Sciences, University of Pavia, Via Bassi, 21, 27100, Pavia, Italy, ³Department of Neurology, New York University School of Medicine, 240 East 38th St 10016, New York, NY, USA., ⁴Cognitive Neuropsychology Center, ASST Grande Ospedale Metropolitano Niguarda, Piazza dell'Ospedale Maggiore 3, 20162, Milan, Italy, ⁵NeuroMi, Milan Center for Neuroscience, Milan, Italy

Distortions of the metric body representation have been documented in healthy individuals. The reverse distortion hypothesis (Linkenauger et al., 2015) posits that the representation of a given body part is distorted inversely to its spatial acuity. Here, we present two experiments aimed at testing such hypothesis on five body parts (hand, foot, nose, lips and back of the neck) with different levels of spatial acuity. We used a line length judgment task to measure two orthogonal dimensions - length and width - for each body part. We performed one-sample and repeated-measures analyses on the estimation errors for length and width, separately. In addition, we used linear mixed effects models to study the differences among the five body parts and the effect of the spatial acuity on the length and width estimation error on the pooled dataset. We found that with the exception of the back of the neck which is accurately represented, all other body parts' dimensions were underestimated. These pattern of results indicate that the visual accessibility does not attenuate the distortions. Interestingly, the hand, foot and lips

representations were similar to one another. While the length distortions are effectively predicted by the spatial acuity, in line with the reverse distortion hypothesis, the width representation is likely to be influenced by a different mechanism. Our results shed light onto the spatial representation of multiple body parts, considering them at higher spatial resolution; and indicate a previously underexplored dissociation between the representation along the vertical and horizontal axes.

Topic Area: PERCEPTION & ACTION: Other

D123 Does it Add Up? Comparing Arithmetic Processing in Bilinguals and Monolinguals

Mona Anchan¹, Jongjin Kim¹, Firat Soyulu¹; ¹The University of Alabama

With more than 25% of school students coming from immigrant households where the primary language spoken at home is not English, it is problematic to expect this bilingual population to perform at the level of their monolingual peers. As a result of using competing languages regularly, representation of math knowledge could be different in bilinguals and monolinguals. Hence, it is important to investigate how bilinguals process simple mathematical tasks which form the basis of higher math. This pilot study examines how bilinguals process single-digit and double-digit addition problems in their first language (L1) as well as English (L2). Similar arithmetic processing is also examined in monolinguals to check for between-group differences. This paradigm allows subjects to provide a free-recall verbal response which is an ecologically valid demonstration of their addition skills and processing time. In addition to behavioral data (reaction time, accuracy), electroencephalography (EEG) provides time-sensitive information differentiated by language of processing and type of addition. Bilinguals showed divergent processing patterns for L1 and L2 between 600-1400 milliseconds: (1) at temporal and parietal sites for single-digit addition; (2) at frontal, temporal, and parietal sites for double-digit addition. Mass Univariate analyses showed processing pattern differences at Fronto-Central sites for double-digit addition. The implications of these results extend well beyond just understanding basic neural mechanisms and can be utilized by teachers to adapt math instruction.

Topic Area: LANGUAGE: Other

D124 Does over-reliance on auditory feedback cause dysfluency? An fMRI study of induced fluency in people who stutter.

Sophie Meekings^{1,2}, Kyle Jasmin³, Cesar Lima⁴, Nimallesh Yogarajah², Efe Carswell Niven², Sophie Scott²; ¹Newcastle University, ²University College London, ³Birkbeck University of London, ⁴ISCTE – University Institute of Lisbon

This study tested the idea that stuttering is caused by over-reliance on auditory self-perception. The theory is motivated by the observation that many fluency-inducing situations (such as talking in synchrony with a confederate, or speaking in noise) alter or obscure the talker's perception of their own speech. Typical speakers show 'speaking-induced suppression' of neural activation in superior temporal gyrus (STG) during self-produced vocalisation, compared to listening to recorded speech. If people who stutter over-attend to the sound of their own voice, they may lack this suppression response. In a 1.5T fMRI scanner, people who stutter spoke in synchrony with an experimenter, in synchrony with a recording, on their own, in noise, listened to the experimenter speaking and read silently. Behavioural testing outside the scanner demonstrated that synchronising with another talker resulted in a marked increase in fluency regardless of baseline stuttering severity. In the scanner, participants stuttered most when they spoke alone, and least when they synchronised with a live talker. There was no reduction in STG activity in the Speak Alone condition, when participants stuttered most. There was also strong activity in STG during the two synchronised speech conditions, when participants stuttered least, suggesting that either stuttering does not result

from over-reliance on feedback, or that the STG activation seen here does not reflect speech feedback monitoring. We discuss this result with reference to neural responses seen in the typical population.

Topic Area: PERCEPTION & ACTION: Other

D125 Local sleep in the awake human brain

Filip Van Opstal¹, Helen Scott¹, Wim Gevers², Esperanza Jubera-Garcia^{1,2}; ¹University of Amsterdam, ²Universite Libre de Bruxelles

Sleep and wake are generally considered as global brain states. However, recent work suggests that sleep-like activity, characterized by slow wave oscillations in the delta and theta range, can occur in large task-related networks in sleep-deprived humans. The present study probed whether the extended use of a very specific neuronal population could cause sleep-like activity in this population in well-rested, awake participants. Volunteers participated in four consecutive sessions spanned over one day in which they performed the texture discrimination task (TDT). Previous studies have shown that the repeated exposure to the TDT results in performance deterioration, but that performance is restored by changing the target's spatial location or by taking a nap in between sessions. Behavioral and neuroimaging studies have related this use-dependent deterioration to local changes in the neural activity of the primary visual cortex. In this study, participants underwent two resting-state EEG recordings before and after the prolonged exposure to the TDT. We predicted an increase in sleep-like activity in primary visual cortex when comparing the second to the first resting-state session (i.e., an increase in slow wave oscillations after extensively performing the TDT). Our behavioral results replicate earlier studies showing a significant decrease in TDT performance after repeated exposure to the task. Crucially, an increase in theta power in the visual cortex is detected in the resting-state condition after extensive exposure to the TDT, suggesting that awake, well-rested humans can demonstrate local-sleep within extensively used neural populations.

Topic Area: PERCEPTION & ACTION: Other

D126 Scene context realigns category representations during processing of tools

Heath Matheson¹, Frank Garcea², Laurel Buxbaum²; ¹University of Northern British Columbia, ²Moss Rehabilitation Research Institute

Representations of tool concepts are increasingly viewed as dynamic and sensitive to goals and task demands. Indeed, observer goals can tune representations within cortical networks supporting concepts. In the present fMRI study, we investigate whether scene context can alter the neural tuning of regions within the tool use network even in a task in which that context is not relevant. Participants performed conceptual (animacy) judgments on images of tools embedded in scenes that either suggested their use (i.e. a kitchen timer on a kitchen counter with vegetables in a pan) or the need for tool transport (i.e. a kitchen timer in an open drawer with other miscellaneous kitchen items). Using pattern similarity analysis (PSA) we show that a) widespread regions of the tool use network including left inferior parietal lobe, the supramarginal gyrus, the primary somatosensory cortex, the lateral occipital complex, and dorsal occipital lobe reflect category information about tools and b) category information predicts patterns in the left supramarginal gyrus more strongly in use contexts than in move contexts, though the context was irrelevant to the animacy judgment task. Together, these results show that the conceptual representation of tools is distributed and that scene context dynamically tunes its neural correlates.

Topic Area: PERCEPTION & ACTION: Other

D127 Sign language experience increases motor resonance during imitation of signs

Athena Willis¹, Lorna Quandt¹; ¹Gallaudet University

We asked whether action experience with American Sign Language (ASL) leads to increased sensorimotor activity during observation of signs. Prior aphasia and fMRI research has given inconclusive evidence on the role of action experience on action processing in fluent signers. On one hand, some work suggests that there is minimal involvement of the action network during the perception of ASL. On the other hand, studies on the impact of action expertise on action processing shows that action expertise leads to increased sensorimotor activity. To reconcile the two differing lines of evidence, we collected EEG while fluent deaf ASL signers (N = 28) and hearing nonsigners (N = 23) viewed videos of signs that had varied sensorimotor characteristics. Both groups watched videos that individually presented one-handed and two-handed ASL signs, with the task of imitating each presented sign. Time frequency data analysis was performed on alpha (8 - 12 Hz) and beta (13 - 30 Hz) oscillations within the first 1000 ms of stimuli presentation. Significant differences were found between EEG activity over parietal and central regions in response to one-handed and two-handed signs, for the deaf signers group ($p < .016$, corrected). However, hearing nonsigners group did not show any significant differences in EEG activity. The results show that action experience with ASL leads to different patterns of sensorimotor activity during imitation of signs. This suggests that in imitative contexts, signers' may be more sensitive to, and exhibit more motor resonance toward, others' communicative actions.

Topic Area: PERCEPTION & ACTION: Other

D128 The role of GABA in modulating brain signal variability

Poortata Lalwani¹, Kaitlin Cassady¹, Molly Simmonite¹, Douglas Garrett², Thad Polk¹; ¹University of Michigan, Ann Arbor, MI, USA, ²Max Planck UCL Centre for Computational Psychiatry and Ageing Research, Berlin, Germany

Variability in the blood-oxygenation level dependent (BOLD) signal in functional MRI is often considered noise in cognitive neuroscience. However, an increasing number of studies highlight BOLD variability as a better predictor of behavior than mean BOLD. Furthermore, the amount of observed BOLD variability typically varies by experimental condition, and those who exhibit greater between-condition modulation tend to perform better on a range of behavioral tasks. But why do some individuals modulate BOLD variability more than others? One key factor may be individual differences in gamma-aminobutyric acid (GABA), the brain's major inhibitory neurotransmitter. GABA is responsible for successful modulation of the dynamics in neural networks that may be captured by BOLD variability. We thus hypothesized an association between GABA levels and modulation of variability. To investigate this hypothesis, we obtained functional MRI data from 62 healthy volunteers (age 18-85) while they performed a visual (face vs. house), motor (right vs. left finger tapping) and auditory (music vs. foreign speech) task. We also obtained MR spectroscopy data to estimate GABA levels in left and right ventrovisual, auditory and somatosensory cortex in the same individuals. Our results suggest that participants modulate BOLD variability in the brain regions relevant to the task they are performing (e.g., in visual cortex during the visual task). Furthermore, GABA levels in each region correlate significantly with modulation of variability in that region, but not in other regions. These results demonstrate that GABA is associated with the modulation of brain signal variability and that this association is region-specific.

Topic Area: PERCEPTION & ACTION: Other

D129 Use of Bayesian Priors in Perceptual Decision-Making in Clinical Subtypes of Parkinson's Disease

Barbara Knowlton¹, Vaibhav Thakur¹, Alessandra Perugini¹, Aasef Shaikh², Michele Basso¹; ¹UCLA, ²Case Western Reserve University

Patients with Parkinson's disease (PD) have been shown to be impaired at incorporating priors in perceptual decision-making. Because PD is a heterogeneous disorder, we investigated whether this impairment is consistent across two major subtypes of the disease, Bradykinetic and Tremor Dominant. In the perceptual decision-making task, participants were shown a pattern on the screen on each trial and decided if the dots were oriented leftward or rightward. The coherence of the orientation signal varied across stimuli, affecting the difficulty of the trial. Stimuli were presented in green or red, and each color had different prior probabilities. For one color, the stimuli were equally likely to be leftward or rightward oriented, and for the other, the prior probabilities were unequal (e.g. 75% leftward, 25% rightward). Each subject performed the task twice, off and on prescribed dopaminergic medication to examine its effect on their performance. To assess whether priors were applied, we examined the value of the psychometric function at the zero coherence condition when the stimulus was fully ambiguous. We found that both groups showed an impairment in applying priors when off medication, as choice probability at zero coherence was unaffected by the prior probabilities. However, on medication, Bradykinetic patients were able to incorporate the priors such that choice probability at zero coherence differed for the equal and unequal prior conditions. However, Tremor Dominant patients in the "on" state showed no such improvement. These results suggest that the relationship between dopaminergic tone and cognition differs for PD subtypes.

Topic Area: PERCEPTION & ACTION: Other

D130 White matter predictors of spelling ability following left hemisphere stroke

Celia Litovsky¹, Nomongo Dorjsuren¹, David Delijani¹, Brenda Rapp¹; ¹Johns Hopkins University

Given the importance of e-communication (texting, e-mail, etc.), written language production (spelling) is critical in daily life and writing impairment is among the most common complaints of stroke survivors (Hillis and Tippett, 2014). While research has examined the cortical networks of spelling (Purcell et al., 2011), no study has investigated their white matter substrates. On the basis of recent work (Yeatman et al., 2013) identifying the importance for reading of the posterior arcuate fasciculus (pAF) and vertical occipital fasciculus (VOF), we examined their role in spelling impairment and recovery. Twenty individuals with post-stroke spelling impairment participated in a three-month spelling rehabilitation. Participants underwent diffusion-weighted imaging before spelling training. Data processing used constrained spherical deconvolution (Tournier et al., 2014) and bilateral pAF and VOF were extracted using hand-drawn ROI-based segmentation. Linear regressions were performed to predict spelling severity and several measures of improvement (rate, generalization, etc.) from the fractional anisotropy (FA) of these ROIs, while controlling for age, time post-stroke, and lesion volume. FA of the left pAF was found to positively correlate with spelling accuracy before training ($p < 0.05$), similar to previous findings implicating the left arcuate in spoken language processing (Breier et al., 2008). In addition, the left and right VOF and the right pAF significantly predicted the magnitude of behavioral response to treatment ($p < 0.05$). These findings extend our understanding of the role of the VOF beyond reading to written word production and contribute to our understanding of the structural connectivity underlying written language production and its recovery.

Topic Area: PERCEPTION & ACTION: Other

D131 Creativity and Machine Learning: Divergent Thinking EEG Analysis and Classification

Carl Stevens¹, Darya Zabelina¹; ¹University of Arkansas

Prior research has shown that increased power in the alpha range (8-13 Hz) of the EEG spectrum is characteristic of increased creativity, both between individuals and between conditions that differ in creative demand (Jauk et al., 2012). The current study investigates the extent to which more and less creative brain states can be differentiated by applying machine learning to EEG data. Participants completed an alternate use task in the lab (adapted from: Abraham et al., 2014; Jauk et al., 2017). Cue words prepared participants to think of normal or uncommon (more demanding) uses for objects prior to the names of common items (i.e., brick) appearing on screen. We hypothesized that reaction time and alpha power would be greater for uncommon uses. We also hypothesized that a machine learning algorithm would reliably classify new data as belonging either to the normal or uncommon condition once the network had been trained. Participants responded faster in the normal condition ($M = 1.99s$, $SD = 0.53$), compared to the uncommon condition ($M = 9.23s$, $SD = 3.99$, $p < .001$). Neural network training was used to cluster independent components of activity. For the uncommon condition, a frontal midline cluster showed greater power in the gamma range (47, 63, and 70 Hz; $p < .01$). Though not statistically significant, alpha power was also greater in the uncommon condition. Additional data are being collected to determine the robustness of state classification. Future research will seek to implement neurofeedback to train individuals to maintain optimally creative states.

Topic Area: THINKING: Other

D132 Thinking about Beauty vs. Function Using fMRI

Erick Guzman¹, Franziska Hartung², John Pyles³, Julia Sienkewicz⁴, Anjan Chatterjee², Alexander Kranjec^{1,3}; ¹Duquesne University, ²University of Pennsylvania, ³Carnegie Mellon University, ⁴Roanoke College

Studies in neuroaesthetics tend to focus on how the reward system is modulated by aesthetic differences between individual items in the context of fine art, landscape, or face stimuli. Currently there is little understanding of how the brain represents distinct kinds of higher-order qualitative judgments regarding design objects. The present study uses fMRI to examine broad differences in neural activity associated with beauty vs. function judgments within a single class of object. Participants ($N=18$) were presented with pictures of chairs and instructed to make different kinds of judgments across three conditions in a blocked design. Conditions included two higher-order judgment conditions; BEAUTY ("Is this a beautiful chair?") and FUNCTION ("Is this a good chair?"); and one lower-order PERCEPTUAL DECISION condition ("Is this a red chair?"). Compared to perceptual decision trials, whole-brain analyses revealed activation peaks in the left fusiform gyrus (LFG) for beauty judgments, and right inferior temporal gyrus (R-ITG) and parietal lobe (supramarginal gyrus and parietal lobule) for function judgments. For the direct contrasts, comparing between higher-order judgment conditions, whole-brain analyses revealed increased activity in the left prefrontal cortex (with peak activations in superior medial gyrus and anterior cingulate) for function>beauty judgments, and no significant results for beauty>function judgments. Overall, results indicate an extensive object judgment network where LFG and R-ITG display biases for processing different kinds of higher-order object qualities. Direct contrast results in prefrontal areas previously shown to participate in the experience of beauty, but here associated with object function judgments, suggest future analyses.

Topic Area: THINKING: Other

D133 Arithmetic word problem solving is more than text comprehension: Neurocognitive evidence from fMRI in 3rd and 4th graders

Chan-Tat Ng¹, Ting-Ting Chang¹; ¹National Chengchi University, Taiwan

Arithmetic word problems are commonly used in teaching and evaluating children's mathematical abilities because of their importance in linking mathematical knowledge and real-world contexts. Nonetheless, despite that most children struggle with this type of problems, very few studies have endeavored to understand the underlying neural mechanisms. Using fMRI technique, the current study investigated the cognitive and brain responses of word problem solving with a specific focus on school-age children. 25 healthy third and fourth graders were asked to perform sentence judgment tasks on either arithmetic word problems (AWP) which contained single-step mathematical operations, or non-arithmetic word problems (NWP) with parallel narratives which contained no numerical information. Behavioral results indicated that children performed more poorly in AWP than in NWP. While AWP performance was strongly associated with both general reading comprehension and arithmetic skills, NWP was only correlated with reading comprehension. Neuroimaging results suggested that brain responses of AWP judgment showed greater activation in the frontal-parietal network including intraparietal sulcus, supplementary motor area, and dorsolateral prefrontal cortex. Moreover, the intraparietal sulcus activation was predictive of out-of-scanner performance on AWP. By contrast, NWP elicited greater activation in medial and ventrolateral prefrontal cortex, plus perisylvian cortex. When reading NWP, both fusiform and superior temporal gyrus activations were correlated with the general reading comprehension performance. In brief, the current study has illustrated distinct differences between arithmetic word problem solving and narrative text comprehension. These findings have further uncovered the neural mechanism involved in critical mathematical skills and potentially contribute to improvement in mathematical education.

Topic Area: THINKING: Problem solving

D134 Brain Activity Patterns During Creative Idea Generation In Eminent and Non-Eminent Thinkers

Evangelia G. Chryssikou¹, Constanza Jacial¹, David B. Yaden², Andrew B. Newberg³; ¹Drexel University, ²University of Pennsylvania, ³Thomas Jefferson University Hospital

An influential model of the neural mechanisms of creative thought suggests that creativity is manifested in the joint contributions of the Default Mode Network (DMN; a set of regions in the medial PFC, including anterior cingulate and retrosplenial cortex, lateral and medial parietal cortex, and the medial temporal lobes) and the executive networks within the dorsolateral PFC. Several empirical reports have offered support for this model by showing that complex interactions between these brain systems account for individual differences in creative performance. The present study examined whether the engagement of these regions in idea generation is modulated by experience, as measured by one's eminence in a creativity-related field. Twenty ($n = 20$) healthy participants eminent in their respective fields (i.e., writing, neuroscience, music, comedy) and twenty ($n = 20$) age- and education-matched non-eminent but successful in their profession control participants were administered a creative generation task (an adaptation of the Alternative Uses Task) and a control perceptual task, while undergoing functional magnetic resonance imaging (fMRI). The participants' verbal responses were recorded through a noise-canceling microphone and were later coded for accuracy and task compliance. Behavioral and fMRI analyses revealed commonalities between groups, but also a distinct pattern of activation in default mode and executive brain regions in the eminent relative to the non-eminent participants during creative thinking. We interpret these findings in the context of the well-documented contributions of these regions in the generation of creative ideas as modulated, in this study, by a lifetime of experience in creativity-related fields.

Topic Area: THINKING: Problem solving

D135 Brain Functional Connectivity of Creativity: Psychophysiological Interaction of Convergent and Divergent Thinking

Abhishek Uday Patil^{1,2}, Deepa Madathil², De-Jung Tseng¹, Daisy Lan Hung^{3,4}, Ovid Jyh-Lang Tzeng^{1,4,5,6,7}, Hsu-Wen Huang⁸, Chih-Mao Huang^{1,5}; ¹Department of Biological Science and Technology, National Chiao Tung University, Taiwan, ²Department of Biomedical Engineering, School of Electronics Engineering, Vellore Institute of Technology, India, ³Institute of Cognitive Neuroscience, National Central University, Taiwan, ⁴College of Humanities and Social Sciences, Taipei Medical University, Taiwan, ⁵Cognitive Neuroscience Laboratory, Institute of Linguistics, Academia Sinica, Taiwan, ⁶Department of Educational Psychology and Counseling, National Taiwan Normal University, Taiwan, ⁷Institute of Advanced Studies, City University of Hong Kong, Hong Kong, ⁸Department of Linguistics and Translation, City University of Hong Kong, Hong Kong

Creativity is defined as one's ability to produce unique or unusual thoughts for problem solving. Such creative thoughts could refer to convergent thinking (i.e. combining remote ideas to produce best solution for specific problem) and divergent thinking (i.e. producing multiple unusual solutions for a particular problem). Previous functional magnetic resonance imaging (fMRI) meta-analysis in convergent and divergent thinking reported that several frontal and parieto-temporal activations are associated with creativity. However, whether two types of creativity involve different dynamic interaction of brain network is unknown. In this fMRI study, we applied psycho-physiological interactions (PPIs) approach to investigate dynamic interaction of functional brain connectivity during convergent and divergent thinking tasks. Twenty-five young participants were instructed to perform the Chinese-Word remote associates test (CAT) to represent the process of convergent thinking, and alternative uses task (AUT) to measure the processes of divergent thinking during scanning. A whole-brain analysis showed primarily left-lateralized fronto-parietal activations for CAT whereas bilateral cortical activation for AUT. PPIs analysis of CAT showed that hippocampus was positively connected to left inferior frontal gyrus, left superior parietal lobule, and left temporal regions, possibly indicating the controlled retrieval and selection of semantic memory. In contrast, PPIs analysis of AUT showed that hippocampus was positively connected to right posterior parietal lobule enabling participants to integrate thoughts related to selecting remotely associated concepts. Our findings provide evidence that functional connectivity of convergent and divergent creativity involve distributed but differential dynamic interactions of brain regions that reflect the specialized network-based processing of diverse creative thinking.

Topic Area: THINKING: Problem solving

D136 Inferior frontal gyrus involvement during search and solution in verbal creative problem solving: A parametric fMRI study

Maxi Becker¹, Tobias Sommer², Simone Kühn^{1,3}; ¹University Medical Centre Hamburg-Eppendorf, Clinic and Policlinic for Psychiatry and Psychotherapy, Martinistraße 52, 20246 Hamburg, Germany, ²University Medical Centre Hamburg-Eppendorf, Department of Systems Neuroscience, NeuroImage Nord, Martinistraße 52, 20246 Hamburg, Germany, ³Max Planck Institute for Human Development, Center for Lifespan Psychology, Berlin, Germany

In verbal creative problems like compound remote associates (CRAs), the solution is semantically distant and there is no predefined path to the solution. Therefore, people first search through the space of possible solutions before retrieving the correct semantic content by extending their search space. We assume that search and solution are both part of a semantic control process which involves the inferior frontal gyrus (IFG). Furthermore, the degree of the IFG involvement depends on how much the search space needs to be extended, i.e. how semantically distant the solution is. To demonstrate this, we created a modified CRA paradigm which systematically modulates the semantic distance from the first target word to the solution via priming. We show that brain areas (left inferior frontal gyrus and middle temporal gyrus)

associated with semantic control are already recruited during search. In addition, we found a linear correlation between the BOLD activation of the IFG (pars orbitalis and triangularis) and the search space extension. However, this linear relationship could only be observed during and shortly before the correct solution but not during search. We discuss the role of the IFG in accessing semantically distant information during verbal creative problem solving.

Topic Area: THINKING: Problem solving

D137 Neural dynamics of generating and evaluating creative and non-creative thoughts

Yoed N. Kenett¹, Evangelia G. Chryssikou², Danielle S. Bassett¹, Sharon L. Thompson-Schill¹; ¹University of Pennsylvania, ²Drexel University

What are the neural dynamics that drive creative thinking? Recent studies suggest that interactions between the control, default mode, and the salience brain networks are an important marker of individual differences in creative ability. However, how different brain regions within these systems might be recruited dynamically during the two key components of the creative process—generation and evaluation—remains far from being understood. In the current study we apply state-of-the-art methods and models from network neuroscience to examine the neural dynamics related to generation and evaluation of creative and non-creative thoughts in a novel within-subject design. Participants completed two functional magnetic resonance imaging sessions, separately by a time interval of one week. In the first imaging session, participants generated either creative (alternative uses) or non-creative (common characteristics) responses to common objects. In the second imaging session, participants evaluated their own creative and non-creative responses to the same objects. Network statistics were calculated to examine and compare dynamic reconfiguration during these four conditions. We found that generating creative thoughts led to significantly higher network reconfiguration than generating non-creative thoughts, whereas evaluating creative and non-creative thoughts led to similar levels of network reconfigurations. Furthermore, we find that such differences are attributed to distinct reconfiguration patterns across the control, default mode, and salience networks. Thus, we show—for the first time—within-subject differences in the neural dynamics related to generating and evaluating creative versus non-creative thoughts.

Topic Area: THINKING: Problem solving

D138 Neural Representations of Physics Learning in Hands-on versus Computer-based Training

Joshua Cetron¹, Justin Hayes², Andrew Connolly², Solomon Diamon², Vicki May², James Haxby², David Kraemer²; ¹Harvard University, ²Dartmouth College

At all levels of STEM education, students engage in hands-on "laboratory" courses as part of physics and engineering curricula. But with the rise of Massive Online Open Courses (MOOCs), it has become increasingly important to understand the role of hands-on engagement in physics concept learning. Our prior work has implicated motor regions in the neural representations of physics concept knowledge that engineering students acquire in the classroom, suggesting that motor experiences such as hands-on demonstrations might be involved in the neural instantiation of the concept of mechanical force. In the present study, we tested this hypothesis directly by training novice students in the concepts of linear and rotational forces. One group of participants experienced hands-on training sessions, whereas the other group experienced computer-based training sessions. After training, all participants completed an fMRI session where they evaluated the mechanical forces acting on real world structures during functional scanning. Participants from both groups showed significant improvements in concept learning after training, and dorsal parietofrontal regions were recruited for the task for both

groups. Specific individual and group differences emerged, however: participants' unique neural representations of the learned concepts differentiated their concept knowledge task performance. These differences were assessed through the use of a novel multivariate neuroimaging analysis aimed at generating a scalar measure of learning: a neural test score. Our results demonstrate the unique representational characteristics of hands-on physics instruction, differentiating laboratory-style instruction from computer-based pedagogical methods.

Topic Area: THINKING: Problem solving

D139 The Effects of Multiple Mild Traumatic Brain Injuries and Task Difficulty on Cognitive Function

Joel Alexander¹, Josephina Rau^{1,2}, Jaime Cloud¹; ¹Western Oregon University, ²Texas A&M

Previous research regarding mild traumatic brain injuries (MTBI) has indicated that even 1 MTBI can result in long-term cognitive deficits in memory, speed of processing, and attention (King & Kirwilliam, 2011; McGrath et al., 2013; Wammes, Good, & Fernandes, 2016). The present further investigated this research with the hypothesis that, after controlling for other influences of cognitive functioning, individuals with 2 or more MTBI would perform more poorly on a battery of cognitive tests than individuals with 0-1 MTBI. It was further predicted that the effect of task difficulty on speed of processing would be influenced by the number of MTBI participants experienced, such that speed of processing would be more negatively affected by task difficulty for participants with two or more MTBI than for participants with 0-1 MTBI. Ninety-six participants (70 women; 26 men) completed memory, speed of processing, and attention tests. The results from the present study partially validated previous research, as deficits were demonstrated in an interaction between speed of processing and task difficulty $F(1, 86) = 7.78, p = .007, \eta^2 = .083$, however, the hypotheses that there would also be deficits in attention and memory was not supported. This research is critical to understanding the potential negative outcomes of suffering multiple MTBI, especially in light of the large number of MTBI suffered by individuals each year, and the potential for these cognitive deficits to have life-lasting effects.

Topic Area: THINKING: Problem solving

Poster Session E

Monday, March 25, 2:30–4:30 pm, Pacific Concourse

E1 Attentional Bias Toward Threat in Adolescents with Different Anxiety Levels

Siqi Chen¹; ¹Texas A&M University

Anxiety is an aversive emotional and motivational state occurring in threatening circumstances (Rachman, 2004). Human beings respond to anxious situations by releasing hormones, such as adrenalin and glucocorticoids, which instantaneously increased heart rate and energy level to cope with a range of different conditions and avoid harmful situations. However, modern times of prolonged stress has caused physical and mental afflictions (Sapolsky, 2004). Adolescence is a critical transition period from childhood to adulthood and is often characterized by emotional instability (Brenning et al., 2015). This period is also a time of increased incidence of anxiety, depression and other psychiatric disorders. Motivated by the increased anxiety problems in adolescents, this study examined how attentional sub-processes contribute to anxiety by investigating neural mechanisms using Electroencephalography (EEG) technology. An attentional blink paradigm was used to investigate the individual difference of attentional sub-processes when exposed to threat-related stimuli. Results suggested that

adolescents with higher levels of anxiety tend to have better performance in negative emotional trials compared to adolescents with lower levels of anxiety. At a neural level, adolescents with high levels of anxiety process emotional threat stimuli with more attentional resources in terms of orienting and executive control of attention. Adolescents with higher levels of anxiety were more likely to experience cognitive conflict regardless of the type of stimuli. A later cognitive process difference of threat stimuli was observed between adolescents with different anxiety level. This study aims to contribute to current adolescent's anxiety intervention and prevention studies. Implications for education are discussed.

Topic Area: ATTENTION: Other

E2 Attentional state dependence of time-resolved inter-network anticorrelated brain activity

Aaron Kucyi¹, Josef Parvizi¹; ¹Stanford University

Functional neuroimaging evidence suggests that the brain's default mode network (DMN) exhibits antagonistic activity with dorsal attention (DAN) and salience (SN) networks across various behavioral states. We aimed to resolve the temporal dynamics and potential state-dependence of this activity using human intracranial electroencephalography (iEEG) with simultaneous recordings within core nodes of the DMN (posteromedial cortex), DAN (dorsal posterior parietal cortex), and SN (dorsal anterior insular cortex). Seven neurosurgical patients performed multiple sessions of the gradual-onset continuous performance task (a test of sustained attention), and we recorded spontaneous iEEG activity during wakeful rest and sleep as well as pre-operative resting state fMRI. During attentional task performance, the three networks showed clearly dissociable magnitudes and temporal profiles of iEEG high-frequency broadband (HFB; 70-170 Hz) activity. When accounting for inter-network temporal lags of activity, we found that better behavioral performance across sessions was tightly associated with greater DAN-DMN, but not SN-DMN, anticorrelation in the HFB range. During wakeful rest and sleep states, HFB anticorrelated activity was diminished, but wider network-level organization remained similar to task states and showed iEEG-fMRI correspondence within individuals. These findings have important implications for interpreting antagonistic network relationships found with functional neuroimaging and confirm the behavioral importance of time-lagged inter-network interactions.

Topic Area: ATTENTION: Other

E3 Fronto-Visual Dynamic Functional Connectivity during a Selective Attention Task is Modulated by Prefrontal High-Definition Transcranial Direct Current Stimulation

Rachel Spooner¹, Michael Rezich¹, Boman Groff¹, Tony Wilson¹; ¹University of Nebraska Medical Center

Studies of visual attention have implicated theta, alpha, and gamma activity in the temporal recognition, protection, and organization of attended representations in visual cortices. In addition, studies have shown that higher-order regions such as the prefrontal cortex are critical to attentional processing, but far less is understood regarding laterality differences in attentional processing in the prefrontal cortices. To this end, we examined the impact of applying high-definition transcranial direct-current stimulation (HD-tDCS) to the left or right dorsolateral prefrontal cortex (DLPFC) on subsequent attentional processing. We predicted that HD-tDCS of the left versus right prefrontal cortex would differentially modulate performance on a visual selective attention task, and alter the oscillatory activity serving such cognitive processes. Our repeated-measures design included 25 healthy adults that underwent three separate sessions of HD-tDCS (sham, active left-, and active right-DLPFC) for 20 minutes. Following HD-tDCS, participants completed an attention paradigm during magnetoencephalography (MEG). The resulting

oscillatory responses were imaged in the time-frequency domain using beamforming, and peak task-related neural activity was subjected to dynamic functional connectivity analyses to evaluate the impact of stimulation site (i.e., left and right DLPFC) on neural interactions. Our results indicated that HD-tDCS over the right DLPFC differentially modulated fronto-visual functional connectivity within distinct oscillatory rhythms compared to HD-tDCS of the left DLPFC and sham. Further, these tDCS-induced alterations in fronto-visual connectivity were uniquely related to behavioral performance on the Flanker task. These findings provide insight into the effects of HD-tDCS on the complex oscillatory mechanisms serving visual selective attention.

Topic Area: ATTENTION: Other

E4 Involvement of the Insula in Top-Down Attentional Processing: An Intracranial EEG Study

Daphné Citherlet^{1,2}, Olivier Boucher^{1,2,3}, Julie Tremblay⁴, Manon Robert¹, Anne Gallagher^{2,4}, Alain Bouthillier³, Franco Lepore², Dang Khoa Nguyen^{1,2,3}; ¹Centre de Recherche du Centre Hospitalier de l'Université de Montréal, CRCHUM, ²University of Montreal, ³Centre Hospitalier de l'Université de Montréal, CHUM, ⁴Centre de Recherche du CHU Sainte-Justine, Montréal

The insula is a paralimbic structure localized deep in the Sylvian fissure. Whereas the posterior insula (pl) is thought to be involved in primary sensory processing, the anterior insula (al) is more involved in attentional processes, playing a crucial role in the "salience network". However, its specific role in attentional processing remains unclear, especially due to the limited temporal resolution of neuroimaging techniques. Our study examines the spatio-temporal dynamics of visual target processing using intracranial EEG recorded directly from the insula. During the extraoperative invasive intracranial EEG monitoring of their drug-resistant seizures, eight epileptic patients completed a three-stimulus visual oddball task involving standard, target, and novel stimuli. A total of 59 electrode contacts in the insula were recorded. Permutation analyses were performed to compare event-related potentials (ERPs) across different conditions during the P300 (225-400 ms) interval, and modulations of gamma band responses (GBRs; 70-150 Hz) were analyzed across different conditions using non-parametric Wilcoxon test from 0 to 1,000 ms post-stimuli. We found that target stimulus detection was associated with a P300 component for 39 % of contacts implanted in the al, reflecting voluntary attentional processing. In the pl, only 16 % of contacts showed responses to target stimulus in the P300 interval. Increased GBRs in response to targets were observed in 53 % of al contacts (from \approx 200-300 ms). Results suggest that visual targets elicit a P300 and GBRs in the al, suggesting that this region is involved in top-down attentional processing of task-relevant information.

Topic Area: ATTENTION: Other

E5 Steady-state visual evoked potentials as an index of internally vs externally directed attention

Eva Gjorgieva¹, Benjamin R Geib¹, Roberto Cabeza¹, Marty G Woldorff¹; ¹Duke University

Attention has been subtyped by whether it is directed externally towards sensory information or internally towards self-generated information, such as during mental imagery or memory retrieval. Attentional shifts between stimuli in different spatial locations can be tracked via eye movements or event-related potentials. However, shifts from externally to internally directed attention are more difficult to measure with these methods. In prior research, steady-state visual evoked potentials (SSVEPs) have been used as an index of visuo-spatial selective attention. The SSVEP is an oscillatory EEG response that resonates at the same frequency as a flickering stimulus. Here we make novel use of SSVEPs to index externally and internally directed attention in a memory study. At encoding, subjects were presented with word stimuli flickering at 18 Hz and instructed to form a mental image for each word and

rate the quality of the image. Results showed reduced SSVEP power as subjects covertly directed attention inward to form a mental image of the word's referent. Objects rated as easier-to-imagine showed a faster return of SSVEP power to pre-imagery baseline. In a subsequent memory test, new and old words were randomly intermixed, and subjects made 6-point recognition responses. Again, SSVEP power dipped while subjects directed attention internally to retrieve the word from memory. Faster reaction times, indicating faster return to external attention, were associated with faster SSVEP increases. This study demonstrates that internal vs. external orienting of attention can be reliably tracked with SSVEPs, and it provides an online time course of that attentional orienting.

Topic Area: ATTENTION: Other

E6 The involuntary capture of visual attention by task-irrelevant ugly-beauty artificial faces: An ERP study

Eriko Matsumoto¹, Tomoya Kawashima¹, Tomoyuki Naito²; ¹Graduate School of Intercultural Studies, Kobe University, ²Graduate School of Medicine, Osaka University

Visual attention is easily captured by peripheral faces particularly high attractive ones or threat-related ones although they present as completely task-irrelevant distractors. Several neuroimaging studies reported that the beauty and the ugly stimuli activated the emotional brain network or the social reward related areas such as orbitofrontal cortex, premotor cortex or basal ganglia. The function of these networks is thought to be related to attention capture by emotionally valuable faces. However, little is known that the mechanisms for ugly or beauty faces capture of attention involuntarily. The study employed RSVP task and measure event-related potentials (ERPs) to test how the task-irrelevant ugly/beauty faces capture attention. We use artificial faces (beauty and ugly) for distractor stimuli which were made by using classification image paradigm (Naito et al., 2017) to control the level of ugliness and attractiveness (beautiffulness). Forty-one participants for behavioral study and twenty participants for ERP study. In each task trial, 20 letters with variable colors were presented rapid serially at the center of the monitor in every 100 ms. Participants were asked to detect target color letter ignoring the peripheral distractor stimulus. The results showed that the rate of correct target detection significantly decreased when ugly face presented as a distractor. N2pc peak amplitude enhanced ugly and beauty distractor condition compare to control condition, also, LPC (late parietal positivity) decreased in ugly condition. These results suggest that emotional valuable face could capture attention before aesthetic perception.

Topic Area: ATTENTION: Other

E7 The neural basis of internal attention: characterizing attentional orienting along a memory array

Thomas Biba¹, Inder Singh², J. Benjamin Hutchinson¹; ¹University of Oregon, ²Northeastern University

An ongoing debate in memory research concerns the degree to which similar mechanisms might underlie perceptual attention and attention to internal representations such as those involved in memory. It is unclear, however, whether and how key dimensions of memory, such as time, might be represented and searched in a similar manner as key dimensions of perceptual attention (e.g., space). The current fMRI study sought to better understand the properties of internal attention by collecting a large number of trials per individual and exploring neural correlates of memory search at the level of the single subject. Specifically, using a temporal adaptation of the Posner cuing paradigm, participants were presented with a sequence of nine abstract color fractal images, clustered in three triads with a variable inter-triad delay period. Participants were presented with a retro cue which either validly cued a probe item from a triad, or invalidly cued an item from a different triad.

Thus, it was possible to assess cue activity related to memory search as a function of both absolute time as well as order. Behavioral results confirmed that attention was selectively deployed to particular events within the sequence of images and neural results implicated parietal and frontal regions in memory search during the cue period with the amount of activity related to the temporal distance of the search. These results provide insight into a candidate core dimension of internal attention as well as help to further articulate the properties of frontal-parietal attention networks.

Topic Area: ATTENTION: Other

E8 Threat reduces value-driven but not salience-driven attentional capture

Andy Jeosu Kim¹, Brian A. Anderson¹; ¹Texas A&M University

The control of attention is biased by prior learning, such that attention is automatically captured by stimuli previously associated with either reward or threat. It is unknown whether value-oriented and threat-oriented mechanisms of selective information processing function independently of one another, or whether they share partially overlapping representational mechanisms. Here, we introduced the threat of electric shock into the value-driven attentional capture paradigm to examine whether the experience of threat influences the attention capturing quality of previously reward-associated stimuli. Participants searched for a shape-defined target, while trying to ignore occasional distractors presented in a previously reward-associated color from a prior training phase. Value-based distraction was assessed with and without the threat of unpredictable electric shock. A 2 x 2 ANOVA with distractor condition (present vs. absent) and presence of shock (shock vs. no shock) investigating oculomotor capture revealed a significant interaction effect, showing that value-driven attentional capture was blunted by the experience of threat. Interestingly, this pattern contrasts with previous reports of threat potentiating attentional capture by physically salient stimuli, which we then replicated using the same task but with physically salient distractors (additional singleton task). To formally assess whether threat differentially modulates value-driven and salience-driven oculomotor capture, we conducted a follow-up 2 x 2 x 2 ANOVA with distractor condition (present vs. absent), presence of shock (shock vs. no shock), and type of distractor (valuable vs. physically salient) as factors. A significant three-way interaction confirmed a dissociation in how threat modulates value-driven and salience-driven attentional capture.

Topic Area: ATTENTION: Other

E9 An Electrophysiological Study of the “Weapon Focus” Effect

Annabell Schulz¹, Mei-Ching Lien², Eric Ruthruff³; ¹Oregon State University, ²Oregon State University, ³University of New Mexico

Studies of eyewitness testimony have consistently found a weapon focus effect: witnesses remember less about the perpetrator’s physical appearance when a weapon is involved in a crime scene. Some have argued that the “unusualness” of weapons within a context draws eyewitnesses’ attention away from the perpetrator (the unusual object hypothesis), whereas others have argued that weapons capture eyewitnesses’ attention automatically regardless of context because they are potentially dangerous objects (the automatic capture hypothesis). We tested these hypotheses using event-related potential measures of where people are attending: the N2pc. Participants searched the target display for a pre-specified face category (a chef vs a cop) and indicated its gender. This target display was always preceded by a cue display containing a gun and a whisk. An N2pc was elicited by the gun regardless of target context, suggesting that weapons capture attention because they are potentially dangerous, not because they are unusual.

Topic Area: ATTENTION: Other

E10 Using Multivariate EEG to Predict a Clinical Measure of Attention

Alexander J Simon¹, David A Ziegler¹, Jyoti Mishra², Joaquin A Anguera¹, Adam Gazzaley¹; ¹University of California San Francisco, ²University of California San Diego

A large proportion of cognitive neuroscience research utilizing electroencephalography (EEG) has focused primarily on interrogating bivariate relationships between one behavioral and one neural variable. However, there may be multiple neural markers that are associated with a single behavioral variable that are not necessarily associated with each other. Here, we sought to use multiple neural markers to more accurately explain a behavior than when using individual neural markers. To achieve this, 93 healthy young adults (age range: 18-35 years old, 58 F/35 M) performed the Test of Variables of Attention (T.O.V.A.®), an assessment of sustained attention and impulse control, while EEG was recorded. Summary statistics from the T.O.V.A.® were used to generate an age and gender normalized “attention composite score” (ACS), which has recently become a clinically-meaningful proxy for attention control. Twenty-one event-related potential (ERP) and spectral markers that are associated with the ACS were identified and entered into an exploratory factor analysis to characterize the relationships between them. Composite scores were generated for each of the factors uncovered by the factor analysis, which were used to predict the ACS using a multivariate regression model in a leave-one-out cross validation procedure. Using this approach, we were able to more accurately predict the ACS than when using univariate methods alone. Thus, we have shed light on the relationships between neural markers that are associated with a clinically-relevant behavioral variable. This work can help improve our understanding of how separate cognitive processes differentially contribute to a behavior in healthy and clinical populations.

Topic Area: ATTENTION: Other

E11 Visual search attention training minimizes task distraction in adults with and without ADHD

Tessa Abagis¹, John Jonides; ¹University of Michigan

We conducted a visual search training regimen over five daily sessions with participants diagnosed with ADHD versus healthy controls. In the task, irrelevant color singleton distractors appeared during self-timed visual search on 50% of trials. Participants completed transfer tasks before and after training and at follow up one month later. We performed a repeated measures ANOVA with within-subjects factors of block (first, second of each session), training day, and distractor presence as well as a between-subjects factor of ADHD status. Over the training days, distraction (distractor present - distractor absent trials) and overall reaction time (RT) and error rate (ER) decreased significantly ($p < 0.001$). This minimized distraction persisted for controls and ADHD participants at a one-month follow up session. Interestingly, ADHD participants performed faster but less accurately than control participants across the sessions ($p < 0.001$). ADHD participants apparently chose to sacrifice accuracy for speed whereas healthy controls chose to sacrifice speed for accuracy. ADHD participants did not display significantly different distraction in RT from controls ($p = 0.10$). However, there was a significant interaction of block by distractor presence such that ADHD participants displayed more distraction than controls during the first task block and less distraction during the second task block ($p < 0.001$). This suggests ADHD participants are more distractible during the beginning of the task, but can ameliorate this with practice. Additionally, improvement in visual attention transferred to closely related visual search tasks.

Topic Area: ATTENTION: Other

E12 Anterior insula responses to emotional stimuli and mindfulness tendency

Hiroki Murakami¹, Nobuhiko Hoaki²; ¹Oita University, ²Hoaki Hospital

Mindfulness is a topic that is currently being investigated as a psychotherapy technique. It is defined as bringing one's complete attention to the experiences occurring in the present moment in a nonjudgmental or accepting way. A few studies have investigated relationships between mindfulness and brain structures, and most of these have indicated that mindfulness is related to the anterior insula. The right anterior insula contains interoceptive representations that substantiate all subjective feelings from the body and perhaps emotional awareness. However, the association between mindfulness and brain activation under emotional situations remains to be fully clarified. Previous study has shown that an increased mindfulness tendency assessed by the Mindful Attention Awareness Scale (MAAS) shows amygdala responses for emotional stimuli. However, the MAAS excludes acceptance items that are core factors in mindfulness. The purpose of the present study was to investigate differences in anterior insula responses for emotional stimuli for the mindfulness tendency examined by using the Five Facet Mindfulness Questionnaire, which assesses the comprehensive mindfulness states. Participants were shown emotional or emotionally neutral pictures. Results of a region of interest analysis indicated that right anterior insula was more responsive in individuals with a higher mindfulness tendency. Moreover, whole brain analysis showed that the right dorsolateral prefrontal cortex was more responsive in individuals with a lower mindfulness tendency. These results suggested that individuals with a higher mindfulness tendency allow reality to be as it is without attempting to avoid, escape, or change it, and has a better recognition of emotional states.

Topic Area: EMOTION & SOCIAL: Emotional responding

E13 Oscillatory networks underlying music reward processing

Alberto Ara^{1,2}, Josep Marco-Pallarés^{1,2}; ¹University of Barcelona, ²Bellvitge Biomedical Institute (IDIBELL)

Previous studies have revealed that listening to pleasant music engages the reward network -including the ventromedial prefrontal cortex and the dorsal and ventral striatum- and areas associated with music perception, such as the superior temporal gyri and right inferior frontal gyrus. However, very little is known about the temporal dynamics underlying such brain interactions. The goal of the present study was to study the oscillatory activity associated with the pleasurable experience of listening to music. Twenty subjects participated in an EEG experiment in which they listened to 30 musical excerpts while they continuously reported the degree of pleasantness they were experiencing. Phase synchronization was computed between all electrode pairs in two oscillatory bands of interest -theta (4-8 Hz) and high beta (20-30 Hz)- in order to identify functional networks underlying music-induced pleasantness. Results showed increased synchronization between right fronto-temporal, right-to-left frontal and left parieto-temporal electrodes in the theta band; and generalized anterior to posterior increased synchronization in the high beta band. Therefore, music-induced pleasantness is related to enhanced music encoding driven by increased fronto-temporal auditory working memory via theta band oscillatory activity, especially in the right hemisphere. In addition, these results also suggest that, in order to gain value, music needs to engage the default mode network in the high beta band, as previously shown in aesthetic appreciation.

Topic Area: EMOTION & SOCIAL: Emotional responding

E14 Trait and State Anxiety Modulate Early (but not late) Fear Processing

Melissa A. Meynadasy¹, Kevin J. Clancy¹, Wen Li¹; ¹Florida State University

Fear perception is a multi-stage process, involving four key operations in the order of sensory-based fear/non-fear categorization (~100ms), fear detection (~300ms), fear valuation (400-500ms), and conscious awareness of fear (500-600ms). Fear perception is also known to be highly variable across individuals, especially in relation to trait and state anxiety. Therefore, the current study (N = 45) analyzed a dataset involving behavioral and event-related potential (ERP) responses to faces containing 7 parametrically varied fear intensities to examine how individual differences in trait and state anxiety would modulate each of these key operations in fear perception. Behaviorally, state anxiety closely correlated with fear detection rates at low-to-peri-threshold levels (2%-27%, r 's = .29-.46) but not at supra-threshold levels (33%-45%). Among the four operations, trait (social) anxiety correlated with the initial fear/non-fear categorization (r = -.30) in that the quadratic pattern of maximal P1 responses to prototype levels (neutral/fear faces) and minimal responses to boundary (peri-threshold) levels was evident only in the low-trait-anxiety group, in contrast to the high-trait-anxiety group that exhibited a linear pattern to prototype and boundary levels indicating a lack of response suppression to ambiguous fearful faces in anxious individuals. The operation of fear detection was found to marginally correlate with state anxiety (r = .29) in that the sigmoid function of P3 responses across the fear levels was present in the high- but not the low-trait-anxiety group, suggesting that state anxiety facilitates early, unconscious fear detection. Finally, no correlations were observed between the two later operations and anxiety, suggesting equivalent higher-order fear processing across these individuals.

Topic Area: EMOTION & SOCIAL: Emotional responding

E15 Using Concurrent fMRI to Measure the Effects of Transcranial Direct Current Stimulation Over Prefrontal Cortex for Emotion Regulation in Depressed and Non-depressed Participants

Wessel O. van Dam¹, Erik K. Wing², Amber Zafar¹, Evangelia G. Chryssikou¹; ¹Drexel University, ²University of Kansas

Neuroimaging studies have identified an impaired top-down regulatory network in depression that includes the dorsal and ventral prefrontal cortex (PFC), resulting in heightened activation in the amygdala and ventromedial PFC for negative stimuli during effortful emotion regulation tasks. Transcranial direct current stimulation (tDCS) is a noninvasive neuromodulation method that has been used successfully to induce measurable changes in mood in unipolar depression. Despite reliable findings, little is known regarding the precise effects of tDCS on cortical excitability in vivo in depression and how such changes relate to emotion regulation. Here, we attempted to address this question using tDCS with concurrent functional magnetic resonance imaging (fMRI). We applied excitatory (anodal) tDCS over left prefrontal cortex (PFC; area F3 per the international 10/20 electroencephalography placement system) together with inhibitory (cathodal) tDCS over the respective area over right PFC (F4) in patients with moderate-to-severe unipolar depression (n = 20) and gender- and age-matched control participants (n = 20). Participants were randomly assigned to receive either active or sham tDCS. They performed two runs of an emotion regulation task prior to the onset of tDCS and two runs of the task during tDCS, administered at 1.5mA with 5cm x 5cm electrodes. Whole-brain, region-of-interest, and connectivity analyses revealed an impaired emotion regulation network in the depressed patients relative to the control subjects prior to stimulation, which was differentially sensitive to active relative to sham concurrent tDCS. We discuss these results in the context of proposed mechanisms of action for tDCS as a treatment for depression.

Topic Area: EMOTION & SOCIAL: Emotional responding

E16 Warm and sensitive parenting predicts adolescents' amygdala activity to angry faces during an emotional face processing task

Angelica F. Carranza¹, Annchen R. Knodt², Johnna R. Swartz¹; ¹University of California, Davis, ²Duke University

Prior research has shown that maltreatment and other negative forms of parenting influence neural activity associated with emotion processing and regulation in children and adolescents. However, relatively little research has examined associations between positive parenting behaviors and neural activity. The goal of the present study was to examine associations between positive parenting (warmth/sensitivity, involvement, and monitoring) and neural activity during an emotional face matching task. Given prior evidence that positive parenting supports the development of emotion regulation, we predicted that positive parenting behaviors such as warmth and sensitivity would be associated with adolescents' self-reported emotion regulation abilities as well as lower amygdala activity in response to negative (i.e., angry and fearful) emotional faces. Hypotheses were tested in 38 adolescents (1 nonbinary, 22 boys, 15 girls) between the ages of 12 and 15 ($M = 13.26$, $S.D. = 1.03$). Participants underwent fMRI scanning while completing a face processing task that included task blocks consisting of matching angry, fearful, and happy facial expressions, and control blocks consisting of matching geometric shapes. There was a negative association between right amygdala activity to angry faces and warm/sensitive parenting, ($r = -.47$, $p < .05$), such that higher warm/sensitive parenting predicted lower amygdala response to angry faces. These results suggest that warm/sensitive parenting, such as positive emotional support for the child, is associated with lower amygdala activity to angry faces in adolescents, which would suggest lower emotional reactivity to negative emotional expressions on a neurobiological level.

Topic Area: EMOTION & SOCIAL: Emotional responding

E17 An Independent Component Analysis Approach to Assessing the Integration of Faces and Voices in Multimodal Emotion Perception: An Electroencephalography Study

Katherine Becker¹, Donald Rojas¹; ¹Colorado State University

Emotion is vital to communication as it instantaneously connects us through subtle changes in facial movements and vocal expressions, with perception occurring via the simultaneous integration of affective vocal and facial information. These expressions activate a constellation of brain areas sensitive to emotional facial expressions, which are distinct from those devoted to prosody recognition. While much is known about the independent contributions of these channels to emotion perception, less research has focused on multimodal affect perception. This study sought to quantify the cognitive and neural underpinnings of this dynamic process by extracting independent components from 39 electrodes. Brain activity was measured using an EEG while subjects ($n=26$) were presented with angry or happy faces (FO), voices (VO), or faces and voices (F+V) presented together. Prosodic stimuli consisted of vocalizations (/a/) produced in neutral, angry, and happy tones. ICA components were extracted using group ICA and the trial-wise component waveforms were correlated with the task structure at each time point. All task conditions were significantly correlated with neural activity, corrected for multiple comparisons $FDR q < .05$. FO and F+V exhibited a N170 like ERP over parieto-occipital electrodes. VO exhibited a PSW potential over frontotemporal sites. Activity was positively correlated with F+V and negatively correlated with both unimodal conditions (200-800ms). Component activity was correlated with anger and happiness, which exhibited anti-correlated activity (250-350, 350-900ms). These results indicate that the brain exhibits a unique pattern of activity when processing multimodal emotional stimuli, which is distinct from that witnessed in unimodal processing.

Topic Area: EMOTION & SOCIAL: Other

E18 Collaboration between team-members is represented in their shared brain activity: A NIRS based hyperscanning study

Naama Maysseless¹, Grace Hawthorne², Allan Reiss¹; ¹Center for Interdisciplinary Brain Sciences Research, Stanford University, School of Medicine, Stanford, ²Hasso Plattner Institute of Design (d.school) Stanford

Team collaboration is an essential component of teams looking to achieve innovative ideas. This study investigated the brain-to-brain synchrony profile that occurs during team collaboration. In order to achieve a naturalistic study design that allowed for social face-to-face interaction and free movements, we used functional near infrared spectroscopy (fNIRS) to measure inter-brain synchrony between two people engaged in a real-life collaborative design project. In addition to neural signatures, we assessed behavioral interaction between participants while they were engaged in creative collaboration. NIRS data demonstrated significant inter-brain neural synchronization between a region centered on the left supramarginal gyrus and a region centered on the left dorsolateral prefrontal cortex and posterior middle temporal gyrus. In addition, these variations in brain-to-brain synchrony were related to collaboration and degree of leadership of the teams. These results indicate that creative collaboration is related to increased association between theory of mind regions and executive function regions between team members. Our study suggests different processes that can promote increased collaboration between team members and can lead to more innovative ideas in a naturalistic design thinking session.

Topic Area: EMOTION & SOCIAL: Other

E19 Communicative Misalignment in Autism Spectrum Disorder

Arjen Stolk^{1,5}, Harshali Wadge¹, Rebecca Brewer², Geoff Bird^{3,4}, Ivan Toni⁵; ¹Helen Wills Neuroscience Institute, University of California, Berkeley, Berkeley, CA, USA, ²Department of Psychology, Royal Holloway University of London, London, UK, ³Department of Experimental Psychology, University of Oxford, Oxford, UK, ⁴Social, Genetic, and Developmental Psychiatry Centre, Institute of Psychiatry, Psychology, and Neuroscience, King's College London, London, UK, ⁵Donders Institute for Brain, Cognition, and Behaviour, Radboud University, Nijmegen, The Netherlands

Communicative impairments are a defining feature of Autism Spectrum Disorder (ASD) that manifest during everyday social interactions. Yet previous studies trying to understand those impairments have largely focused on the perceptual biases, social motivation, cognitive flexibility, or mentalizing abilities of individuals studied in isolation. Here, using social interactions stripped of those biases, we characterized a novel cause for their communicative impairments. We found that adults with ASD ($N=22$) matched neurotypical individuals ($N=30$) in their ability and propensity to generate and modify intelligible communicative behaviors for the benefit of a communicative partner, questioning suggestions of diminished social motivation or impaired cognitive flexibility. However, individuals with ASD selectively struggled to align the meaning of communicative behaviors with their partner when meaning relied on referencing their recent communicative history. This communicative misalignment explains why autistic individuals are vulnerable in everyday interaction, which entails fleeting ambiguities, but succeed in social cognition tests involving stereotyped contextual cues. These findings provide novel boundaries to the general notion that ASD is linked to altered mentalizing abilities and illustrate the cognitive and clinical importance of considering social interaction as a communicative alignment challenge.

Topic Area: EMOTION & SOCIAL: Other

E20 Cooperation, but not competition, increases gamma band inter-brain synchronization

Paulo Barraza¹, Alejandro Perez², Eugenio Rodríguez³; ¹Centro de Investigación Avanzada en Educación, CIAE, Universidad de Chile, ²University of Toronto, ³Laboratorio de Neurodinámica, Escuela de Psicología, Pontificia Universidad Católica de Chile

The human history of evolutionary success and adaptation has been arguably built upon the bases of inter-subject collaboration. Despite its importance, the neurodynamic mechanisms that underlie the actions coordination in a cooperative way, and their differences with competitive interactions are unknown. To elucidate these issues, we simultaneously measured the EEG activity among interacting dyads (hyperscanning), while they were performing a simple reaction time task in a cooperative or competitive way. In behavioral terms the results were as expected: i) the subjects of the dyads were quicker to answer when they competed with each other than when they cooperated, and ii) the cooperation rate improved over time. Regarding the hyperscanning EEG results, we found that cooperative interaction induced a transient increase of brain-to-brain gamma phase synchrony, unlike competitive interactions that increased theta inter-brain synchronization. Our findings support the idea that there are at least, two neurodynamic mechanisms associated with the interaction between subjects: i) a more basic one triggered by the fine motor coordination between members of the dyads, during the competition phase, linked to the inter-brain synchrony in low-frequencies (e.g., theta band), and ii) another induced by more complex processes that go beyond the simple coordination of actions, which involves the coordination of shared intentions, which would be reflected in brain-to-brain synchronization in high-frequencies (e.g., gamma band).

Topic Area: EMOTION & SOCIAL: Other

E21 Event-related potential markers of empathy for pain are modulated by the ingroup/outgroup status of the victim and of the perpetrator of harm

Brian Gonsalves¹, Douglas Rosales¹, Cameron Ryczek¹; ¹California State University, East Bay

Previous research has found that neural responses to images of people in pain are modulated by ingroup/outgroup status of the victim, with enhanced responses to images of ingroup victims. Some research suggests that such responses may be further modulated by the ingroup/outgroup status of the perpetrator of harm, such that empathic responses will increase when an outgroup perpetrator harms an ingroup member (e.g. Molenberghs et al 2016). We tested this idea by presenting participants with images of one person harming another. Images showed the hand of a perpetrator causing harm to either the hand or foot of the victim, or showed hands and feet interacting in a non-harmful way. Race of the perpetrator and victim was manipulated by varying the skin tone of the hands and feet in the images. Participants were recruited who self-identify as either Black or White. Event-related potentials were recorded while participants viewed images and rated how much pain the victim was experiencing in each image. ERP results revealed an enhanced positivity beginning around 100ms for painful relative to non-painful images. Within responses to painful images, there was a similar enhanced positivity when participants viewed images of an ingroup victim relative to viewing an outgroup victim. Finally, within responses to an ingroup member being harmed, there was a similar positivity for harm being caused by an outgroup member compared to that caused by an ingroup member. Results show that early bottom-up processing is modulated by group status of both victim and perpetrator.

Topic Area: EMOTION & SOCIAL: Other

E22 Functional Connectivity Analysis of Risk-Taking and Impulsivity

Jeffrey Rouse¹, Yush Kukreja², Jeremy Cohen³; ¹Tulane University School of Medicine, ²Tulane University, ³Xavier University of Louisiana

Cognitive control and default mode network (DMN) regions have been associated with impulsivity. Less is understood regarding the neural correlates of risk-taking. Our study investigated whether the degree of self-reported impulsivity as measured by the UPPS-P Impulsive Behavior Scale and self-reported risk taking as measured by the Domain Specific Risk-Taking Scale (DOSPERT) is associated with unique functional connectivity patterns in resting state fMRI. 50 healthy subjects (30 females) were randomly selected from the Nathan-Kline Institute Rockland Sample, with an average age of 31.2 (SD=7.87). Resting state images were preprocessed and functional connectivity analysis was performed using CONN, with DOSPERT subscales and UPPS score as covariates and correcting for multiple comparisons. Overall Risk-Taking Behavior scores were positively correlated with left lateral parietal region of the DMN connectivity to multiple regions, including bilateral temporal lobe subregions, bilateral parietal opercula, and left cerebellar lobule regions. Overall Risk Perception scores were negatively correlated with connectivity of the left lateral parietal region of the DMN to multiple regions, including portions of the salience and dorsal attention network, precuneus, and left cerebellum. Also, the cerebellar vermis and left occipital pole showed significant negative correlation with multiple cortical and subcortical regions. Overall Expected Benefit scores were positively correlated with connectivity of the left cerebellar lobule and fusiform cortex to multiple regions. Connectivity patterns significantly positively correlated both with DOSPERT subscales and overall UPPS score differed from those observed with DOSPERT scores alone. Results suggest that risk-related behavior and perception brain networks are largely distinct from impulsivity-related substrates.

Topic Area: EMOTION & SOCIAL: Other

E23 WITHDRAWN

E24 MANY FACETS OF THE SOCIAL BRAIN IN PSYCHIATRIC CONDITIONSSORDERS

Marina Pavlova¹; ¹Department of Psychiatry and Psychotherapy, Medical School, Eberhard Karls University of Tübingen, Tübingen, Germany

The social brain (networks underlying nonverbal communication, body language reading, and facial assessment of counterparts) has many facets playing a decisive role in majority of neuropsychiatric conditions such as autistic spectrum disorders, schizophrenia, and major depression. We intend to give impulses for discussion of the following issues: (i) Contribution of neuroimaging in understanding of the social brain: Brain connectivity matters. With the advent of sophisticated techniques over the past decades, brain imaging has sparked a wide range of research in neuropsychiatry. Yet brain imaging faces with a set of open issues. One of them is time, which is a key to understanding the organization of functional networks. Brain topography alone does not allow us to understand pathological changes in brain activation; (ii) Relationship between behavior and brain activity: Behavior matters. This relationship is far from simple even in individuals, free from the rich complexities of psychopathology; and (iii) Sex specificity of the social brain: Sex matters. Many neuropsychiatric disorders characterized by aberrant social cognition display a skewed sex ratio: females and males are affected differently in terms of clinical picture, prevalence, and severity. However, the origin of this sex/gender specificity is unclear. We will present novel and discuss previous behavioral and brain imaging findings (e.g., obtained with ultra-high field fMRI at 9.4 T) on dynamic body language reading and affective face recognition shedding light on the sex specificity of the social brain.

Topic Area: EMOTION & SOCIAL: Other

E25 Resting-state functional connectivity fails to exhibit neural homophily between friends

Carolyn McNabb¹, Laura Burgess¹, Amy Fancourt², Patricia Riddell¹, Kou Murayama^{1,3}; ¹University of Reading, United Kingdom, ²Queen Anne's School, United Kingdom, ³Kochi University of Technology, Japan

Previous research suggests that the proximity of individuals in a social network predicts how similarly their brains respond to naturalistic stimuli. The relationship between social network proximity and brain connectivity in the absence of external stimuli, however, has not been examined. This study investigated whether neural homophily between friends exists at rest. Resting-state functional magnetic resonance imaging (rs-fMRI) data from 51 12- to 14-year-old girls attending a local school were accompanied by social network information from all girls in their year groups. Participants were asked to rate the amount of time they voluntarily spent with each person in their year group and then directed social network matrices and community structure were determined from these data. rs-fMRI data were corrected for motion and divided into 272 functional regions. Time-series correlations between all regions (representing functional connectivity) were performed for each subject. Between-subjects comparisons were made using Pearson's correlation and the DeltaCon similarity function. Correlation and similarity scores within each dyad were analysed as a function of social distance and whether dyads belonged to the same network community. No statistically significant relationships between social distance, community homogeneity and correlation strength or similarity index of resting state brain networks were observed. Although neural homophily between friends exists when viewing naturalistic stimuli, this finding does not extend to rs functional connectivity. Rs connectivity may be less susceptible to the influences of a person's social environment, whereas responses to naturalistic stimuli may reflect conscious cognitive processing, influenced by social interactions.

Topic Area: EMOTION & SOCIAL: Other

E26 Social values modulate culture-related and individual differences in neural correlates of moral decision making: A cross-cultural functional MRI study

Yang Chen Lin¹, Robert Doole¹, Hsu-Wen Huang², Chih-Mao Huang^{1,3}; ¹National Chiao Tung University, Hsinchu, Taiwan, ²City University of Hong Kong, Hong Kong, ³Cognitive Neuroscience Laboratory, Institute of Linguistics, Academia Sinica, Taiwan

Moral cognition is crucial for social interaction and prosocial behavior. It involves unconscious and deliberate decision-making processes of cognitive and affective mentalizing systems to evaluate an (in)appropriate behavior and social harmony. In the present study, we investigate how social values (i.e., independence and interdependence) modulate culture-related and individual differences in behavioral outcomes as well as neural substrates of moral decision making. Sixteen young Taiwanese participants (8 males, mean = 23.75) and 16 young Western participants (9 males, mean = 24.81 SD = 2.97) were recruited in this cross-cultural functional magnetic resonance imaging study and were instructed to perform the modified version of moral evaluation to make a good/bad evaluation of an intentional action after presenting a set of visual scene that depicts social interactions between individuals. The social values, characterizing participants into independence or interdependence, was assessed by individual's self-report on the Singelis Self-construal Scale (SCS; Singelis, 1994). Taiwanese participants had higher SCS scores in interdependence than their Western counterparts (Taiwanese: 5.75; Westerners: -1.81; $P < 0.001$). A whole-brain fMRI analysis revealed that both Taiwanese and Westerners recruited brain activation in inferior frontal gyrus, anterior cingulate cortex, posterior superior temporal sulcus (pSTS/TPJ), and hippocampus, indicating a culture-invariant neural network for moral decision making. Moreover, regions of interest (ROIs) analysis showed a significant correlation between social values (independence vs. interdependence) and fMRI signal measured in right TPJ, with higher social score for greater TPJ

activation. Our results provide neuroimaging evidence that socio-cultural orientations affect individual differences in evaluation processes during moral decision making.

Topic Area: EMOTION & SOCIAL: Other

E27 The pain of sleep loss: A brain characterization in humans.

Adam Krause¹, Aric Prather², Tor Wager³, Martin Lindquist⁴, Matthew Walker¹; ¹University of California, Berkeley, ²University of California, San Francisco, ³University of Colorado, Boulder, ⁴Johns Hopkins University

Sleep loss increases the experience of pain. However, the brain mechanisms underlying altered pain processing following sleep deprivation are unknown. Moreover, it remains unclear whether ecologically modest night-to-night changes in sleep within an individual confer consequential day-to-day changes in experienced pain. Here, we first demonstrate that acute sleep-deprivation amplifies pain reactivity within human (male and female) primary somatosensory cortex, yet blunts pain-reactivity in higher-order valuation and decision-making regions of the striatum and insula cortex. Consistent with this altered neural signature, we further show that sleep deprivation expands the temperature range for classifying a stimulus as painful, specifically through a lowering of pain thresholds. Moreover, the degree of amplified reactivity within somatosensory cortex following sleep deprivation significantly predicts this expansion of experienced pain across individuals. Finally, outside of the laboratory setting, we similarly show that even modest night-to-night changes in sleep quality (increases and decreases) within an individual determine consequential day-to-day changes in experienced pain (decreases and increases, respectively). These data reveal a central brain mechanism underlying the impact of sleep loss on pain perception, and furthermore, establish that the association between sleep and pain is expressed in a night-to-day, bidirectional relationship within individuals. More generally, such findings highlight sleep as an important therapeutic target for pain management within and outside the clinic, including circumstances where sleep is frequently short, yet pain is abundant (e.g. the hospital setting).

Topic Area: EMOTION & SOCIAL: Other

E28 Does maternal odor influence social perception in the infant brain?

Sarah Jessen¹; ¹University of Luebeck

The most important caregiver for a young human infant is most often the mother, and a variety of signals and mechanisms ensure a close bonding between mother and infant. One potentially essential yet understudied signal is maternal odor as a potent chemosensory signal. While maternal odor is known to play an important role in mother-infant-interaction in other altricial species such as rodents, we only know very little about its role in early human development. The present study therefore investigated the potential impact of maternal odor on infant brain responses in an emotion perception task. Infants were randomly assigned to one of three groups (each $n=25$): a "maternal odor" group exposed to maternal odor, a "stranger odor" group exposed to the odor of an unfamiliar mother of a same-aged infant (control 1), and a "no-odor" group (control 2). We recorded the electroencephalographic (EEG) signal while the infants saw happy and fearful faces. We found that infants exposed to their mother's odor did not show the age-typical fear response (indicated via an enhanced Nc response) that was found in both control groups combined ($t(73) = -2.01, p = .048$). Furthermore, resting-state data from the same infants point to an enhanced cortical tracking response (intersubject synchrony) in the presence of maternal odor ($p_{\text{perm}} = .011$). In sum, maternal odor appears to reduce infants' attention to threatening signals, which provides evidence for the important role of indirect maternal signals for emotion regulation in infancy.

Topic Area: EMOTION & SOCIAL: Development & aging

E29 A pattern-similarity analysis approach to cognitive control in color-word Stroop.

Michael Freund¹, Todd Braver¹; ¹Washington University in St. Louis

Classic experimental paradigms such as Stroop have been instrumental for testing theories of cognitive control. Typically, brain imaging studies of such tasks have used univariate analysis approaches, with multivariate pattern analysis methods infrequently adopted. Here, we explore the utility of pattern similarity analysis for identifying dissociable components of neural coding in a spoken color-word Stroop fMRI study (N = 37). Three task dimensions were tested with three representational models: target (color/correct response), distractor (word/incorrect response), and congruency (target==distractor?). Analyses were conducted at the areal level, using an anatomically constrained cortical atlas recently developed for the Human Connectome Project (Glasser/Multi-Modal Parcellation). Our distractor model was selectively correlated with similarity structures from early visual cortex (V1, V2), whereas our target model was correlated with structures widely distributed across the brain, but strongest in sensorimotor areas. In contrast, our congruency model best described similarity structures in fronto-parietal and cingulo-opercular regions, including dorsolateral prefrontal (dlPFC), superior and inferior parietal, and anterior cingulate cortex. Supporting the functional relevance of these measures, individual differences in model fits were associated with enhanced behavioral performance. Specifically, stronger distractor decoding was associated with a smaller Stroop effect in early visual cortex, but a larger effect in perisylvian regions, possibly reflecting strength of stimulus encoding and depth of distractor processing. Conversely, stronger target decoding in dlPFC was associated with fewer Stroop errors, potentially reflecting better representation of task goals. These results highlight the potential of pattern similarity techniques for decomposing classic cognitive control tasks from a representational perspective.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E30 A role for the paravermis in the control of verbal interference: comparison of bilingual and monolingual adults

Roberto Filippi¹, Eva Periche-Tomas¹, Andria Papageorgiou¹, Peter Bright²; ¹University College London, Institute of Education, London, UK, ²Anglia Ruskin University, Cambridge, UK

We have reported cerebellar involvement in control of verbal interference: specifically, the paravermis, showed higher grey matter density and activation in individuals who were better at controlling verbal interference in a sentence interpretation task (Filippi et al., 2011). The current study extends the investigation to compare brain structure sensitivity to verbal interference control across two groups, English monolingual (N = 41) and multilingual (N = 46) adults. Using voxel-based morphometry, our goal was to identify i. systematic structural volume differences and ii. differences in regional patterns of grey matter sensitivity to performance on the sentence interpretation task, controlling for group variability in age, nonverbal reasoning and vocabulary knowledge. We found no evidence for a between group performance advantage and the only structural difference was enhanced grey matter volume in lateral temporal cortex (BA21) in bilinguals, an area associated with auditory language processing. However, we found a significant group effect in grey matter sensitivity to task performance: stronger sensitivity in the paravermis in bilinguals compared to monolinguals in accuracy performance in the high (relative to low) verbal interference condition. We also observed more sensitivity in bilinguals within medial prefrontal cortex and dorsal anterior cingulate cortex in this condition, areas associated with attentional control and resolution of conflict from distracting stimuli (e.g., Burgess et al., 2007; Weissman et al., 2005). Our findings suggest that multilanguage acquisition mediates regional involvement within the language network, conferring enhanced functional plasticity within structures (including the paravermis) in the service of optimal control of linguistic interference.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E31 Delta and theta power indicators of inhibition to food: A time-frequency analysis of high- and low-calorie go/no-go tasks

Alex M. Muir¹, Rebekah E. Rodeback¹, Kaylie A. Carbine¹, Ariana Hedges-Muncy¹, Michael J. Larson¹; ¹Brigham Young University

Inhibitory control, the ability to withhold dominant responses in order to correctly respond to task-relevant demands, has important implications for our ability to maintain a healthy diet. Electroencephalogram (EEG) oscillations related to inhibitory control show increased delta power is related to increased motor inhibition while increased theta power is associated with increased inhibitory control. To better understand the neural indices underlying food-related inhibitory control, we analyzed delta and theta power from the EEG data of 186 healthy participants (females = 119; age: 24.5 ± 7.7 years). Participants performed two go/no-go tasks where either high- or low-calorie food cues were the no-go stimuli. On the day of data collection, all participants fasted for one meal, got at least 7 hours of sleep, and refrained from consuming caffeine or participating in vigorous physical activity. For theta power, a 2-Trial by 2-Task ANOVA revealed a main effect of trial type (p<0.001), task (p=0.008), and a significant Trial by Task interaction (p=0.005). For delta power, we found a main effect of trial (p<0.001) and a significant Trial by Task interaction (p<0.001). However, there was not a main effect of task (p=0.07). Follow-up t-tests revealed a greater power difference between go and no-go trials when inhibiting responses to high-calorie as compared to low-calorie foods for both theta and delta frequencies (p theta=0.005; p delta<0.001). Results suggest that increased recruitment of both motor inhibition and inhibitory control resources are utilized to withhold dominant responses towards high-calorie compared to low-calorie foods.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E32 EEG Correlates of Involuntary Cognitions from External Control

Alexander J. Cook¹, Wei Dou¹, Ezequiel Morsella^{1,2}, Mark W. Geisler¹; ¹San Francisco State University, ²University of California, San Francisco

The Reflexive Imagery Task (RIT; Allen et al., 2013) reveals that the activation of action sets can result in involuntary cognitions that are triggered by external stimuli. In the basic RIT, participants are presented with an image of an object (e.g., CAT) and instructed to not think of the name of the object. Involuntary subvocalizations of the name (the RIT effect) arise on roughly 80% of the trials. We conducted two EEG studies to explore the neural correlates of the RIT effect. In Study 1, subjects (n = 8) were presented with one object at a time in one condition and two objects simultaneously in another condition. Four regions were defined by electrode sites: frontal (F3-F4), parietal (P3-P4), right hemisphere (F4-P4), and left hemisphere (F3-P3). In Study 2, we investigated the Two-object condition of Study 1. In this variant of the RIT, participants, before being presented with the two objects, decide which object (the one on the left or on the right) to not think the name of. For Study 1, a 4 (Regions) × 2 (One-Object condition vs. Two-Object condition) repeated-measures ANOVA of alpha coherence showed a significant main effect of Region, F(3, 21) = 70.90, p < .001, with significant differences in alpha correlation between frontal (M = 1.35), parietal (M = 0.95), right hemisphere (M = 0.65), and left hemisphere (M = 0.59), ts(15) > 6.00, ps < .001, but no contrast between left and right hemispheres, t(15) = 0.76, p = .23.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E33 EEG network coherence in the 40 Hz gamma band modulates attentional state and task performance

Cognitive operations that use external cues to guide behavior require sustained attention, which is mediated by several brain regions. The basal forebrain (BF) increases acetylcholine release in the PFC to enhance attention, while in the PFC, the emergence of gamma oscillations (~40 Hz) during attention has been known to form a task-positive dorsal-attentional network with the post-parietal cortex (PPC). However, recent findings associated the BF-PFC gamma network with a task-negative state, highlighting the lack of understanding of gamma oscillations and their influence on sustained attention. Here, using a Sustained Attention to Response Task, we investigated pre-stimulus gamma and their long-range synchrony in mice during distinct attentional states. We first identified attentive (active engagement) and inattentive (long-term disengagement) states based on short-term performance, and discovered that pre-stimulus PFC/BF gamma are stronger in inattentive states, supporting more recent findings. However, when we further classified attentive states into correct and error (momentary attentional lapse) trials, PFC/BF gamma were stronger in correct trials, consistent with earlier findings. Together, these results reveal a non-linear relationship between gamma amplitude and performance. Interestingly, while PFC-PPC synchrony was stronger in correct trials, BF-PFC synchrony was stronger in error trials despite weaker amplitudes, implying the involvement of the BF-to-PFC gamma network during an attentional lapse. Taken together, these findings indicate that stronger BF/PFC gamma does not necessarily predict better performance, but rather that coherence within gamma networks may be the key to understanding the role of gamma oscillations in sustained attention and task performance.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E34 Fronto-striatal contributions to the control of response interference: a functional magnetic resonance imaging study

Claudia C. Schmidt¹, David C. Timpert^{1,2}, Isabel Arend³, Simone Vossel^{1,4}, Gereon R. Fink^{1,2}, Avishai Henik³, Peter H. Weiss^{1,2}; ¹Cognitive Neuroscience, Institute of Neuroscience and Medicine (INM-3), Research Centre Juelich, Juelich, Germany, ²Department of Neurology, University Hospital Cologne, Cologne, Germany, ³Department of Psychology and the Zlotowski Center for Neuroscience, Ben-Gurion University of the Negev, Beer-Sheva, Israel, ⁴Department of Psychology, University of Cologne, Cologne, Germany

While the role of cortical regions in cognitive control processes is well accepted, the contribution of subcortical structures (e.g., the striatum), especially to the control of response interference, is still debated. Therefore, the present study aimed to further investigate the cortical and subcortical neural mechanisms of response interference control. For that purpose, thirteen healthy young participants underwent event-related functional magnetic resonance imaging (fMRI) while performing a unimanual version of the Simon task. In this task, successful performance requires the resolution of stimulus-response conflicts in incongruent trials. Behavioural results showed an asymmetrical Simon effect that was more pronounced in the contralateral hemifield. The contrast of incongruent trials compared to congruent trials (i.e., the overall Simon effect) significantly activated clusters in the right anterior cingulate cortex (ACC), the caudate nucleus bilaterally, and the right posterior insula. A regression analysis revealed that the magnitude of the contralateral Simon effect significantly co-varied with activation in the left dorsolateral prefrontal cortex (DLPFC). The current pattern of brain activations corroborates the notion that the cognitive control of response interference is supported by a fronto-striatal network, with an essential contribution of the caudate nucleus.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E35 Functional dissociation of EEG theta rhythms between prefrontal and visual cortices and their synchronization during sustained attention

Hio-Been Han^{1,2}, Ka Eun Lee^{1,3}, Jee Hyun Choi^{1,4}; ¹Korea Institute of Science and Technology, ²Korea Advanced Institute of Science and Technology, ³Seoul National University, ⁴Korea University of Science and Technology

Previous literature has identified the importance of a coherent oscillatory network between distal brain regions contributing to task performance, such as the fronto-visual theta (4-12 Hz) network. However, the conceptual framework has been challenged by recent evidence which suggests region-specifically different functions of cortical theta rhythms, especially those in the prefrontal cortex (PFC) and the visual cortex (VC). Because of their opposite functional correlates against attention, as PFC theta correlates while VC theta anti-correlates with attention, the underlying principle behind their functional network during sustained attention remains poorly understood. Here, we show that PFC/VC theta are different neuronal entities having distinct functional correlates, so that their connectivity increases during sustained attention when one (i.e., visual) is suppressed. Analyzing EEG signals from mouse brain during Go/No-Go task, we found PFC (VC) theta was stronger (weaker) in good-performance epochs than in bad-performance epochs. Interestingly, the synchronization between two oscillations increased during the epochs with good performance, despite the suppression of theta in VC. The fronto-visual phase-coherent theta network showed a predominant posterior-to-anterior direction on the order of few milliseconds. Along with the improved synchrony, the delay showed a subtle but systematic decrease, suggesting a boost of information relay from the posterior to the anterior brain region. Our findings not only provide empirical evidence for the distinction between the theta of PFC and VC, but also reveal the overlooked aspect of long-range synchrony between functionally different oscillators in the cerebral cortex.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E36 Impairments in Conscious Error Awareness are Associated With ADHD and Predict Symptom Change

Amber Schwartz¹, Jessica Tipsord¹, Brittany Alperin¹, Sarah Karalunas¹; ¹Oregon Health & Sciences University

Attention-Deficit Hyperactivity Disorder (ADHD) is a common childhood disorder with heterogeneous symptom trajectories. The mechanisms behind ADHD symptom remission and persistence remain unclear. Performance monitoring, which involves the ability to recognize errors and make behavioral adjustments, is one aspect of self-regulation that may contribute to symptom change. However, it is unclear whether impaired performance monitoring is associated with ADHD, specifically, or with the comorbid symptoms of Oppositional Defiant Disorder (ODD) that are often present in the disorder. Both early (e.g., error-related negativity, ERN) and later (e.g., error-related positivity, Pe) stages of performance monitoring can be quantified on failed inhibitory go/no-go trials via EEG-recorded event-related potentials. Here, better performance monitoring is hypothesized to be associated with ADHD independent of comorbid ODD symptoms and to predict ADHD symptom improvement. Method: 75 children from an ongoing longitudinal study (Control= 35, ADHD= 40) completed behavioral ratings and semi-structured clinical interviews to assess ADHD symptoms. At annual follow-up visits 3-5 years later, ADHD assessment was repeated and children completed a computerized emotional go/no-go with EEG recorded. Results: ERN amplitudes did not differ between groups. During positive emotion conditions, controls had higher Pe amplitudes (M=9.34, SD=6.49) than ADHD participants (M=5.57, SD=5.62), $F(1,71)=5.64$, $p=.02$. Results remained the same when controlling for ODD-related symptoms. Among the ADHD group, higher Pe amplitude predicted a greater ADHD symptom improvement after controlling for baseline symptom severity, $b=-.40$, $p=.005$. Conclusions: Performance monitoring impairments in ADHD are independent of comorbid ODD

symptoms. This cognitive skill may be associated with ADHD symptom remission.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E37 Preserved performance monitoring and error detection in left hemisphere stroke

Eva Niessen¹, Jana Ant², Stefan Bode³, Jochen Saliger⁴, Hans Karbe⁴, Gereon Fink^{1,2}, Jutta Stahl⁵, Peter Weiss^{1,2}; ¹Research Centre Juelich, Germany, ²University Hospital Cologne, Germany, ³University of Melbourne, ⁴Neurological Rehabilitation Centre Godeshohe, Germany, ⁵University of Cologne, Germany

Cognitive control is often affected by stroke. When errors occur while executing an action, the performance monitoring system signals the need for more cognitive control, which has been shown to be most effective when participants detect an error. The current study aimed at investigating the integrity of performance monitoring and error detection in left hemisphere stroke patients. Besides clinical and neuropsychological testing, 24 stroke patients and 32 healthy age-matched controls performed a Go/Nogo task with simultaneous electroencephalography (EEG) recordings. EEG data were analyzed at single-electrode level with event-related potentials [e.g., the error-related negativity (Ne/ERN) and error positivity (Pe)], and additionally with more sensitive whole-brain multivariate pattern classification analyses (MVPA). Interestingly, despite severe cognitive deficits (e.g., aphasia, apraxia) and executive dysfunction (impaired trail making test), no behavioral impairments or electrophysiological variations related to performance monitoring and error processing were observed in stroke patients. Patients showed similar reaction times, post-error slowing, error rate and error detection rate, as well as similar amplitudes and latencies of the Ne/ERN and Pe components when compared to controls. These findings were supported by MVPA results. Electrophysiological abnormalities during stimulus processing (i.e., N2 and P3) in stroke patients demonstrate the specificity of these findings. In contrast to previous studies, by employing a (compared to other clinical studies) large patient sample and a well-controlled experimental paradigm with a standardized error signaling procedure, we show that performance monitoring is a preserved cognitive control function in left hemisphere stroke patients and is hence unlikely to impede rehabilitative therapies.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E38 Preventing a thought from coming to mind elicits increased right frontal beta just as stopping action does

Anna Castiglione¹, Johanna Wagner¹, Michael Anderson², Adam Aron¹; ¹University of California, San Diego, ²University of Cambridge, UK

How do we stop thoughts and memories from coming to mind? It is possible that preventing retrieval recruits a similar stopping mechanism as motor stopping. In the stop-signal task an electrophysiological signature of action-stopping is increased early right frontal beta band power for successful vs. failed stop trials. Here we tested whether the requirement to stop an unwanted thought from coming to mind also elicits this signature. We recorded scalp EEG during a Think/No-Think task and a subsequent stop signal task in 42 participants. In the Think/No-Think task, participants first learned word pairs. In a second phase, they received the left-hand word as a reminder and were cued either to retrieve the associated right-hand word ("Think") or to stop retrieval ("No-Think"). At the end of each trial, participants reported whether they had experienced an intrusion of the associated memory. Finally, they received the left-hand reminder word and were asked to recall its associated target. Behaviorally, there was worse final recall for items in the No-Think condition, and decreased intrusions with practice for No-Think trials. For EEG, we reproduced increased early right frontal beta power for successful vs. failed

action stopping. Critically, No-Think trials also elicited increased early right frontal beta power and this was stronger for trials without intrusion. These results suggest that preventing a thought from coming to mind also recruits fast prefrontal stopping.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E39 Proactive versus Reactive Distraction Filtering: Evidence from a Combined EEG and Eye-tracking Study

Salahadin Lotfi¹, Caed Burdis¹, Madeline Rech¹, Lukas Dommer¹, Caitlin Michalski¹, Emily Anhalt¹, Richard Ward¹, Christine Larson¹, Han-Joo Lee¹; ¹University of Wisconsin-Milwaukee

Proactive filtering (PF) preemptively modulates selective target processing, whereas reactive filtering (RF) relies on late adjustments of attentional control in response to distractors. This study sought to examine the specific behavioral, eye-gaze and neural correlates of PF and RF, using the distraction context manipulation paradigm (Marini et al, 2016). This flanker task has three blocks: No-Distraction (presenting only the central arrow), Infrequent-Distraction (60% congruent, 20% incongruent, and 20% single-arrow trials, designed to trigger RF), and Frequent-Distraction (60% incongruent, 20% congruent, and 20% single-arrow trials; designed to trigger PF). The task indexes "conflict-cost" (i.e., incongruent RT – congruent RT) and "filtering-cost" (i.e., single-arrow RT in Distraction conditions – single-arrow RT in No-Distraction). Consistent with previous studies, behavioral data showed that PF significantly lowered the conflict-cost while increasing the filtering-cost. Particularly, eye-tracking data revealed that PF is characterized by prolonged fixations on the central target with reduced attention deployed toward the peripheral area, compared to the RF, indicating that the heightened filtering-cost in PF may be caused by the narrow attentional focus with inflexible or deficient attentional deployment toward the areas surrounding the central target. N2 (well-established ERP component of conflict monitoring) showed a lower amplitude in PF, indicating this pre-emptive mode of distraction control was in operation in anticipation of forthcoming distractors compared with RF. This study provides useful data that illuminate the specific behavioral, eye-gaze, and neural correlates of PF as compared with RF.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E40 To Play or Not to Play: Do Active Video Games Improve Electrophysiological Indices of Food-Related Inhibitory Control in Adolescents?

Kaylie A. Carbine¹, Joshua L. Smith¹, Hanel Watkins¹, Bruce Bailey¹, Michael J. Larson¹; ¹Brigham Young University

Many adolescents do not obtain recommended amounts of daily physical activity, increasing the risk of multiple health problems. Physical activity may also be related to cognitive processes that regulate food intake, such as food-related inhibitory control (i.e., the ability to withhold dominant responses to eat palatable foods). One barrier to increasing physical activity in adolescents may be the high levels of daily screen time spent watching TV or playing video/computer games. A possible solution to increasing physical activity that may appeal to adolescents is active video games. We aimed to test how acute bouts of active or sedentary video gaming affected neural indices of food-related inhibitory control. One way to measure inhibitory control is through the N2 and P3 components of the event-related potential (ERP), which are larger when an individual withholds a dominant response. Using a within-subjects design, fifty-nine adolescents (M[SD]age=13.29[1.15], 49% female) participated in two sessions where they completed either 60 minutes of active or sedentary video gaming, immediately followed by two go/no-go tasks where either high- or low-calorie foods cues were no-go stimuli. A 2-Session by 2-Task by 2-Trial ANOVA was conducted on N2 and P3 ERP amplitudes. Adolescents recruited more inhibitory control resources when withholding

responses to high- than low-calorie foods (as indicated by a larger N2 amplitude; $p=.04$). Active video gaming did not affect N2 or P3 amplitudes ($ps>.15$). While adolescents may increase recruitment of inhibitory control resources to manage dominant responses to high-calorie foods, active video gaming did not change acute food-related inhibitory control.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

E41 A multilevel modelling approach to quantify channel based neural variability during postural-working memory dual tasking in young and old adults using fNIRS

Sushma Alphonsa¹, Carla Orellana¹, Sarah Schwartz¹, Ron Gillam¹; ¹Utah State University

Traditional neural analyses have generally taken the aggregating and ANOVA based approach to analyze fNIRS data. In this study, we used a multilevel modeling (MLM) approach to assess the cortical activation by evaluating the area of the hemodynamic response curve (AUC) for eight regions of interest (ROI: DLPFC, MPFC, SMA and M1) for the left and right hemispheres. This was done by accounting for the participant-level variability at the individual channel level. A pseudo-randomized block design with a dual-tasking paradigm was used. Specifically, an n-back (0-back, 1-back, 2-back and 3-back) working memory task was developed to systematically change the cognitive load. 48 healthy participants, 24 young (Male = 12, 18-40 years) and 24 old (Male = 12, 60-85 years), performed an n-back working memory task while simultaneously performing a postural control task (feet together, double leg standing task) with their eyes closed. AUC for oxygenated (HbO) and deoxygenated (HbR) hemoglobin concentrations were used as an index of cortical activation. The MLM analyses revealed a significant group x task interaction for HbO. For HbR, there were two interactions: group x task and group x ROI. For both HbO and HbR, young adults displayed greater overall activation across tasks. Age-related decline in activation in the ROI indicated that the older adults did not efficiently recruit the working memory networks during dual-tasking as compared to young adults. Additionally, these findings are the first to account for changes at the participant level during dual-tasking using the MLM approach.

Topic Area: EXECUTIVE PROCESSES: Working memory

E42 A neural architecture for working memory, evidence accumulation and cognitive control

Zoran Tiganj¹, Nathanael Cruzado¹, Marc W. Howard¹; ¹Boston University

Constrained by results from classic behavioral experiments we provide a neural-level cognitive architecture for navigating memory and decision making space as a cognitive map. We propose a canonical microcircuit that can be used as a building block for working memory, spatial navigation, decision making and cognitive control. The controller controls gates to route the flow of information between the working memory and the evidence accumulator and sets parameters on the circuits. We show that this type of cognitive architecture can account for results in behavioral experiments such as item recognition and judgment of recency. We compare predictions of the formal model to recent neurophysiological data. The neural dynamics generated by the cognitive architecture provides a good match with neurophysiological data from rodents and monkeys. For instance, it generates cells tuned to a particular amount of elapsed time (time cells), to a particular position in space (place cells) and to a particular amount of accumulated evidence. Furthermore, this approach can be useful in identifying brain regions involved in working memory, decision making and cognitive control as well as in understanding the interaction between those regions.

Topic Area: EXECUTIVE PROCESSES: Working memory

E43 An Indexing Theory for Working Memory based on Fast Hebbian Plasticity

Florian Fiebig¹, Pawel Herman¹, Anders Lansner^{1,2}; ¹Lansner Laboratory, Department of Computational Science and Technology, KTH Royal Institute of Technology, 10044 Stockholm, Sweden, ²Department of Mathematics, Stockholm University, 10691 Stockholm, Sweden

Working memory (WM) is a key component of human memory and cognitive function. Computational models have been used to uncover the underlying neural mechanisms. However, these studies have mostly focused on the short-term memory aspects of WM and neglected the equally important role of interactions between short- and long-term memory (STM, LTM). Here, we concentrate on these interactions within the framework of our new computational model of WM, which accounts for three cortical patches in macaque brain, corresponding to networks in prefrontal cortex (PFC) together with parieto-temporal cortical areas. In particular, we propose a cortical indexing theory that explains how PFC could associate, maintain and update multi-modal LTM representations. Our simulation results demonstrate how simultaneous, brief multi-modal memory cues could build a temporary joint memory representation linked via an "index" in the prefrontal cortex by means of fast Hebbian synaptic plasticity. The latter can then activate spontaneously and thereby reactivate the associated long-term representations. Cueing one long-term memory item rapidly pattern-completes the associated un-cued item via prefrontal cortex. The STM network updates flexibly as new stimuli arrive thereby gradually over-writing older representations. In a wider context, this WM model suggests a novel explanation for "variable binding", a long-standing and fundamental phenomenon in cognitive neuroscience, which is still poorly understood in terms of detailed neural mechanisms.

Topic Area: EXECUTIVE PROCESSES: Working memory

E44 Brain electrical differences along working memory retrieval are related with the processes: maintenance or manipulation and the difficulty

Talia V. Román-López¹, Carlos Sánchez-Gachuz¹, Ulises Caballero-Sánchez¹, Silvia A. Cisneros-Luna¹, Jesus A. Franco-Rodríguez¹, Mónica Méndez-Díaz², Oscar Prospéro-García², Alejandra Ruiz-Contreras¹; ¹Facultad de Psicología, Universidad Nacional Autónoma de México, ²Facultad de Medicina, Universidad Nacional Autónoma de México

Working memory (WM) requires the ability to maintain (Mt) and manipulate (Mp) information. Differences between both processes are evidenced behaviorally and by means of the Event-related potentials (ERPs) at the delay period. We previously have showed changes in ERPs between both processes at the retrieval phase. However, the effect of difficulty on each process at the retrieval is less known. We evaluated ERPs during the retrieval of information as a function of the WM process (Mt or Mp) and its task-demand (low and high). ERPs was recorded to 38 subjects, during two independent Delay Match-to-Sample Tasks performance. In Mt task, they indicated if the test-stimulus matched in color, or color and shape (target stimuli; low and high difficulty, respectively) or not (non-target) to the encoded stimulus. In Mp task, participants indicated if the encoded shape was rotated 90° or 180° (target stimuli; low and high difficulty, respectively) or not (non-target). Higher percentage of correct responses and shorter reaction times were observed for Mt than for Mp; target trials were faster than non-target. ERPs 25% Fractional Area Latency at 200-800ms post-stimulus onset at the retrieval phase was shorter for low (vs. high) difficulty trials, for both Mt and Mp. Also, target trials had shorter latency in both Mt and Mp than non-target trials. Low difficulty target trials had shorter latency compared to high target difficulty trials. These results suggest retrieval in WM depends on both the type of processing required (Mt or Mp) and on the task-demand.

Topic Area: EXECUTIVE PROCESSES: Working memory

E45 Connectome-based predictive modeling of working memory in multiple sclerosis

Heena Manglani¹, Stephanie Fountain-Zaragoza¹, Ruchika Shaurya Prakash¹; ¹The Ohio State University

Working memory impairments in multiple sclerosis (MS) are associated with decrements in functional independence, psychological well-being, and quality of life. However, heterogeneity in working memory across people with MS may be related to individual differences in disease status and linked to neural functional alterations. Connectome-based predictive modeling (CPM) is a data-driven approach used to predict individual differences in behavior (e.g., sustained attention, personality traits, cognitive impairment) from patterns of functional connectivity. The present study sought to identify and test connectivity-based neural markers of working memory, as these may provide useful targets for cognitive rehabilitation interventions in MS. In the current study, 36 adults with relapsing-remitting MS completed two measures of working memory: the Paced Visual Serial Addition Test (PVSAT) in the MRI and WAIS-IV working memory subtests on a separate day. We first tested whether the previously-identified sustained attention CPM generalized to predict this domain of cognitive function in a neurological disease sample. This model did not successfully predict working memory (i.e., PVSAT accuracy) in our sample of individuals with MS. As such, we employed CPM to derive a novel neural marker of working memory, identifying functional connectivity networks within task-based fMRI collected during PVSAT that were predictive of working memory performance. To assess the internal validity of this model, we tested its ability to predict individuals' WAIS-IV working memory index (WMI) scores. We found that the working memory network model successfully predicted significant variance in WMI, supporting this model as a robust network-based marker of working memory.

Topic Area: EXECUTIVE PROCESSES: Working memory

E46 Decoding verbal short-term memory in non-perceptual parietal and frontal regions: Evidence for a buffer account

Qiuhai Yue¹, Randi C. Martin¹; ¹Rice University

Buffer accounts of verbal short-term memory (STM) assume that there are dedicated buffers for maintaining different kinds of information whereas embedded processes accounts argue against the existence of buffers and claim that STM consists of the activated portion of long-term memory (LTM). We addressed this debate by determining whether STM recruits the same neural substrate as LTM, or whether additional regions are involved in short-term storage. We used fMRI with representational similarity analysis (RSA) to examine the representational correspondence of multi-voxel neural activation patterns with the theoretical predictions for the maintenance of both phonological and semantic STM. In the phonological domain, a speech processing region in the left superior temporal gyrus showed RSA evidence of phonological coding during the encoding period of a phonological STM task, but not during the delay period. In contrast, the left supramarginal gyrus showed RSA evidence of phonological retention during the delay period. In the semantic domain, the triangular part of the left inferior frontal gyrus showed marginally significant RSA evidence of semantic coding during the encoding period of a semantic STM task, but not during the delay period. In contrast, the left angular gyrus, the left posterior middle temporal gyrus and the left middle frontal gyrus showed RSA evidence of semantic retention during the delay period, with the angular gyrus allowing for decoding of either phonological and semantic STM, depending on the task context. The results provide clear support for a buffer account of phonological STM, although evidence for semantic buffer is equivocal.

Topic Area: EXECUTIVE PROCESSES: Working memory

E47 Enhanced working-memory performance by cross-frequency coupled transcranial alternative current stimulation

Byoung-Kyong Min^{1,2}, Kyung Mook Choi³, Hyun-Seok Kim³, Min-Hee Ahn³; ¹Department of Brain and Cognitive Engineering, Korea University, Seoul 02841, Korea, ²McGovern Institute for Brain Research, Massachusetts Institute of Technology, Cambridge, MA 02139, USA, ³Institute for Brain and Cognitive Engineering, Korea University, Seoul 02841, Korea

Transcranial current stimulation is a potent neuromodulation technique used to enhance human cognitive functions in a non-invasive manner. In this study, we investigated whether a cross-frequency coupled transcranial alternative current (CFC-tAC) stimulation improved working-memory performance. Sixteen participants were recruited for a tAC-treated group, and sixteen age-sex-matched controls also participated in this study as a sham group. They were instructed to perform a modified Sternberg task, where a combination of letters and digits was presented in a 3-different workload condition (3, 5, and 7 items to be encoded) before and after the tAC or sham stimulation. The stimulation group was treated by a CFC-tAC stimulation for 20 mins (input channel: F3, return channels: Fp1, Fz, F7, and C3). We analyzed the behavioral data using a repeated-measures ANOVA. We observed a significant decrease in reaction times ($F(1,7) = 13.495, p < 0.01$; pre-tAC: 940.63 ms, post-tAC: 796.74 ms) and a significant increase in the accuracy of task performance ($F(1,7) = 6.102, p < 0.05$; pre-tAC: 76.99%, post-tAC: 86.49%) in the tAC-treated participants, particularly in a most difficult task condition (i.e., 7-workload). Our observations are indicative of a feasibility to enhance cognitive performance of normal participants by the CFC-tAC non-invasive stimulation.

Topic Area: EXECUTIVE PROCESSES: Working memory

E48 The effect of cerebellar HD-tDCS on higher order cognition

Ted Maldonado¹, Jessica A. Bernard¹; ¹Texas A&M University

Transcranial direct current stimulation (tDCS) uses weak electrical current to modulate neural activity in an effort to alter behavior. The existing literature suggests that tDCS stimulation over M1 and prefrontal cortex (PFC) alter motor and cognitive performance, respectively. The cerebellum, traditionally implicated in motor behaviors and learning, has an increasingly recognized role in higher order cognition. However, the necessity and contribution of the cerebellum to cognition remains relatively unknown. tDCS allows for temporary functional alteration in the cerebellum to investigate the role of the cerebellum in higher order cognition. The current work employed a between subjects design using an HD-tDCS system to apply anodal, cathodal, or sham stimulation to the cerebellum or PFC to examine the effect HD-tDCS has on Stroop and Sternberg task performance. Critically, we predict similar performance changes in both the PFC and cerebellum, suggesting both regions play a similar role in cognition. Preliminary analyses show trends suggesting non-polarity specific increases in accuracy during the Sternberg after stimulation over the PFC, but not the cerebellum. There were no significant effects of stimulation on Stroop performance, though a preliminary trend suggests the magnitude of the Stroop effect is smaller in the cerebellar condition than in the PFC, after anodal stimulation. Together, the current results suggest an effect of stimulation on cognition when applied over the PFC but not the cerebellum, perhaps suggesting the cerebellum has a more peripheral role in cognition. The lack of stimulation effect in the cerebellum requires further investigation on how tDCS affects the cerebellum.

Topic Area: EXECUTIVE PROCESSES: Working memory

E49 The N2pc and Individual Differences in Working Memory

Sally Borgatti¹, Juniper Hollis¹, Kirsten Lydic¹, Zoe Pestana¹, Amy Lowe¹, Heather Welty¹, Chynna Aming¹, Cindy Bukach², Catherine Reed³, Jane Couperus¹; ¹Hampshire College, ²University of Richmond, ³Claremont McKenna College

The N2pc has been shown to be an effective marker of attentional object selection when presented with a visual search task, reflecting selection of a target item among distractors (Eimer, Kiss, and Nicholas, 2011). Moreover, when visual search targets are known in advance, the search process is guided by representations of target features utilizing visual working memory at the time of search, thus guiding attention to objects with target-matching features (Grubert and Eimer, 2016). However, little is known about the influence individual differences in working memory on the N2pc. Here, 103 adults (ages 18-30) completed a visual search task designed to elicit the N2pc. Participants were asked to search for either a pink or blue vertical U among lateral facing U's and indicate if the gap was at the top or bottom of the U. Participants also completed a task switching, visual short term memory, and a spatial working memory task. As in previous studies, a significant interaction between hemisphere of presentation and electrode (P07/P08) demonstrated the presence of the N2pc ($F(1,99)=11.26, p=.001$). Additionally, there was a significant interaction between this and spatial working memory ($F(1,99)=4.61, p=.034$). There were no other significant interactions with the N2pc. This suggests that it is specifically spatial working that is reflected in the N2pc rather than visual working memory or executive function more generally. Moreover, individual differences in spatial working memory impact the N2pc, with those who have slower responses (i.e. poorer spatial working memory) exhibiting a larger N2pc.

Topic Area: EXECUTIVE PROCESSES: Working memory

E50 The strength of alpha-beta oscillatory coupling predicts motor timing precision

Tadeusz Kononowicz¹, Laetitia Grabot¹, Tom Dupre La Tour², Alex Gramfort³, Valerie Doyere⁴, Virginie van Wassenhove¹; ¹Cognitive Neuroimaging Unit, CEA DRF/Joliot, INSERM, NeuroSpin center, 91191 Gif-sur-Yvette, ²LTCI, Telecom ParisTech, Université Paris-Saclay, ³Inria, Université Paris-Saclay, Saclay, France, ⁴Neuro-PSI, Université Paris-Sud, Université Paris-Saclay, CNRS, Orsay, France

Precise timing makes the difference between harmony and cacophony, but how the brain achieves precision during timing is unknown. In this study, human participants generated a time interval while being recorded with magnetoencephalography. Building on the proposal that the coupling of neural oscillations provides a temporal code for information processing in the brain, we tested whether the strength of oscillatory coupling was sensitive to self-generated temporal precision. On a per individual basis, we show the presence of alpha-beta phase-amplitude coupling (α - β PAC) whose strength was associated with the temporal precision of self-generated time intervals, not with their absolute duration. Our results provide evidence that active oscillatory coupling engages α oscillations in maintaining the precision of an endogenous temporal motor goal encoded in β power - the when of self-timed actions. We propose that oscillatory coupling indexes the variance of neuronal computations, which translates into the precision of an individual's behavioral performance.

Topic Area: EXECUTIVE PROCESSES: Working memory

E51 Bilingualism modulates L1 word processing in the developing brain

Olga Kepinska¹, Myriam Oliver¹, Zhichao Xia^{1,2}, Rebecca Marks³, Leo Zekelman^{1,4}, Jocelyn Caballero¹, Roeland Hancock^{1,5}, Stephanie L. Haft^{1,6},

Priscilla Duong^{1,7}, Yuuko Uchikoshi⁸, Ioulia Kovelman³, Fumiko Hoeft^{1,5,9}; ¹University of California, San Francisco, ²Beijing Normal University, ³University of Michigan, ⁴Harvard University, ⁵University of Connecticut, ⁶University of California, Berkeley, ⁷Palo Alto University, ⁸University of California, Davis, ⁹Haskins Laboratories

In bilinguals, evidence suggests that second language (L2) is processed using the first language's (L1) network. Recent findings also show an interaction between the L1 and L2, suggesting that L2 acquisition also influences L1 processing. With most studies on bilingualism concentrating on L2 representations and processing in the brain, here, we investigated whether experience with additional language(s) in childhood influences processing of the L1. Typically developing kindergartners performed an auditory L1 (English) word match task blocked alternating with periods of rest during fMRI. In the task upon hearing two words, they indicated with a button press whether the words were the same or different. Data from 79 kindergartners were analyzed. The children were 5-6 years old and had varying levels of L2 experience, operationalized as the numbers of years of exposure to any language but L1 (0.05-6.38 years). Whole-brain fMRI analysis with years of exposure to L2 as a regressor of interest (controlling for children's age, L2 age of onset of acquisition, gender and handedness) revealed that brain activity during the task was modulated by L2 exposure. A cluster localized in the left middle temporal gyrus showed lower levels of activation in children with longer L2 exposure. Our results suggest L2 exposure may impact L1 auditory word-related brain activation in a very young sample, pointing to developing efficiency in processes governing L1 perception as a function of L2 exposure: the more experience with a language other than the L1, the less active the left posterior temporal cortex during the task.

Topic Area: LANGUAGE: Development & aging

E52 Feedback-Related ERPs Predict Learning Speed

Isabelle Moore¹, Calais Larson¹, Annie Fox¹, Yael Arbel¹; ¹Massachusetts General Hospital Institute of Health Professions

The efficiency with which a learner processes external feedback has implications for both learning speed and performance. A growing body of literature suggests that the feedback-related negativity (FRN) event-related potential (ERP) and the fronto-central positivity (FCP) ERP reflect the extent to which feedback is used by a learner to improve performance. To determine whether the FRN and FCP predict learning speed, 82 participants aged 7:6 - 11:0 learned the non-word names of 20 novel objects in a two-choice feedback-based declarative learning task. Participants continued the task until reaching the learning criterion of 2 consecutive training blocks with accuracy greater than 90%, or until 10 blocks were completed. Learning speed was determined by the total number of incorrect responses before reaching the learning criterion. Using linear regression models, the FRN amplitude in response to positive feedback was found to be a significant predictor of learning speed when controlling for age. The FCP amplitude in response to negative feedback was significantly negatively associated with learning speed, meaning that large FCP amplitudes in response to negative feedback predicted faster learning. An interaction between FCP and age suggested that for older children in this sample, smaller FCP amplitude in response to positive feedback was associated with increased speed, while for younger children, larger FCP amplitude predicted faster learning. These results suggest that the feedback related ERP components are associated with learning speed, and can reflect developmental changes in feedback-based learning.

Topic Area: LANGUAGE: Development & aging

E53 Natural Semantic, Syntactic, and Phonological Processing in Adults and 5-year-old Children

Event-related potential studies investigating semantic and syntactic processing in adults are ubiquitous, but few emphasize natural language comprehension and even fewer investigate phonological processing. The results from similar studies in young children prove heterogeneous and difficult to interpret. The present study compared ERP responses to naturally produced semantic errors, syntactic errors (incorrect inflectional morphemes on singular present tense verbs), and phonological errors (incorrect allomorphs on plural nouns, e.g. shoe/s/ and horn/s/) in adults and 5-year-old children listening to naturally spoken stories for comprehension. Both adults and children show an N400 in response to semantic violations and an anterior negativity in response to syntactic violations, consistent with previous literature. Importantly, the extended duration of the anterior negativity and absence of a P600 in response to syntactic violations in the current study indicates that the anterior negativity to posterior positivity transition reported in the vast majority of previous studies is driven by processes that are not necessarily invoked during typical language comprehension. The novel approach to investigating phonological processing revealed a phonological mapping negativity in both adults and children that was not dependent on setting up and violating strong lexical predictability. The three distinct ERP indices of semantic, syntactic, and phonological processing during natural speech comprehension may prove an effective tool to investigate individual differences in language processing skill among both typically developing children and those with emerging language disorders.

Topic Area: LANGUAGE: Development & aging

E54 Rapid Automatized Naming Speed in Hearing and Deaf Skilled Readers Reveals Language Modality Independent Relationship

Diana Andriola¹, Clifton Langdon¹; ¹Gallaudet University

INTRODUCTION. Rapid automatized naming (RAN) speed is well-documented as a predictor of reading outcomes across languages. However, previous studies have failed to find correlations between RAN and reading in deaf children with reading delays (Andriola & Allen, 2018; Dyer et al, 2003). Here we use functional near-infrared spectroscopy (fNIRS) to investigate the RAN-reading relationship in hearing and deaf skilled readers. Hypothesis: If the RAN-reading relationship depends on spoken language, only hearing children's RAN speed will correlate with reading performance. Additionally, neural activation patterns in hearing children will show robust recruitment of RAN-associated regions (e.g., left inferior frontal gyrus, supplementary motor area). **METHODOLOGY.** We recruited 7 deaf native signers of American Sign Language (ASL) (mean age = 8.76yr, SD = 2.02yr) and 7 typically-hearing native English speakers (mean age = 8.76yr, SD = 1.61yr). The fNIRS task consisted of four 9x4 RAN arrays (colors and letters) and two 9x4 fixation cross arrays. Participants were instructed to quickly name each color or letter. **RESULTS.** When matched for IQ and reading comprehension, deaf and hearing children performed similarly on RAN tasks. Deaf children's reading skills strongly correlated with RAN (letters and colors); hearing children's reading skills significantly correlated with letters, but not colors. fNIRS results for deaf and hearing groups show modulation of neural activity in multiple ROIs correlated with reading. **DISCUSSION.** Our results clarify the RAN-reading relationship in deaf and hearing skilled readers, suggesting that early rich language experience supports similar developmental pathways for skilled reading in hearing and deaf children.

Topic Area: LANGUAGE: Development & aging

E55 Reaction Time Variability in Lexical Decision Task Performance and Reading Network Activation in Children with Dyslexia

For several decades, Dyslexia has been characterized by deficits in phonological processing and awareness. Studies have shown individuals with Dyslexia to have significantly slower lexical access and processing speeds. These deficits equate to an impairment in the ability to quickly and correctly read and interpret written text. This could be, in part, due to differences observed between groups in the activation of frontal and temporo-parietal regions during reading. Here, we examine the effects of reaction time on reading task performance and reading network activation through functional magnetic resonance imaging (fMRI) and a novel, adaptive task design. Our subject pool consisted of 71 right-handed, monolingual children between 8-12 years of age. Given the heterogeneous nature of dyslexia symptoms, we created an adaptive model to account for the more nuanced complexities of the disorder and potential confounds. By normalizing accuracy rate across participants based on performance in both orthographic and phonological tasks, task-fatigue and similar motivational confounds were eliminated -- thus, offering more precise assessments of reading ability. Analysis of the behavioral data has indicated significant differences between subject group and task performance. Additionally, initial analyses of the phonological task functional data revealed differences in activation of the cerebellum, superior temporal gyrus, and inferior frontal gyri. Given the initial findings, we can see similar, more significant differences in activation for these regions of interest using reaction time as a regressor. Further experimentation is needed to determine the generalizability of these deficits in processing speed to other contexts and skills.

Topic Area: LANGUAGE: Development & aging

E56 Working memory 'Brain Training' for Older Adults – does it work?

Olga Matysiak¹, Aleksandra Bramorska¹, Aneta Brzezicka^{1,2}, Natalia Jakubowska¹, Wanda Zarzycka¹; ¹University of Social Sciences and Humanities, Warsaw, Poland, ²Cedar-Sinai Medical Centre, Los angeles, USA

Aging, even in the absence of pathological conditions, is associated with cognitive decline. Executive functions and memory seem to be most affected. To remediate age-related deficits cognitive training programs have been developed. Of particular interest are working memory (WM) interventions, especially that there was evidence that WMC can be augmented in older age. In intervention research on WM, training has been also associated with both decreases and increases of brain activity in task-relevant brain regions. In the present study we attempted to verify the effectiveness of a 5-week-long dual n-back task regime. Six tests (e.g. Sternberg Task, OSPAN, Syllogisms Task) served as cognitive assessment at baseline and post-training sessions. Two tests were additionally accompanied by EEG recording. Data analysis provided support for the efficacy of our intervention in healthy elders. Almost all post-training results were higher after the intervention, especially in the active training group. Furthermore, WMC appeared to be the significant predictor of the training progress: the participants characterized by higher initial WMC performed better in training from the very first day and had steeper learning curve. These differences were accompanied by neurophysiological dissimilarities. We discuss this result, among others, in terms of high complexity and requirements of a training task. We conclude that, although electroencephalographic data has provided us with information about the mechanisms of WM training to a certain extent, more research is needed to understand its neural impact.

Topic Area: LANGUAGE: Development & aging

E57 ERP evidence for phonological priming in American Sign Language in a semantic task

Brittany Lee^{1,2}, Katherine J. Midgley¹, Phillip J. Holcomb¹, Karen Emmorey¹, Gabriela Meade^{1,2}; ¹San Diego State University, ²University of California, San Diego

Phonological units in American Sign Language (ASL) include handshape, location, and movement. Previous ERP priming studies have investigated how overlap in these phonological units affects the processing of target signs. Results across studies have revealed mixed phonological priming effects. Target signs with primes overlapping in location elicited larger amplitude N400s than targets with phonologically unrelated primes (Gutiérrez, Müller, Baus, & Carreiras, 2012), while target signs with primes overlapping in both handshape AND location elicited smaller amplitude N400s than targets with phonologically unrelated primes (Meade, Lee, Midgley, Holcomb, & Emmorey, 2018). We compared processing of target signs in a handshape-only overlap condition, a location-only overlap condition, and a handshape AND location overlap condition to target signs in a phonologically unrelated condition. Deaf signers viewed pairs of ASL signs and pressed a button whenever they saw a country sign (e.g., FRANCE). Results thus far show smaller amplitude N400s for targets with primes overlapping in both handshape AND location compared to targets with unrelated primes. Targets with primes sharing only handshape also elicited smaller amplitude N400s relative to targets with unrelated primes. Targets with primes sharing only location elicited the opposite effect: larger amplitude N400s relative to targets with unrelated primes. Thus, shared handshape may facilitate lexico-semantic processing while shared location makes sign recognition more effortful, and these effects do not seem to be simply additive.

Topic Area: LANGUAGE: Other

E58 Somatotopic phonological priming and prediction in the motor system

Luigi Grisoni¹, Friedemann Pulvermüller^{1,2,3}; ¹Freie Universität Berlin, Brain Language Laboratory, Department of Philosophy and Humanities, 14195 Berlin, Germany, ²Berlin School of Mind and Brain, Humboldt Universität zu Berlin, 10099 Berlin, Germany, ³Einstein Center for Neurosciences, 10117, Berlin, Germany

Classic theories claim that motor and premotor cortex contribute to motor execution but not to language comprehension. This position became problematic in light of neuroscientific experiments showing motor activation during passive speech processing (Fadiga et al., 2002), phonological mapping of speech sounds within the motor cortex (Pulvermüller et al., 2006), and causal effects of motor cortex stimulation on the processing of speech sounds (Schomers et al., 2016). A phonological theory grounded in bodily action and perception mechanisms seems to capture these novel findings (Pulvermüller & Fadiga, 2010), although a debate is still ongoing (Hickok, 2013). To clarify whether the motor system contributes to phonological processes, we investigated neurophysiological indexes of phonological priming. Testing adult human participants, we show that already before the presentation of a phoneme, context-induced phonological predictions are reflected by an event-related potential (ERP) whose latency, polarity and shape is consistent with the Readiness Potential, a component of the event-related potentials (ERP) traditionally associated with action preparation. Furthermore, phonemes elicited significantly larger stimulus-evoked (Mismatch Negativity-like) responses when presented in articulatory-incongruent (e.g. "[t]" in the context of "[p]" and "[b]" in the context of "[d]") than in articulatory-congruent (e.g. "[t]" in the context of "[d]" and "[b]" in the context of "[p]") contexts, a pattern reminiscent of neurophysiological priming. Cortical generators were localized in areas traditionally associated with language processing, including left inferior frontal cortex and temporal pole, and, crucially, in motor areas. These results provide conclusive evidence for the relevance of the motor system in language processing.

Topic Area: LANGUAGE: Other

E59 Stability of phonological neural codes covaries with word predictability: Evidence for cross-level predictions in language processing

Jona Sassenhagen¹, Benjamin Gagl¹, Christian J. Fiebach^{1,2}; ¹University of Frankfurt, Germany, ²Brain Imaging Center, Frankfurt, Germany

Language comprehension requires the segmentation of continuous sound waves into individual speech tokens – phonemes – which are then re-assembled into words, phrases, and sentences. Classical language models assume a strictly bottom-up process, so that differences in the probability of a word in a specific context (e.g., sentence) should not influence acoustic-phonemic processing. In contrast, the domain-general neurophysiological Predictive Coding theory, well established for, e.g., vision, suggests that successful top-down predictions cancel out bottom-up input signals. A strict application of predictive coding to language implies that the phonemes of a semantically expected word (e.g., "He drank his tea with milk and ...") are predictable so that the bottom-up signal will be canceled out. Such top-down interactions across linguistic levels of representation are at the core of current theoretical discussions concerning the predictive nature of language. To investigate the existence of cross-level hierarchical predictions in language comprehension, we modeled electroencephalographic and magnetoencephalographic brain activity elicited by spoken sentences, using an established model that reconstructs speech-evoked brain activity from sequential combinations of neural signatures of phonemic representations. If (higher-level) semantic expectations directly influence (low-level) phoneme processing, phonemes should be less represented in brain activity elicited by highly predictable words. Supporting this hypothesis, we observe a significantly reduced match between modeled and speech-evoked brain signals for more predictable words ($r < -.7$). This provides evidence for the existence of hierarchical, cross-level predictions during speech comprehension. Higher-level (semantic) anticipations 'explain away' acoustic-phonemic input, thereby reducing processing demands at the earliest stages of language perception.

Topic Area: LANGUAGE: Other

E60 The Reading Brain Project: An Open Science Data-Sharing Initiative

Anya Yu¹, Benjamin Schloss¹, Chun-Ting Hsu², Lindsey Ma¹, Chih-Ting Chang³, Marissa Scott¹, Ping Li¹; ¹The Pennsylvania State University, USA, ²Kokoro Research Center, Kyoto University, Japan, ³Institute of Linguistics, Academia Sinica, Taiwan

The past decade has seen a surge of neuroimaging studies of reading. However, most are limited to small sample sizes with no common tasks across studies. These problems make reproducibility difficult. Open data-sharing offers a solution to the reproducibility issue. In this poster we discuss our effort on data sharing with the community through The Reading Brain Project, an NSF-funded study that aims to understand the neurocognitive processes underlying scientific text comprehension by adult native speakers (N=52), non-native second language readers (N=56), and middle-school students (N=52). Our study consists of multimodal neuroimaging data from resting-state fMRI, task-based fixation-related fMRI, and DTI. Participants also completed a battery of cognitive tests including standardized measures of executive functions (inhibition, planning, and working memory), language performance (expository and narrative reading comprehension and vocabulary), and language and reading background surveys recording self-reported language proficiency and reading habits. Results have shown that reading performance correlates with connectivity in semantic integration regions. Additionally, readers' e-device usage negatively correlates with activity in the right dlPFC and cerebellum for texts with higher centrality, suggesting that electronic

habits may affect skills in integrating conceptual representation. Finally, Representation Similarity Analysis shows that semantic models predicted brain activity better than visual models for L1 but not L2 readers, suggesting that L2 proficiency influences conceptual representation quality. This poster provides a framework for how to use this dataset to test theories in text reading such as the Extended Language Network, and to compare against other datasets that are smaller in size.

Topic Area: LANGUAGE: Other

E61 White-matter connectivity of left occipitotemporal regions for reading music and words: the impact of musical expertise

Florence Bouhali^{1,2}, Valeria Mongelli^{3,4}, Michel Thiebaut de Schotten², Laurent Cohen²; ¹UCSF, ²Institut du Cerveau et de la Moelle épinière (ICM), Paris, France, ³Max Planck Institute for Psycholinguistics, Nijmegen, Netherlands, ⁴University of Amsterdam, Netherlands

Anatomical connectivity profiles play a causal role in the emergence of functional specialization. Thus, the specialization of the VWFA for reading has been linked to its preferential structural connectivity to distant language regions. We investigated how anatomical connectivity relates to the segregation of regions specialized for musical notation and words, within the ventral occipitotemporal cortex (vOT). In a cohort of professional musicians and non-musicians, we used probabilistic tractography to identify the connections of individual word and music reading peaks within left vOT. Despite the close proximity of these regions, we observed significant differences in structural connectivity in all participants, notably with music reading peaks more connected to posterior superior temporal regions than word peaks. Such differences independent from musical expertise could contribute to the partial segregation of music and word peaks. Furthermore, musical expertise modulated vOT connectivity in two ways. First, music tracts were larger in musicians than in non-musicians, associated with marginally higher connectivity to music-related regions. Second, the spatial similarity between music and word tracts was increased in musicians, consistently with the increased overlap of language and music functional networks in musicians, as compared to non-musicians. Hence, preferential connectivity to overlapping language and music distant regions may contribute to a partial co-localization of word and music reading regions in vOT, with subtler differences biasing more posterior regions for music reading.

Topic Area: LANGUAGE: Other

E62 A functional role for primary motor cortex in memory for manipulable and handwritten words

Chelsea Gordon¹, Alexandria Pabst¹, Ramesh Balasubramaniam¹; ¹University of California, Merced

Processing manipulable words activate premotor and parietal cortices involved in the manipulation of that object despite the absence of movement. Previous work also indicates motor cortex involvement during the perception of handwritten and typed words. Primary motor cortex (M1) has been implicated in the formation and consolidation of implicit motor memories, however not much is known about its functional role in semantic memory. In the present study, we exposed participants to videos of 90 words, one at a time, to be encoded for later recognition. Half of the presented words had manipulable referents (e.g., spoon) while the other half had non-manipulable referents (e.g., opinion). One-third of each group of the words were handwritten, one-third typed, and one-third were static words. Finally, half of the participants (17) received continuous theta-burst stimulation (cTBS) to M1 to downregulate neural activity in this region, while the other half (17) received sham stimulation. Once the learning phase was complete, participants were asked to perform a recognition test for the previously viewed stimuli. We found that downregulating M1 led to decreased recognition for words with

manipulable referents and greater recognition for words for nonmanipulable referents. We also found that while sham participants had the shortest reaction times when recognizing manipulable words that were learned as handwritten, M1 participants had higher reaction times when words were both handwritten and manipulable. These findings highlight the functional role of M1 in handwritten word perception, and in memory for certain kinds of semantic content.

Topic Area: LANGUAGE: Semantic

E63 How are abstract concepts neurally represented across languages?

Robert Vargas¹, Marcel Just¹; ¹Carnegie Mellon University

Previous work suggests that abstract concepts can be defined, in part, on their Verbal Characterization [how much a concept is defined in terms of other concepts (e.g. faith [more verbal] vs. gravity [less verbal])]. Considering that verbal processing is a function of language, differing cultures and languages could influence the degree of generalizability of abstract concepts. Neural representations of 28 abstract concepts (defined as activation levels across 120 voxels with a stable semantic tuning curve across concepts) were assessed between a group of native English speakers and native Mandarin Chinese speakers. A classifier (Gaussian Naive Bayes) trained on neural signatures in a subset of the data for each subject decoded the concepts in an independent subset (mean rank accuracy was 0.82 for English speakers and 0.62 for Mandarin speakers, chance threshold = 0.53, $p < 0.01$). Representational similarity across languages was assessed by correlating the activation patterns of individual concepts using a previously defined network which dissociates between verbal and sensorimotor processing of abstract concept representations. Results show that concepts related to Mathematics and Physics shows high similarity across English and Mandarin (e.g. force, multiplication, subtraction, heat, acceleration, and gravity) while concepts previously thought to rely on primarily verbal processing were dissimilar across languages (e.g. truth, faith, and ethics). In conclusion, abstract concepts which rely more on sensorimotor function are more common across language while abstract concepts which rely more on verbal process tend to be more language specific.

Topic Area: LANGUAGE: Semantic

E64 Learning an artificial sign language: An ERP study

Tania Delgado¹, Jared Gordon¹, Seana Coulson¹; ¹University of California, San Diego

Recent work in cognitive science has addressed how communicative pressures impact the structure of the language system to increase its learnability. One claim that has emerged from this work is that cultural evolution makes languages more amenable to the neural processing architecture. Here we address this claim by recording EEG as participants learned an artificial semiotic system that used gestures to convey concepts from six different domains (cooking, photography, beauty salons, church, prison, and concert halls). In each domain, there was a person (e.g. chef), location (restaurant), object (frying pan), and action (to cook). For half of the conceptual domains, signals were improvised pantomimes; signals for the other conceptual domains were derived from an artificial sign language that had been subject to cultural evolution. Taken from a previous laboratory study on iterated language learning, evolved signs included gestural markers that indicated whether its referent was a person, location, object, or action (Motamedi et al., 2016). In the EEG study, participants were shown videos of gestures that were either improvised or evolved. After each video, a word appeared and participants pressed a key to indicate whether the word matched or mismatched the previous sign. For both improvised and evolved signs, mismatches elicited larger amplitude N400 than matches ($F(1,31)=34.4$,

$p < .0005$). However, mismatch effects were more prominent in evolved signs ($F(28,868)=1.6$, $p < .05$). This study provides a clearer view of how cultural transmission alters language to adapt to a learner's brain.

Topic Area: LANGUAGE: Semantic

E65 The frontal post-N400 positivity is elicited to unexpected-plausible words in low, but not weak, constraining contexts

Patrick Ledwidge¹, Adam Ramsey¹, Chloe Huston¹; ¹Baldwin Wallace University

The distinct operations underlying the frontal and posterior post-N400 ERP positivities (PNP) are a matter of recent conversation. It has been suggested that syntactically and semantically incongruent words require a revised parse of the sentence and elicit the posterior PNP. Conversely, the frontal PNP seems to reflect failed semantic predictions to unexpected but plausible words in low, moderate, or high-constraining contexts. The goal of this study, however, was to examine the role of the frontal PNP to unexpected-plausible words within contextually ambiguous, weak constraining sentences in which expectations for upcoming words are vague or ambiguous. During EEG recording, 36 neurotypical undergraduates read narrative discourses that were initially contextually ambiguous, and thereby providing little-to-no lexical expectations (weak constraint). A descriptive title was presented after sentence 1 ($n = 13$), sentence 2 ($n = 11$), or not presented ($n = 12$). We hypothesized that frontal PNP amplitudes would be greater before the title (weak constraint-unexpected-plausible), but not after (high constraint-expected). Contrary to our hypothesis, the frontal PNP (740-1300ms) did not differ between the weak constraint unexpected-plausible words and high constraint expected words. However to unexpected-plausible words, the frontal PNP was significantly larger in the low constraint than the weak constraint context. Based on these findings, we suggest that unexpected-plausible words in weak constraining contexts do not elicit a frontal PNP, possibly because no prediction exists and thus cannot be violated. Rather, a context must be accessible (even if only providing a low constraint) for unexpected-plausible words to elicit the frontal PNP.

Topic Area: LANGUAGE: Semantic

E66 The Linguistic-Gestural Processing of Self-Adaptors, Emblems, and Iconic Gestures: An fMRI study

Kawai Chui¹, Kanyu Yeh¹, Ting-Ting Chang¹; ¹National Chengchi University, Taiwan

The study investigated the neural network for the processing of symbolic and non-symbolic meanings across speech and gesture. Self-adaptors, emblems, and iconic gestures are optimal to form a continuum of semantic distinctions in relation to the accompanying speech. The linguistic-gestural stimuli were presented in a setting that very much resembled that of daily conversation with a speaker and an addressee, a wide variety of clauses and gestures, and the participants not performing any specific task. The results showed common brain regions for both symbolic and non-symbolic gestures with stronger activations in right and left fusiform gyri, and for speech in bilateral superior temporal gyri. Differences were found, in that iconic gestures elicited greater activation than emblems in right and left fusiform gyri, precuneus, left superior parietal lobule, right supramarginal gyrus and left anterior cingulate cortex, whereas self-adaptors elicited increased levels of activation in bilateral superior parietal lobules than emblems. Altogether, the findings showed that the brain is sensitive to meanings presented across modalities (Holle et al., 2008; Xu et al., 2009). The brain regions involved in speech-gesture integration varied across types and cross-modal semantic relations. Gestures with symbolic meanings directly related to speech primarily recruited regions associated with visual processing and episodic memory since the gestural meaning was determined vis-à-vis the accompanying speech that they

depicted different aspects of the same event. On the contrary, higher demands of visual feature discrimination were needed for processing non-symbolic gestures (Buccino et al., 2001).

Topic Area: LANGUAGE: Semantic

E67 Left inferior frontal gyrus less active for greater syntactic complexity: Magnetoencephalography evidence from minimal Arabic phrases and sentences

Suhail Matar^{1,2}, Julien Dirani², Alec Marantz^{1,2}, Liina Pykkänen^{1,2}; ¹New York University, ²New York University Abu Dhabi Research Institute

A growing body of literature has generated several disparate hypotheses regarding a fundamental question in language processing: Which brain regions are responsible for syntactic processing? Hypotheses include: a) Syntax is not processed independently in the brain; b) Syntactic processing is distributed across several left-hemispheric regions, and c) The left inferior frontal gyrus (LIFG) –specifically, the pars opercularis– is the locus of syntactic structure building. In this magnetoencephalography (MEG) study, we attempt to tackle this disparity by using an adjectival modification paradigm in Standard Arabic. Fifteen participants read grammatical noun-adjective phrases ('truck red'/'the-truck the-red', meaning 'a/the red truck'), or sentences ('the-truck red', meaning 'The truck is red.'). Though lexical content is identical, and though they are visually minimally different, sentences are more syntactically complex than phrases, since they include tense information. We find an increase in MEG-measured activity in the left anterior temporal lobe (LATL) for both phrases and sentences, compared to single adjectives – in line with previous studies implicating the LATL in basic composition. Contrary to hypothesis (c), activity in the pars opercularis is lower for the syntactically complex sentences compared to phrases, 270-320ms after adjective onset. Our results provide evidence against all the hypotheses above. They indicate separate semantic and syntactic processing of our stimuli. Additionally, rather than syntactic structure building, the LIFG's role appears to be different, perhaps reflecting structure projection as has been recently proposed (Matchin et al., 2018): unlike our sentences, the simple phrases could be driving the anticipation and projection of upcoming syntactic structure.

Topic Area: LANGUAGE: Syntax

E68 Shared neural representations of syntax during an online dyadic communication

Wenda Liu¹, Holly P. Branigan², Lifan Zheng¹, Yuhang Long¹, Martin J. Pickering², Chunming Lu^{1,3}; ¹State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, ²Department of Psychology, University of Edinburgh, ³IDG/McGovern Institute for Brain Research, Beijing Normal University

When people communicate, they come to see the world in a similar way to each other by aligning their linguistic representations. However, the neural mechanism for shared syntactic representations between communicators is still not well understood. Here we addressed this issue by measuring the brain activity of both communicators in a series of dyadic communication contexts, by employing the functional near-infrared spectroscopy (fNIRS)-based hyperscanning approach. Two communicators alternatively spoke sentences with either the same or with different syntactic structures. Results showed a significantly higher-level increase of interpersonal neural synchronization (INS) at right posterior superior temporal cortex when communicators produced the same syntactic structures compared to the condition when they produced different syntactic structures. These increases of INS correlated significantly with the communication quality. These findings suggest that INS underlies shared syntactic representations during an online dyadic communication, and brain areas in both hemispheres rather than the left hemisphere only, are involved in shared representations of syntax.

E69 Tool-use triggers improvements in syntactic abilities

Simon Thibault^{1,2,4}, Véronique Boulenger^{3,5}, Alice Catherine Roy^{3,5}, Claudio Brozzoli^{1,2,4,6}; ¹ImpAct Team, INSERM U1028, CNRS UMR5292, Lyon, France, ²Lyon Neuroscience Research Centre, ³Dynamique Du Langage, CNRS UMR5596, Lyon, France, ⁴University of Lyon 1, ⁵University of Lyon 2, ⁶Karolinska Institutet, Stockholm, Sweden

A core neural network (i.e. Inferior Frontal Gyrus and Basal Ganglia) is involved in both tool-use and syntactic processes. Sensorimotor learning is known to induce brain plasticity, therefore opening to possible beneficial transfer effects between tool-use and language. This study aimed to test whether syntactic functions improve after tool-use training in French native healthy adults. Syntactic abilities were measured via comprehension of complex relative clauses, before and after one of three possible training regimes. One group (N=21) underwent 18-minutes tool-use training requiring to insert pegs on a board with a pinch. To control for the specificity of the tool-use training benefits, two control groups were either trained on the same task with the hand (N=21) or instructed to watch a video during the same amount of time (N=19). Syntactic performance was indexed by inverse efficiency, ratio between response time and accuracy. Within each training group, the median of their initial syntactic abilities allowed to identify participants with high (HA) and low abilities (LA). Within-group ANOVAs show that HA participants solved the syntactic task significantly better after tool-use training compared to before, but not after hand training or video watching. The same analyses for LA participants reveal similar improvements regardless of training type. Overall, for HA participants a single tool-use session enhances syntactic abilities. The results in the control groups suggest that such enhancement is linked to the specific requirement of tool-use. These findings offer encouraging evidence for transfer effects from sensorimotor training to cognitive functions implemented in overlapping brain regions.

Topic Area: LANGUAGE: Syntax

E70 Tracking grammatical dependencies through interference

Albert Kim¹, Shannon McKnight¹; ¹University of Colorado, Boulder

We used event related potentials (ERPs) to investigate the ability of language comprehenders to represent grammatical dependencies, which link chunks of meaning in a sentence. 196 participants read sentences like 1-4, which contain a dependency between the subject noun “key” and the main verb “was/were”. This dependency faces potential interference from an intervening second noun, “cabinet(s)”, which may erroneously be linked to the verb. The key to the cabinet was in the drawer. Control No Attractor The key to the cabinet were in the drawer. Anomaly No Attractor The key to the cabinets was in the drawer. Control Attractor The key to the cabinets were in the drawer. Anomaly Attractor Across all subjects, sentences like 2 elicited a left anterior negativity (LAN) followed by a P600 ERP effect at the verb (“was” or “were”), relative to 1, indicating representation of the subject-verb dependency. Sentences like 4 elicited a smaller LAN+P600 response, relative to 1 or 3, indicating that the subject-verb dependency faced interference from the “agreement attractor” noun “cabinets” (replicating a previous finding by a different group). Sentence type 3 elicited a P600 effect relative to 1, indicating that participants erroneously pursued a dependency between the attractor noun and the verb (cabinets was), which is perceived as violating agreement constraints. Finally, participants spanned a continuum between people expressing LAN and P600 dominated effects. These LAN and P600 effects correlated with executive function ability, suggesting a relationship between executive function and the ability to track grammatical dependencies.

Topic Area: LANGUAGE: Syntax

E71 Common cortical representations during episodic memory retrieval

Gayoung Kim¹, Sue-Hyun Lee^{1,2}; ¹Department of Bio and Brain Engineering, College of Engineering, Korea Advanced Institute of Science and Technology (KAIST), ²Program of Brain and Cognitive Engineering, College of Engineering, Korea Advanced Institute of Science and Technology (KAIST)

Memory retrieval has been considered as reinstatement of previously encoded memory representations in the brain. Prior studies have reported that multiple cortical regions are involved in the episodic memory retrieval. However, because of the diversity of memory tasks and paradigms used in the prior research, it still remains unclear which cortical regions are commonly used in memory retrieval. To address this issue, we performed an event-related functional MRI experiment comprising separate learning and retrieval sessions. During the learning session, participants were presented with 6 short movie clips. One day after the learning, the participants conducted the retrieval session inside the scanner. In this session, there were two retrieval tasks: action retrieval task and context retrieval task. During the action retrieval task, the participants were instructed to focus on recalling the actor’s action while they were asked to attend to the recall of the context in which the action took place during the context retrieval task. Using multivariate pattern analysis, we found significant decoding of individual episodic memory traces in the intraparietal sulcus during both retrieval tasks. Moreover, to clarify whether action retrieval activates the neural populations that are also activated during context retrieval, we directly compared the response patterns observed during action retrieval and that during context retrieval. Focusing on the intraparietal sulcus, we found successful cross-generalization across the response patterns elicited during the action and context retrieval tasks. These suggest that the intraparietal sulcus is commonly recruited during episodic memory retrieval and represents shared information across different retrieval tasks.

Topic Area: LONG-TERM MEMORY: Episodic

E72 Cortical reinstatement in young and older adults

Paul F. Hill¹, Danielle R. King¹, Joshua D. Koen², Michael D. Rugg¹; ¹Center for Vital Longevity and School of Behavioral and Brain Sciences, University of Texas at Dallas, ²Department of Psychology, University of Notre Dame

Patterns of cortical activity elicited during recollection overlap with patterns elicited by the initial experience of the recollected event (‘cortical reinstatement’), and this retrieval-related activity is widely held to represent the ‘content’ of recollection. Hence, age-related differences in the strength of cortical reinstatement may contribute to age-related differences in the accuracy and specificity of recollection. Here, young (N=24, mean age 22 years) and older (N=24, mean age 70 years) adults underwent fMRI as they studied words paired with images of faces or scenes. At test, participants performed recognition judgments on old and new test words and, for each recognized word, tried to recall the category of the image paired with it at study. Using univariate analyses of mean-signal change, we operationalized cortical reinstatement as regions where category-selective encoding and recollection effects overlapped. To identify recollection effects that were unique to each image class, we exclusively masked each category-selective recollection contrast (source correct > source incorrect) with the analogous recollection contrast. We then inclusively masked the resulting recollection contrasts with the corresponding category-specific encoding contrasts (i.e., face > scene, scene > face). To eliminate potential reinstatement effects that varied by age, we exclusively masked each category-selective effect with the respective age by recollection interaction contrast. This procedure identified robust reinstatement effects for both faces (in precuneus and bilateral anterior medial temporal lobe) and scenes (in parahippocampal and retrosplenial cortex). In both cases, the effects were age-invariant. The data support prior findings suggesting that category-level cortical reinstatement effects are insensitive to age.

Topic Area: LONG-TERM MEMORY: Episodic

E73 Decoding power spectra in unimodal and multimodal episodic memory recollection

Megan Rudrum¹, Thomas H.B. FitzGerald¹, Heidi M. Bonnici¹; ¹University of East Anglia

Experiencing a memory completely and richly requires remembering many sensory features of an event. Integration of these sensory elements is required to enable recollection as a coherent and whole experience. Growing evidence suggests a role for the left lateral parietal cortex in vivid, multisensory remembering. In an fMRI study, Bonnici et al. (2016) show that the angular gyrus in the left parietal cortex has greater activity during multimodal episodic recall compared to unimodal suggesting its role in this integrative process of sensory features. In the present study, we extend this previous work and explore the modifications of scalp EEG power spectra in unimodal and multimodal memory recollection. Participants first learnt three clips for each mode category: audio (just sound), visual (silent video), and audiovisual (audio and visual combined). Each clip was preceded by a representative cue word and practiced being recalled within a six second period as vividly and accurately as possible. During EEG recording, in each trial participants were presented with a cue word and asked to recall the associated clip within six seconds, as they had been trained. Time-frequency analysis revealed no differences between modality in oscillatory power within theta and gamma bands. In conclusion, the findings suggest that the neural oscillation power in theta and gamma bands are not sensitive to modality during recollection of detailed episodic experiences.

Topic Area: LONG-TERM MEMORY: Episodic

E74 Distinct regions of the human hippocampus are associated with memory for different spatial locations.

Brittany Jeye¹, Sean MacEvoy¹, Scott Slotnick¹; ¹Boston College

In the present functional magnetic resonance imaging (fMRI) study, we evaluated whether distinct regions of the hippocampus were associated with spatial memory for items presented in different locations of the visual field. During encoding, participants maintained fixation and viewed abstract shapes presented in the upper-right quadrant, the lower-right quadrant, the upper-left quadrant, or the lower-left quadrant. During retrieval, old shapes were presented at fixation and participants classified each shape as previously in the "upper-right", "lower-right", "upper-left", or "lower-left". Analyses revealed that accurate spatial memory for shapes in each quadrant of the visual field was associated with distinct hippocampal sub-regions (identified by contrasting hits > misses for each quadrant). For instance, accurate spatial memory for shapes in the upper-right quadrant was associated with activity in hippocampal sub-regions that were distinct from the hippocampal sub-regions associated with accurate spatial memory for shapes in the lower-right, upper-left, and lower-left quadrants. A multi-voxel pattern analysis (MVPA) of hippocampal activity revealed a significant correlation between behavioral spatial location accuracy and hippocampal MVPA accuracy across participants. The present results indicate that unique hippocampal regions are associated with different visual field locations during memory and that patterns of activity in the hippocampus contain information about spatial location.

Topic Area: LONG-TERM MEMORY: Episodic

E75 Examination of the role of alpha oscillations and attention in the modulation of episodic memory by value

Jessica E Brown¹, Briana M Silck¹, Robert S Ross¹; ¹University of New Hampshire

Episodic memory is the ability to remember the events of one's life and is supported by brain oscillations which may be modulated by the value of to be remembered information. Decreases in alpha oscillations (8-13 Hz) are present when an individual is attending to a stimulus and have been associated with successful recognition memory. Additionally, individuals show better memory for information associated with high compared to low value rewards. The better episodic memory for higher rewards may be due to value influencing episodic memory processing. However, higher valued rewards may lead to increased attention to those rewards instead of memory processing itself. In this study, neurotypical adults completed a recognition memory task where 200 object stimuli were placed in colored background contexts with high (n = 100) and low (n = 100) value during learning while undergoing EEG brain activity recording. During retrieval, participants were shown the stimuli again mixed with new stimuli without the contexts being present and asked which context they saw the stimulus in during the learning phase. The images placed in high-value contexts showed significantly more accuracy than the images shown in low-value contexts. The images in the high-value context also showed more alpha desynchronization over posterior parietal areas than the images in the low-value context. These oscillatory differences indicate that individuals may devote more attention to contexts that they value more and therefore have a better memory for information associated with these high-value contexts.

Topic Area: LONG-TERM MEMORY: Episodic

E76 How memory reinstatement changes over time

Camille Gasser¹, Alexa Tomparny², Lila Davachi¹; ¹Columbia University, ²University of Pennsylvania

Adapting to our environment relies on our capacity to form and retrieve lasting memories. Understanding how memories strengthen and transform over time and through consolidation processes is critical to understanding how these memories might guide behavior. For example, successful retrieval has been associated with stronger reinstatement of encoding activity patterns. Specifically, enhanced representational similarity between encoding and retrieval brain activity patterns (called encoding-retrieval similarity, or ERS) has been shown during successful retrieval in regions including sensory cortex, posterior medial cortex (PMC), angular gyrus, and hippocampus. The current research asks how the location and strength of reinstatement changes over time, potentially as a result of post-encoding consolidation processes. In a multi-day fMRI study, participants encoded a series of object-scene pairs. They were asked to retrieve half of these associations during an immediate memory test, and the remaining half during a delayed memory test one week later. We found that category-selective cortical regions such as lateral occipital cortex and parahippocampal place area showed evidence of episodic reinstatement only during immediate retrieval, and a searchlight analysis revealed a cluster in occipital cortex that exhibited significantly greater reinstatement during immediate relative to delayed retrieval. By contrast, right hippocampus showed significant reinstatement only after a week-long delay, and PMC exhibited reinstatement at both immediate and delayed retrieval. Future analyses will ask how these reinstatement effects are related to post-encoding connectivity between the hippocampus and neocortex, which likely contributes to the stabilization or transformation of mnemonic representations over time.

Topic Area: LONG-TERM MEMORY: Episodic

E77 Incentivizing visual search performance impairs incidental memory encoding.

Allison Neeson¹, Sarah DuBrow², Lena Skalaban³, Lila Davachi⁴, Vishnu Murty¹; ¹Temple University, ²University of Oregon, ³Yale University, ⁴Columbia University

Reward incentives have been shown to enhance hippocampal-dependent memory benefits, for both rewarded events and non-rewarded salient events during reward anticipation. However, some evidence suggests that certain factors, such as performance anxiety, may negate or diminish reward modulated memory benefits. To further elucidate how performance incentives interact with incidental memory encoding, we investigated how incentivizing performance on a rewarded visual search task influenced subsequent memory. Sixty participants performed a visual search task in which they were instructed to find hidden objects embedded in complex scenes. We instructed participants in the performance group (n=30) to practice for a later rewarded test, while we provided trial-by-trial performance feedback. Participants in the control group (n=30) completed the visual search task without any mention of a future rewarded test or performance feedback. Immediately following the task, both groups completed three surprise memory tests. Participants in the performance group performed faster and more accurately on the visual search task, which was congruent with their performance goals. However, for the surprise memory tests, we found that both object memory ($p = 0.02$) and object-scene associative memory ($p = 0.007$) were significantly worse for the performance group versus the control group, while there was no between-group difference in object-position memory. These findings suggest that inducing a performance-mindset during a visual search task can impair incidental memory encoding, despite reward motivation. Future work will investigate which factors underlie these performance decrements, such as arousal and levels of processing.

Topic Area: LONG-TERM MEMORY: Episodic

E78 Mnemonic Similarity Task shows deficits in familiarity recognition in Parkinson's disease without cognitive impairment

Nessa Kim¹, Colin McDaniel¹, Christian La¹, Tanusree Das¹, Kathleen Poston¹; ¹Stanford University

Although Parkinson's disease (PD) is characterized as a movement disorder, cognitive symptoms often manifest in several domains including in memory. Early-stage PD patients have shown impairment in immediate and delayed free recall of episodic memory. We explored whether PD is associated with disrupted episodic memory retrieval by investigating whether patients without mild cognitive impairment (PD-noMCI) show deficits in the discriminative ability of recognition memory when a memory or "mnemonic" cue is presented. We administered the Mnemonic Similarity Task (MST) to 17 PD-noMCI both on and off dopamine medication and to 18 age-matched healthy controls (HC). This task presents pictures of objects to be remembered. In the recognition test, subjects must determine whether the presented mnemonic item is an exact "repeat" of, similar to ("lure"), or unseen from before ("new"). Lure items were categorized depending on their level of similarity. Regardless of medication status, the PD and HC groups show similar response accuracy. However, we found PD both on and off medication incorrectly responded "new" to lures more frequently than HC. We investigated this performance within each bin and observed that while on medication, PD patients more frequently responded "new" to more similar lure items (bin 1, $p=0.002$; bin 2, $p=0.01$) and while off medication, more frequently to less similar lure items (bin 4, $p=0.03$) than HC. PD performance on incorrect trials suggests a potential deficit in familiarity with cues despite their mnemonic similarity with the initial presentation.

Topic Area: LONG-TERM MEMORY: Episodic

E79 Neural activity during episodic counterfactual thinking in anxious and non-anxious individuals

Natasha Parikh¹, Kevin S. LaBar¹, M. Zachary Rosenthal¹, Jacqueline DeRosa¹, Gregory W. Stewart¹, Felipe De Brigard¹; ¹Duke University

When people mentally revisit past regretful decisions, they often imagine alternative ways in which such events could have occurred instead. For individuals with anxiety, episodic counterfactual thinking (eCFT) can become persistent and debilitating. Yet, little is known about neural differences between anxious and non-anxious individuals during eCFT, and less is known about the effects of eCFT on the autobiographical memories (AM) they are derived from. The current study explores these issues. Participants provided 45 regretful memories and rated them on emotional impact. During fMRI, participants first remembered their AM. The AM were assigned to three conditions. In the remember condition, participants simply moved on to the next memory. Otherwise, participants then imagined better ways (upward eCFT condition) or worse ways (downward eCFT condition) the memory could have occurred. Finally, participants reactivated all AM, re-rated their emotional impact, and recalled the condition in which each was presented previously. We found that people with higher anxiety showed activation in lateral prefrontal, insula, and caudate during upward eCFT creation but more temporal pole activity during downward eCFT creation. Furthermore, people with higher anxiety also showed differential engagement of structures such as the parahippocampal and middle temporal gyri during AM recall as a function of having been previously reactivated either in an upward or a downward eCFT. Together, these results suggest that people with higher, but not lower, levels of anxiety are differently recruiting the brain during counterfactual creation, and these neural differences are carried into the way the associated AM is later reactivated.

Topic Area: LONG-TERM MEMORY: Episodic

E80 Neural signatures of memory content and temporal distance identified using overt, in-scanner autobiographical memory retrieval

Adrian W. Gilmore¹, Alina Quach¹, Sarah E. Kalinowski¹, Stephen J. Gotts¹, Daniel L. Schacter², Alex Martin¹; ¹National Institute of Mental Health, NIH, Bethesda, MD 20892, ²Harvard University, Cambridge, MA 02138

What regions support the retrieval of information from memory? Recent work has suggested that the answer to this question lies critically in the nature of to-be-remembered material. Research in autobiographical memory has consistently implicated roles for regions such as medial prefrontal and medial parietal cortex and the medial temporal lobe. Critically, our understanding of autobiographical retrieval has been hampered by limitations of research methods—typical fMRI studies rely on periods of covert recall that obscure both the order in which event details are recalled as well as the manner in which they are re-experienced. Here, we extended this prior literature by asking participants (N = 40) to engage in 2-minute periods of continuous overt (spoken) recall while undergoing multi-echo fMRI. In response to retrieval cues, participants recalled memories from 3 time periods: earlier in the same day, approximately 1 year prior, or a period of 5-10 years prior. As a non-autobiographical control condition, participants were asked to describe events being depicted in photographic images. fMRI data were denoised using multi-echo ICA. Regions associated with autobiographical retrieval included posterior cingulate and medial prefrontal cortex, whereas regions associated with controlled retrieval (particularly in lateral prefrontal cortex) were associated with the picture description task. Effects of temporal distance were observed in regions associated with stimulus familiarity, including the parietal midline. These findings support recent separations of the neural correlates of autobiographical and "lab-based" retrieval tasks, and highlight an important role for overt recall in understanding retrieval processes in human memory.

Topic Area: LONG-TERM MEMORY: Episodic

E81 Post-Encoding Amygdala-Cortical Connectivity Is Related to Valence-Specific Emotional Memory Biases

The modulatory role of the amygdala in 'online' encoding of emotional events is well-documented, and yet its potential role to modulate human episodic memory during 'offline' post-encoding periods in a valence-specific manner has not been clarified. While prior work has shown greater retrieval-related reactivation of visuosensory encoding processes for negative memories, we test the novel hypothesis that increased amygdala-visuosensory coupling following encoding predicts inter-individual differences in the degree of negative memory bias, defined as better memory for negative as compared to positive stimuli. Twenty-nine young adults were scanned as they incidentally encoded negative, positive, and neutral pictures, each briefly preceded by a line-drawing sketch of the picture. Twenty-four hours later, participants were scanned during a surprise recognition memory task in which all of the old sketches and an equal number of new sketches were presented for an Old/New judgement. Resting-state scans were collected immediately before and after encoding, allowing us to measure the relation between inter-individual differences in pre-to-post encoding increases in amygdala resting-state functional connectivity (RSFC) and negative memory bias. RSFC analyses revealed increased amygdala coupling with visuosensory and frontal regions predicted the degree of negative and positive memory bias, respectively. These findings support the modulatory role of the amygdala following encoding and provide the first demonstration that the targets of modulation are associated with the degree and direction of emotional memory bias. Future work is needed to understand how these post-encoding mechanisms could map on to exaggerated negative memory biases in psychopathology and positive memory biases in aging.

Topic Area: LONG-TERM MEMORY: Episodic

E82 Pre-trial fluctuations in pupil diameter affect goal-state orienting and accuracy during episodic remembering

Kevin P. Madore¹, Anna M. Khazenzon¹, Cameron W. Backes², Anthony D. Wagner^{1,3}; ¹Department of Psychology, Stanford University, ²Symbolic Systems Program, Stanford University, ³Wu Tsai Neurosciences Institute, Stanford University

Moment-to-moment interactions between goal states, attention, and episodic memory retrieval may influence when individuals remember and when they forget. We recorded concurrent EEG+pupillometry during an encoding/retrieval paradigm with 80 young adults to examine how (a) multimodal indices of attentional lapses relate to goal-state representation and episodic memory, and how (b) trait differences in media multitasking, attentional control, and related constructs may contribute to these relationships. At encoding, participants performed two tasks, classifying individual objects on either a conceptual or perceptual dimension. At retrieval, participants oriented to one of three retrieval goals (concept before? vs. percept before? vs. new item?) and then viewed an old or new object and made the retrieval judgment. We examined how trial-by-trial tonic fluctuations in pupil diameter (a) before orienting to the retrieval goal and (b) before viewing the object and making the retrieval judgment affect accuracy. Across goal states, fluctuations in pre-trial pupil diameter (1000ms before goal orienting) significantly predicted retrieval performance — average pre-trial pupil diameter was lower for misses than hits. Moreover, variability in pre-trial pupil diameter (1000ms before viewing the object and making the retrieval judgment) significantly predicted responses across goal states — variability was higher for false alarms than correct rejections. Higher scores on media multitasking and inattention were significantly negatively related to d' for each orienting/goal-state condition. Increases in inattention were also related to pronounced pupil-accuracy relationships. These results highlight how preparatory attention and goal-state representation impact episodic remembering.

Topic Area: LONG-TERM MEMORY: Episodic

E83 Strengthening structure: learning modulates event segmentation

Oded Bein¹, Lila Davachi²; ¹New York University, ²Columbia University

Most of our everyday life is highly predicted and repetitive. For example, we typically take the same route to the same office. Event segmentation theories posit that continuous experience is segmented into discrete episodes, or events, at event boundaries. It has been hypothesized that an "event model" is maintained to guide behavior within each event, and that 'event-boundaries' result from a context change which elicits a prediction-error, signaling the need for a new event model. But how is event segmentation influenced by repeated events as they become more predictable, as in our everyday life? We examined event segmentation over repetition. Participants viewed black-and-white objects superimposed on a color background. The background color changed every 4 objects, creating an event boundary. Each list repeated 5 times and was followed by an order memory test for pairs of objects from the list. Behaviorally, markers of event-segmentation evident in prior work with once-presented lists persisted even when lists repeated. These included: longer encoding response times (RTs) at the boundary and faster RTs during within versus across event order memory judgments. Neurally, different brain regions demonstrated varying sensitivity to event-structure, which differentially changed with repetition. Focusing on hippocampal sub-regions, multivariate representational similarity analysis revealed that the dentate gyrus may contribute to segmentation by promoting pattern separation of items occurring across an event boundary. These results suggest that repeating events are still segmented in memory and that different regions may support learning of different aspects of the structure of our environment.

Topic Area: LONG-TERM MEMORY: Episodic

E84 Testing frequency specificity of noninvasive brain stimulation effects on hippocampal network involvement in recollection success versus precision

Shruti Dave¹, Molly Hermiller¹, Aneesh Nilakantan¹, Melissa Gunlogson¹, Brennan Durr¹, Erica Karp¹, Stephen VanHaerants¹, Joel Voss¹; ¹Northwestern University

The quality of information retrieved during successful episodic recollection can vary in precision. Noninvasive neurostimulation has been used to test the causal role of the distributed hippocampal network for recollection success versus precision, with some evidence indicating that multi-day high-frequency transcranial magnetic stimulation can improve recollection precision but not success. However, memory outcomes such as precision could respond preferentially to specific stimulation patterns, such as those that mimic the endogenous theta-nested-gamma activity profile characteristic of memory processing by the hippocampal network. Here, we tested for frequency specificity using single-day stimulation applied at theta or beta frequencies to characterize noninvasive access to the hippocampal-cortical network and its episodic memory functions. Subject-specific stimulation locations in left parietal cortex were identified based on their baseline fMRI connectivity with the hippocampus. In a within-subjects study (N = 16), theta, beta, or sham control stimulation was delivered prior to an episodic memory task involving object-location associations. Both stimulation types increased spatial recollection precision relative to sham. Critically, effects of noninvasive stimulation were selective for recollection precision versus success. Additional analyses of fMRI connectivity changes due to stimulation collected during episodic memory encoding for each of the stimulation sessions will be used to identify mechanisms of recollection precision changes due to stimulation. These findings indicate that the hippocampal posterior-medial network targeted by stimulation is crucial for episodic memory precision, without substantial variation based on the pattern of stimulation used to engage the network.

Topic Area: LONG-TERM MEMORY: Episodic

E85 The Effects of Age on Subjective and Objective Estimates of Recollection

Saad A. Alghamdi^{1,2}, Paul F. Hill¹, Michael D. Rugg^{1,3}; ¹Center for Vital Longevity, University of Texas at Dallas., ²King Saud University, Riyadh, Saudi Arabia., ³University of Texas Southwestern Medical Center.

Episodic memory performance declines steeply with increasing age. It has sometimes been reported however that this decline is more marked when recollection is estimated by 'objective' measures such as source memory performance than when it is estimated by 'subjective' measures such as the 'Remember/Know' procedure. Here, our main goal was to directly contrast recollection estimates derived from these procedures in the same samples of young and older participants (24 adults per age group). Following identical study phases in which words were paired with either faces or scenes, participants' memories were assessed in separate test blocks using either Remember/Know or source memory procedures. Contrary to several prior reports, the deleterious effects of age on recollection estimates did not differ according to test type. Thus, we found no evidence that age differentially impacts subjective and objective recollection estimates. Additionally, and consistent with prior findings, effects of age on estimates of familiarity-driven recognition were small and non-significant.

Topic Area: LONG-TERM MEMORY: Episodic

E86 The impact of semantic processing on memory encoding, brain oscillations and representational similarity in EEG

Marie-Christin Fellner¹, Martina Bauer¹, Nikolai Axmacher¹; ¹Institute of Cognitive Neuroscience, Ruhr University Bochum

Semantic processing crucially influences memory encoding and retrieval, however controlling semantic content of stimuli in an experimental setting is challenging. Humans tend to process meaningless stimuli semantically and see meaning even in abstract shapes. We here made use of this spontaneous semantic processing by presenting random line drawings, so-called squiggles. In experiment 1 (N=20) the squiggles were presented repeatedly and rated for meaningfulness. On average 38% of squiggles were rated as meaningful (M+). These ratings were intraindividually stable and correlated to later naming of the squiggle, while interindividually ratings and naming were varying between squiggles. Presentation of M+ rated squiggles was accompanied by stronger decreases in alpha/beta power (~8-20Hz) at widely distributed brain sites. Representational similarity analysis revealed significant item-specific information across repetitions only for M+ items. Similarity of EEG responses between M+ items was significantly correlated with the amount of semantic similarity between the names later chosen for the squiggles by a given participant. These findings demonstrate that subjective meaningfulness is based on semantic processing of the M+ items. In a second EEG experiment (N=24) we added a recognition memory task after the meaningfulness rating. Recognition rates were significantly higher for M+ than M- items. Both M+ ratings and successful memory encoding were accompanied by stronger decreases in alpha/beta power. The results demonstrate a link between semantic processing, memory formation and decreases in alpha/beta power. A third ongoing experiment 3 applies Experiment 1 in the MRI scanner to shed further light on the regions involved in generating subjective meaningfulness.

Topic Area: LONG-TERM MEMORY: Episodic

E87 Time course of encoding and delayed recognition in human memory

Domile Tautvydaite¹, Alexandra Adam-Darque¹, Aurélie L. Manuel¹, Armin Schnider¹; ¹Laboratory of Cognitive Neurorehabilitation, University Hospital of Geneva and University of Geneva, Switzerland

The medial-temporal lobe (MTL) is crucial for encoding novel information, but may also be involved in memory retrieval and recognition (Nadel & Moscovitch, *Curr Opin Neurobiol* 1997). The time course of these processes is unknown. Recent evoked potential studies suggested that MTL-mediated encoding may be an early process, occurring 200-300 ms after stimulus presentation (James et al., *Hippocampus* 2009; Thézé et al, *Hippocampus* 2017). In the present study, we juxtaposed encoding and recognition in a single continuous recognition paradigm (CRT) with meaningful designs. 20 healthy subjects performed a CRT containing New stimuli (New trials), thought to induce encoding, which were then repeated up to 4 consecutive times (RepX trials), a procedure thought to produce an over-familiarity with the stimulus. These stimuli later reappeared after 9 to 15 intervening items, thus requiring recognition (LateRep trials). Waveform ERP analyses yielded a strong frontal positivity in response to New stimuli at 320-435 ms in comparison to RepX and LateRep trials, suggesting that encoding occurs in this early period. LateRep trials, in comparison to New stimuli and RepX trials, induced a strong posterior positivity at 435-500 ms, indicating that recognition occurs in this late period. These results suggest that encoding of novel stimuli is initiated before recognition of previously encountered material. The results complement earlier studies indicating rapid limbic influences on memory processing, not only for encoding, but also for orbitofrontal reality filtering (Thézé et al. *Front Behav Neurosci* 2017).

Topic Area: LONG-TERM MEMORY: Episodic

E88 Composing Concepts: EEG oscillations during integration of visual, lexical, and auditory stimuli

Hannah M. Morrow¹, Jordan Barry¹, Eiling Yee¹; ¹University of Connecticut

According to current views of semantic memory, our conceptual knowledge about concrete objects is represented (in part) across the brain regions that are active when those objects are perceived. But how is information from those regions integrated, or "bound" into a coherent whole? One mechanism proposed to support binding is the synchronized firing of neurons (e.g., Singer & Gray, 1995). In particular, gamma-band activity may support local interactions, while theta-band activity may support longer-range interactions (Von Stein & Sarnthein, 2000). To test this theory, we recorded participants' EEG while they were presented with pairs of visual and auditory stimuli that were either congruent or incongruent (e.g., a picture of a lion followed by either a roar, or a bang sound, respectively), with the prediction that integration should be greater for congruent pairs (Schneider et al., 2008). Critically, we also manipulated whether the sounds following the pictures were non-lexical (e.g., a roar sound) or lexical (e.g., the word "roar"), predicting that the interactions involved in integrating lexical information would be longer-range (e.g., from visual areas to anterior temporal lobe and/or inferior frontal gyrus) and thus produce more theta-band activity compared to integrating non-lexical information, which we predicted would produce more local gamma-band activity. Consistent with these predictions, we found that pictures followed by congruent auditory words produced greater theta, whereas pictures followed by congruent non-lexical sounds produced greater gamma. These results add to evidence that neural synchrony supports binding, and that the cortical distance may influence which frequencies are involved.

Topic Area: LONG-TERM MEMORY: Semantic

E89 Predicting Semantic Fluency Using Large-scale Language Corpora

Ming Hsu^{1,2}, Zhihao Zhang¹, Andrew Kayser^{2,3,4}; ¹Haas School of Business, University of California, Berkeley, ²Helen Wills Neuroscience Institute,

Semantic memory – our acquired knowledge of the world – plays a central role in human behavior. Disorders of semantic memory, as assessed by category fluency and other tasks, characterize important neurological diseases and are routinely evaluated in clinical settings. Despite a rich literature on the computational mechanisms of semantic memory retrieval, the few studies that attempt to quantitatively predict its output (e.g. Griffiths et al 2007) still rely on prior data collected from human participants. Here we examine the feasibility of predicting semantic fluency using publicly available large-scale language corpora, including news and social media, by leveraging recent advances in artificial intelligence and natural language processing. Specifically, we evaluate word embeddings models that represent words as vectors in a high dimensional space based on their distributional and semantic properties. As a first step, we hypothesized that items with higher similarity to the cue would have higher probability of being recalled in the fluency task. To test this hypothesis, we collected semantic fluency data for a variety of consumer product category cues, and compared the empirical recall probabilities against predictions generated by word embeddings. We find a consistently high degree of accuracy in tracking empirical retrieval probability across different cues ($p < 0.001$ to $p < 0.05$), indicating that reliable semantic memory signals can be extracted from large-scale text corpora. Models for more detailed predictions (e.g. item-item transitions) are under development. Together these initial findings show the promise of applying quantitative approaches from computational linguistics to better understand memory processes.

Topic Area: LONG-TERM MEMORY: Semantic

E90 Semantic Richness in Preclinical Alzheimer's disease

Nathaniel Klooster¹, Arun Pilania¹, David Wolk¹, Anjan Chatterjee¹; ¹University of Pennsylvania

Patients with preclinical Alzheimer's disease (AD) display evidence of cerebral amyloid, but perform normally on neuropsychological assessment. Measures sensitive to subtle cognitive change during this stage of disease would have significant impact for screening and measuring outcomes in intervention studies. We tested the hypothesis that semantic richness changes early in the AD trajectory. Here, we assess productive and receptive semantic richness, using tests adapted from the psycholinguistic and language-learning literatures in older adults and relate performance to structural imaging and molecular PET imaging (Amyloid and Tau). The Word Associates Test (WAT) measures depth of vocabulary used in first and second-language learning research. Participants choose four correctly matching synonyms or collocations from among eight possibilities for each target word. The number of senses a word can take (e.g. pen: a writing instrument, to write a letter, an enclosure for animals, the University of Pennsylvania) is a measure of semantic richness used widely in psycholinguistic studies. In the Senses-listing task, participants are given one minute to list as many senses as possible for target words chosen from normed databases. Performance across tasks differentiates MCI patients from healthy participants. In healthy participants, integrity of MTL subregions vulnerable to early AD pathology, including perirhinal and entorhinal cortices, predicts performance, and amyloid status in cognitively "normal" adults shows a trend in predicting performance. These preliminary results highlight the necessity of the MTL for rich semantic knowledge and suggest that probing semantic memory shows promise in differentiating healthy aging from preclinical AD.

Topic Area: LONG-TERM MEMORY: Semantic

E91 The Influence of Exploratory Choice on Semantic Search

Nathan Tardiff¹, Sharon L. Thompson-Schill¹; ¹University of Pennsylvania

While much work has focused on the determinants and neural correlates of exploratory choice, the consequences of exploration for information processing and behavior are less well understood. Semantic search is one domain in which differences in exploratory state are likely to affect performance. Indeed, there are established parallels between exploratory foraging behavior and semantic search in verbal fluency tasks (e.g., animal naming), where subjects' output consists of patches or clusters of closely related words interspersed with switches to new clusters. In this study, subjects completed a two-armed bandit task prior to generating animal names. Importantly, volatility in the bandit task was manipulated between subjects (high vs. low) in order to produce differences in the frequency of exploration and thus exploratory state. We considered two alternative hypotheses: 1) increased exploration in the high volatility condition would lead to increased switching during naming and greater semantic distance between items; 2) increased neural gain post-exploration might make it easier to stay in a patch by reducing retrieval competition, potentially leading to less switching and less semantic distance between items in the high volatility group. Our volatility manipulation was successful, with the high volatility group exploring in the bandit task significantly more than the low volatility group. While we found no effect of the volatility manipulation on naming, the amount of time since exploration did affect performance: subjects who explored in the last two trials produced animal name lists with greater average semantic similarity than subjects who explored less recently.

Topic Area: LONG-TERM MEMORY: Semantic

E92 The organization of object concepts in modality specific brain association areas: A quantitative approach

skiker kaoutar¹, Maouene Mounir¹; ¹University of Abdelmalek Essaadi

In this paper, we propose a quantitative approach to describe how object concepts organize within modality specific association brain areas. Our approach builds on the idea that an object concept is distributed in different modality specific association areas as a collection of sensorimotor features learned through our experiences and interactions with objects (Lambon Ralph et al. 2017; Martin 2016). The data consists of familiar object concepts (eg. cat, table, car) from different semantic categories (eg. animal, tool, vehicle) and their corresponding sensory and motor features including visual, auditory, olfactory/gustatory, tactile and motor features. Within each modality, object concepts are organized as a network with two object concepts are linked if they share at least one feature in common. We suppose that, in each modality specific association brain area, object concepts are organized differently. We use graph measures including clustering coefficient, path length and efficiency to examine how object concepts organize in visual, auditory, motor, olfactory/gustatory and tactile modality specific association areas. Clustering coefficient indicates to what extent object concepts are connected with each other and path length traces the distances between them. Our results show that object concepts are connected in different ways in modality specific areas. Within the visual modality specific areas, object concepts are densely connected compared in other modalities indicated by high clustering coefficient. This approach allows to describe how object concepts organize in different modality specific brain areas and provides cognitive neuroscientists with a guideline in studying object concepts.

Topic Area: LONG-TERM MEMORY: Semantic

E93 Learning-induced transition of mapping high-dimensional motor space in a complicated reward-based motor skill learning

Sungshin Kim^{1,2}, Yera Choi¹, Emily Yunha Shin¹; ¹Center for Neuroscience Imaging Research, Institute of Basic Sciences, ²Sungkyunkwan University

Human motor skill learning is a complicated process of generating a novel movement pattern to achieve a task goal. To date, most neuroimaging studies investigating neural mechanism of motor skill learning have employed target-reaching, sequential force control, or sequence learning tasks and little research has involved a more complicated motor skill learning task. Here, we designed a novel fMRI experiment in which subjects wear a MR-compatible data-glove and learn to control a computer cursor over a 5-by-5 grid by manipulating fingers. To investigate how extensive training changes neural representation of mapping between high-dimensional motor space and low-dimensional task space, subjects participated in two fMRI sessions separated by five training sessions. The extensive training decreased interaction between the motor and visual modules but increased interaction between the motor and reward modules. We also found the central executive, salience, and dorsal/ventral attention networks were strongly modulated by trial-by-trial reward in the early learning phase, but the extensive training reduced the sensitivity of these networks to the rewards. Interestingly, the rewards also modulated activities in the hippocampal-cortical declarative memory network. As a result of the extensive training, the modulated region shifted from anterior and mid portion to posterior portion of hippocampus and posterior cingulate regions, substantiating their respective roles of encoding and retrieval of spatial mapping.

Topic Area: LONG-TERM MEMORY: Skill learning

E94 Practice in your sleep: sleep replay improves motor function

Larry Y. Cheng¹, Tiffanie Che¹, Goran Tomic¹, Marc W. Slutzky¹, Ken A. Paller¹; ¹Northwestern University

We examined consequences of sleep-dependent processing for learning complex motor skills in healthy individuals. We investigated a variant of a special motor task called a myoelectric computer interface, which was developed for stroke rehabilitation. Muscle activity recorded from electrodes on proximal and distal arm muscles systematically moved an onscreen cursor. Participants gradually learned to precisely move the cursor by activating single muscles or pairs of muscles. To succeed on each trial, the participant moved the cursor to an illuminated target square on the screen and held it there for approximately 500 ms. Each of 16 target locations was associated with a unique sound that played when each trial began and when the correct response was produced. After the learning session, 8 of the sounds were repeatedly played during slow-wave sleep to initiate replay of learned responses, a procedure known as Targeted Memory Reactivation (TMR). Post-sleep testing showed that TMR produced a relative improvement in movement speed and efficiency of the cursor path, with no tradeoff in accuracy. This improvement was evident both for movements that involved proximal muscles and for those involving distal muscles, although the latter tended to improve more. Results showed that TMR during sleep can enhance performance of a newly learned, complex motor skill involving precise muscle control. These results suggest that TMR may be helpful for stroke patients in conjunction with motor-rehabilitation therapy. Further studies are needed to determine whether effects are cumulative over multiple nights and with difficult learning regimens requiring training over multiple days.

Topic Area: LONG-TERM MEMORY: Skill learning

E95 Decreased local functional brain connectivity can predict conversion to MCI or dementia

Eun Hyun Seo¹, Jinsick Park²; ¹Premedical science, College of Medicine, Chosun University, Gwangju, Korea, ²Department of Biomedical Engineering, Hanyang University, Seoul, Korea

Background: It is known that functional brain network is disrupted from the very early stage of Alzheimer's disease (AD) spectrum. In the current study we investigated functional brain network parameters associated with future cognitive decline in cognitively normal (CN) elderly and individuals with mild cognitive impairment (MCI). Methods: Functional and structural MRI data, clinical and neuropsychological data were downloaded from the Alzheimer's Disease Neuroimaging Initiative (ADNI) database. In the final analysis, 52 CN elderly and 48 elderly with MCI were included. Image data preprocessing was carried out using MELODIC of FMRIB's Software Library. BOLD time course was extracted according to AAL atlas. Based on interregional correlation matrices of 90 ROIs, network parameters were calculated using Brain Connectivity Toolbox. Logistic regression analysis was performed to examine the ability of network parameters to predict conversions. Results: MCI group had reduced network density ($p=0.025$), clustering coefficients ($p=0.036$), and global efficiency ($p=0.025$) but longer path length ($p=0.025$) than CN group. For followed sample, 15 were converted to dementia or MCI and 58 were nonconverted. Baseline network parameters between converters and nonconverters were significantly different. Logistic regression revealed that age and clustering coefficient significantly predicted the conversion from CN to MCI or MCI to dementia. Discussion and Conclusions: Our findings indicate that resting-state functional network parameters can play important role to predict future cognitive decline. Especially, decreased local functional brain connectivity can predict conversion to MCI or dementia. The current study suggests that inclusion of functional brain network parameters facilitate early detection of clinical progression.

Topic Area: METHODS: Neuroimaging

E96 Revealing the Brain Network Structure of Individual Differences in Cognitive Control

Shelly R. Cooper¹, Joshua J. Jackson¹, Todd S. Braver¹; ¹Washington University in St. Louis

In cognitive neuroscience, fMRI is often used to impose specific task states in order to understand the neural underpinnings of cognitive functions. While individual variability may be characteristic of the brain network or region (task-independent), tasks may also have global effects (i.e., non-specific to brain network) that reveal individual differences. This is particularly salient for cognitive control, which is dependent upon the task at hand. We therefore hypothesized that specifying task states and brain networks as independent factors would best capture the underlying structure of individual differences. Structural equation models (SEM) were built from the Human Connectome Project dataset (based on the full release; $n=1200$), focusing on cognitive control-related tasks (N-back/Relational) and networks (frontoparietal/cinguloopercular). Four competing SEM models were tested that varied in whether both networks and tasks were treated as independent latent factors or not. Models were evaluated on goodness-of-fit indices and variance explained in a criterion outcome behavioral index of working memory function (List Sort task). The model with both tasks and networks specified as separate latent factors had the best fit index (chi-square, $p<.001$), and also explained the most total variance in working memory with the strongest predictor being the multi-network N-back factor. These findings suggest that considering tasks and networks as dissociable sources of cognitive individual difference is useful for interrogating brain-behavior relationships, especially in the cognitive control domain. Further work will explore the effects of adding additional brain networks (e.g., default mode) and tasks (e.g., language, social) to determine the generality of these conclusions.

Topic Area: METHODS: Neuroimaging

E97 The effects of lesions on the modular organization of the brain: A comparison of simulated and real lesions

Yuan Tao¹, Brenda Rapp¹; ¹Johns Hopkins University

Simulation studies directed at understanding the effects of lesions on functional organization have shown that damage to nodes supporting cross-module or within-module integration have opposite effects on whole-brain modular organization (Honey & Sporns, 2008). However, the consequences of actual lesions have been scarcely studied. In this work we examined the consequences of brain lesions in chronic stroke (n=15) and the simulated impact of these lesions in healthy individuals (n=23). A reference modular structure was computed from controls and, on this basis, global (participation coefficient, or PC) and local (within-module density, or WD) integration coefficients were calculated for each node. For each lesion mask, we computed its PC and WD damage scores by averaging the respective integration coefficients. Simulated lesions were created by applying every lesion mask to each control dataset and modularity (Newman's Q) was calculated for all datasets. Finally, lesion-mask PC and WD damage scores were correlated with modularity. Consistent with previous studies, simulated lesions with larger PC damage resulted in higher modularity (Pearson $r=0.43$, $p<0.05$), while WD damage had the reverse effect ($r=0.46$, $p<0.05$). However, for actual lesions, PC damage was negatively correlated with modularity ($r=-0.48$, $p<0.05$), and WD damage was uncorrelated with modularity ($r=0.07$, n.s.). The discrepancy between simulated and real lesions indicates that lesion-driven functional re-organization cannot be explained as a simple subtraction of nodes from the healthy brain. Instead, the findings indicate that lesions lead to functional connectivity changes in which global connectors play a pivotal role.

Topic Area: METHODS: Neuroimaging

E98 The relevance of resting-state functional connectivity to cognitive brain activations and behavior

Richard H. Chen¹, Takuya Ito¹, Ravi D. Mill¹, Michael W. Cole¹; ¹Rutgers, the State University of New Jersey - Newark

Human fMRI research has typically focused on investigating how behaviors are associated with task-related brain activations. More recently, research has provided evidence linking resting-state functional connectivity (RSFC) to individual differences in behavior. Furthermore, there exists a strong statistical relationship between RSFC and task activations, despite RSFC being measured without active task manipulations. However, the underlying mechanisms remain unclear regarding how task-related behaviors (and associated task activations) are linked to RSFC, and how changes in RSFC may impact task-related activations and behavior. We hypothesize that there are both unique (independent) and shared (dependent) contributions from RSFC and task activations to behavior. We further hypothesized that activity flow – the movement of task activations over brain connections – can explain observed shared variance between task activations and RSFC (Cole et al. 2016). Using a multiple-regression approach, we accurately predicted 2-back working memory task performance using RSFC and task activations, independently (task activations: $r = 0.26$, RSFC: $r = 0.32$). In a partial correlation analysis, we found that task activations share 40% of variance with RSFC in its relationship with behavior. Comparatively, 23% of the variance in the RSFC-behavior relationship is shared with task activations. These results indicate that RSFC is strongly associated with task activations in its relationship with behavior, consistent with RSFC network architecture contributing to behavior and cognition via activity flow over routes described by RSFC.

Topic Area: METHODS: Neuroimaging

E99 The science of the singular: single-item decoding with multivariate analyses

Benjamin R. Geib¹, Simon W. Davis¹, Erik A. Wing², Marty G. Woldorff¹, Roberto Cabeza¹; ¹Duke University, ²Rotman Research Institute

Over the past decade, multivariate pattern analysis (MVPA) has become a widely used and highly useful analysis approach in fMRI. With this technique, in nearly all cases, a machine learning classifier is trained to differentiate the fMRI responses to two classes of stimuli (e.g., faces and scenes) each consisting of dozens of individual exemplars. Here, using a novel set of algorithms, we demonstrate the ability to reliably decode the fMRI responses to single-items, from single presentations, even when the dataset consists of hundreds of such individual items. Moreover, across multiple datasets, we demonstrate that our algorithm is reliable across different types of stimuli; for example, it can be trained on words to classify object pictures (N=300 stimuli) or trained on scene pictures to classify words (N=96 stimuli) and vice versa. Finally, by utilizing representational similarity analysis (RSA), we demonstrate that the misclassifications of a particular stimulus occurs in a systematic fashion, namely incorrectly classifying it as a related stimulus type. For example, when attempting to classify a mammal (say Dog), the algorithm most often false alarms to other mammals. The ability to classify individual items, as opposed to classes, greatly increases the specificity of MVPA and permits the design of more naturalistic paradigms with more diverse stimulus sets. As such we believe this technique will be highly useful for a wide-array of cognitive neuroscience applications.

Topic Area: METHODS: Neuroimaging

E100 Predictive validity of word reading tests for estimating premorbid IQ

Peter Bright^{1,2}, Izobel Clegg¹, Farah Hina¹, Ian van der Linde^{2,3}; ¹Department of Psychology, Anglia Ruskin University, Cambridge, UK, ²Vision & Eye Research Unit (VERU), School of Medicine, Anglia Ruskin University, ³Department of Computing & Technology, Anglia Ruskin University

The 50-item National Adult Reading Test (NART; Nelson, 1982; NART-R; Nelson & Willison, 1991), first published in 1982, remains a widely used method for estimating premorbid intelligence in neurological patients. However, using 92 neurologically healthy British participants, it was only recently restandardised against the most recent revision of the Wechsler Adult Intelligence Scale (WAIS-IV; Bright et al., 2018). In the current study we analysed NART and WAIS-IV data in a larger sample (N = 145) to assess reliability of our published estimates, and address whether inclusion of demographic data might improve precision of estimates. We also compared NART estimates in a smaller sample (N=45) with those derived from the 70-item UK version of the Test of Premorbid Functioning (TOPF, 2011). In the larger sample, NART-FSIQ linear correlations remained strong (although marginally lower) and the regression equations produced estimates within one FSIQ point of our published figures. Inclusion of age yielded a modest but significant improvement (from $R^2=.43$ to $R^2=.45$). In our smaller sample the NART outperformed the TOPF, indicating that inclusion of more test items in this case does not lead to better precision of FSIQ estimates. Application of a recent genetic algorithm approach for optimising the relationship between neuropsychological test data (van der Linde & Bright, 2018) reinforces this view, showing not only that more than half the stimuli included in the reading tests provide minimal or no diagnostic contribution, but that FSIQ estimates can be substantially improved while reducing arduousness and test duration for patients.

Topic Area: METHODS: Other

E101 tDCS Modulation of Dopamine Systems

Michael Imburgio¹, Hannah Ballard², Astin Cornwall¹, Darrell Worthy^{1,2}, Jessica Bernard^{1,2}, Joseph Orr^{1,2}; ¹Department of Psychological and Brain Sciences, Texas A&M University, ²Texas A&M Institute of Neuroscience

Transcranial direct current stimulation (tDCS) is a brain modulation technique that is quickly growing in popularity. However, evidence for its efficacy in modulating executive function and treating clinical disorders is inconsistent. Prior work suggests that an individual's baseline dopamine level moderates the effect of stimulation on executive function, which may partially explain the inconsistencies throughout the literature. The current study examined the effects of bilateral dorsolateral prefrontal cortex (DLPFC) stimulation, previously demonstrated to increase striatal dopamine, on three behavioral correlates of dopamine. The effects of stimulation on each measure were further examined as a function of an individual's aggregate score on each measure prior to stimulation, a proxy baseline dopamine measure. The effect of stimulation on eye-blink rate, a correlate of striatal dopamine, was dependent upon an individual's baseline dopamine. The results of the study suggest that bilateral DLPFC stimulation is more effective at increasing dopamine in individuals with high baseline dopamine. The current work has implications for researchers that attempt to modulate executive function using tDCS. Additionally, understanding the relationship between the effects of tDCS and baseline dopamine can help clinicians identify patients for which tDCS might be an effective treatment method.

Topic Area: METHODS: Other

E102 The Face Image Meta-Database and ChatLab Disfigured Face Database: Tools to Facilitate Neuroscience Research on Face Perception and Social Stigma

Clifford Workman¹, Anja Jamrozik¹, Miriam Rosen¹, Anjan Chatterjee¹; ¹The University of Pennsylvania, Philadelphia, PA, USA

Many stimulus sets comprised of static faces are publicly available. Researchers nevertheless struggle to find stimuli best suited to their studies (e.g., <https://goo.gl/bUv46y>). A comprehensive index of face-sets, their features, and how to access them has not been available. Furthermore, in view of mounting evidence that facially disfigured people are socially stigmatized, the absence of a disfigured face stimulus set that can be used to probe the stigmatizing behaviors they experience is a critical gap. We built the Face Image Meta-Database (fIMDb) to aid researchers in finding appropriate face stimuli: <https://cliffordworkman.com/resources>. It includes data (or estimates) for around 90 sources of stimuli on: numbers of photo sets, numbers of individuals photographed (and their characteristics), total numbers of images, and more. We have also constructed the ChatLab Disfigured Face Database (CDFD) from images identified through print and online sources that depict individuals with facial disfigurements. We estimate that the fIMDb includes links to over 2.5 million images of over 32,000 individuals spanning 242 stimulus sets. The CDFD contains 492 images of 49 unique individuals with facial disfigurements before and, when available, after corrective treatment. The fIMDb received around 500 unique visitors in the week following its release, suggesting it addresses a previously unmet need. Furthermore, the CDFD is the only set of disfigured face stimuli, of which we are aware, available to researchers. We anticipate that the availability of these tools will facilitate research on face perception and provide researchers impetus to examine the social consequences of facial disfigurement and stigmatization.

Topic Area: METHODS: Other

E103 The Neuroimaging Informatics Tools and Resources Clearinghouse

Christian Haselgrove^{1,3}, Albert Crowley², David Kennedy³, Abby Paulson², Nina Preuss², Matt Travers²; ¹Neuromorphometrics, Inc, ²Turner Consulting Group, Inc, ³University of Massachusetts Medical School

The Neuroimaging Informatics Tools and Resources Clearinghouse (NITRC) is a neuroinformatics knowledge environment for MR, PET/SPECT, CT, EEG/MEG, optical imaging, clinical neuroinformatics, computational neuroscience, and imaging genomics tools and resources. NITRC's mission is to foster a user-friendly knowledge environment for the neuroinformatics community. By continuing to identify existing software tools and resources, NITRC's goal is to support researchers dedicated to enhancing, adopting, distributing, and contributing to the evolution of neuroimaging analysis tools and resources. Located at www.nitrc.org, the Resource Registry (NITRC-R) promotes software tools and resources, vocabularies, test data, and databases, extending the impact of previously funded contributions. NITRC-R gives researchers greater and more efficient access to the tools and resources they need by categorizing and organizing existing tools and resources, facilitating interactions between researchers and developers, and promoting better usability through enhanced documentation and tutorials. As of November, 2018, over 1,000 public resources are listed on NITRC-R. The NITRC Image Repository (NITRC-IR) now makes almost 60,000 scans for over 10,000 subjects publicly available at no charge, and the NITRC Computational Environment (NITRC-CE) provides computation services for several domains downloadable to your machine or via Amazon Web Services. NITRC is an established knowledge environment for the neuroimaging community and is a trusted source for the identification of resources in this global community. We encourage the neuroinformatics community to continue providing valuable resources, design and content feedback, and to utilize these resources in support of data sharing requirements, software dissemination, and cost-effective computational performance.

Topic Area: METHODS: Other

E104 Ultrasonic modulation of higher order visual pathways in humans

Verena Braun¹, Joseph Blackmore¹, Michele Veldsman¹, Robin Cleveland¹, Christopher Butler¹; ¹University of Oxford

Transcranial ultrasonic stimulation (TUS) has been used to target primary sensory regions of the human brain. Its effect on higher-order and deeper cortical areas has not been studied. Moreover, concerns have recently arisen that TUS effects may be driven indirectly through stimulation of early auditory pathways. We investigated whether TUS can modulate higher-order visual processing both in superficial (middle temporal area (MT)) and deep (fusiform face area (FFA)) regions. We further examined the efficacy of auditory stimulus masking. Magnetic resonance imaging was used to map skull anatomy and functional regions of interest (MT and FFA) for each participant (n=21). Segmented imaging datasets formed the basis of 3D ultrasound simulations to determine transducer placements and source amplitudes. Thermal simulations ensured that temperature rises were <0.5 °C at the target and <3 °C in the skull. TUS (500 kHz, 300 ms 50% duty cycle bursts) was applied to MT whilst participants performed a visual motion detection task (n=19) and to FFA during a face identity detection task (n=11). EEG data were collected throughout. TUS to MT led to decreased motion detection rates compared to trials without stimulation and stimulation-dependent differences were identified in oscillatory activity in the beta frequency range. We show that TUS can be used in humans to modify electrophysiological activity in higher-order visual pathways in a task-specific and anatomically precise manner.

Topic Area: METHODS: Other

E105 Under slept and Overanxious: The neural correlates of sleep-loss induced anxiety in the human brain

Losing sleep causally triggers anxiety. Disturbed sleep, including Non-REM slow-wave activity (SWA), is comorbid with all anxiety disorders, while sleep-deprivation increases anxiety in healthy individuals. Still, the underlying brain mechanisms of this effect remain unknown. Here, we test the hypothesis that sleep-loss induced anxiety is triggered by a neural profile observed in anxiety disorders: amplified activity within the limbic network due to impaired top-down regulation by medial-PFC. We further examined the palliative role of Non-REM SWA in restoring this network and thus reducing anxiety. 18 healthy adults (20.2±1.5y, 9F) participated in two counterbalanced experimental sessions: (1) after a rested night of polysomnography-recorded sleep, and (2) after 24-hours of sleep-deprivation. Anxiety states were measured in each session prior to a functional-MRI scan assessing affective brain reactivity. Findings reveal that sleep-deprivation triggered a 30% increase in anxiety ($p < 0.01$) and led to amplified reactivity within the amygdala and dorsal-anterior cingulate, yet marked hypoactivity in medial-PFC ($p < 0.05$). Critically, the degree of medial-PFC disengagement predicted 1) the magnitude of sleep deprivation-induced anxiety across individuals and 2) the loss of top-down mPFC-amygdala connectivity following sleep-loss (both $p < 0.05$). Finally, greater amounts of Non-REM SWA in the sleep rested night predicted the palliative overnight reduction in anxiety, further associated with greater re-engagement of medial-PFC activity the next day ($p < 0.05$). Together, these data establish a neuropathological model explaining the anxiogenic impact of sleep loss and emphasize sleep intervention, specifically deep Non-REM sleep, as a novel therapeutic target for the amelioration of anxiety in non-clinical and clinical populations.

Topic Area: OTHER

E106 Age-related differences on implicit and explicit motor sequence learning in children from 6 to 12 years of age

Jin Bo¹, Yu Xing², Bo Shen³; ¹Eastern Michigan University, ²Central China Normal University, ³Wayne State University

Previous studies have documented developmental invariance in implicit sequence learning (Meulemans et al., 1998) in comparison to explicit learning (Reber 1992). The current study examined the age-related differences on the implicit and explicit sequence learning, and how the fundamental motor ability impacted the sequence learning in elementary school students. Eighty-four students aged from 6 to 12 were recruited in Wuhan, China. We first tested age-independency of implicit learning and the age-dependency of explicit learning. Results showed that both the implicit and explicit learning had a similar age-related pattern (both $P < 0.05$; $z = 0.58$, $P > 0.05$) of change during the learning phase. However, age-related differences were found during the post-learning phase in the explicit learning ($r = 0.41$, $P < 0.01$), but not in the implicit learning ($r = 0.34$, $P > 0.05$). Significant age effect was found on consolidation after 15 minutes of break (both $P < 0.01$). Such results were partially consistent with the hypothesis of “developmental invariance in implicit learning”. We then explored the effect of fundamental motor skills on motor sequence learning. Movement Assessment Battery of Children was used to assess children’s manual dexterity, balance, and object manipulative skills. Results did not reveal any associations between the fundamental motor skills and two types of motor sequence learning, suggesting additional impact of daily activities, beyond basic motor ability, on motor learning in child development.

Topic Area: PERCEPTION & ACTION: Motor control

E107 Altered Motor Dynamics during Response Competition in Adults with Type 1 Diabetes

Type 1 diabetes has been shown to alter the structure and function of the brain. Of the cognitive faculties affected, psychomotor speed is the most consistently reported. In the current study, we examined the neural dynamics serving motor processing during response competition using an arrow based Flanker task and magnetoencephalography (MEG). Participants included adults (ages 19-35, $N = 39$) with type 1 diabetes (T1D) who had no major complications or comorbidities and a group of demographically-matched controls (ages 19-35, $N = 40$). MEG analyses were focused on movement-related neural oscillations, with time zero defined as motor execution. Time-frequency decomposition indicated strong beta and gamma responses in both groups, which were imaged using a beamformer and subsequently time series were extracted from the peak voxel of each response. Statistical analyses revealed a significant group-by-condition interaction for the ipsilateral beta event-related desynchronization (ERD; $F = 9.01$, $p = .004$), where participants with T1D had a smaller Flanker effect relative to controls. In addition, a significant group effect was observed in the contralateral post-movement beta-rebound (PMBR; $t = 2.22$ $p = .030$), where participants with T1D had a stronger response than controls. There was also a trend for a group-by-condition interaction in the ipsilateral PMBR response ($F = 3.58$, $p = .062$). No significant differences were found in the gamma range ($ps > .300$). These results suggest spectrally-specific alterations in motor dynamics during response competition in T1D, which may be critical to understanding the neural basis of deficits in psychomotor speed.

Topic Area: PERCEPTION & ACTION: Motor control

E108 Altered Speech Responses to Transient Mid- and Whole-Utterance and to Constant Formant Perturbations

Inez Raharjo^{1,2}, Hardik Kothare^{1,2}, John Houde¹, Srikantan Nagarajan¹; ¹University of California, San Francisco, ²University of California, Berkeley

We can hear and monitor different aspects of our speech, including our formants which convey vowel identity. If what we hear does not match our intended speech, we tend to compensate to ‘fix’ the speech we produce. In a lab setting, this compensation response has been investigated using two different perturbation scenarios. In one scenario, the perturbation is introduced unexpectedly and temporarily, which can be introduced at utterance onset or transiently at mid-utterance. These perturbations cause speakers to have a transient compensation response. In another scenario, if this ‘unexpected’ perturbation is constantly repeated, the perturbation becomes expected and an adaptation response will likely take place. Here we explored three questions: 1) the transient compensation responses to transient mid-utterance formant perturbation, 2) the relationship of (1) responses to formant perturbations initiated at utterance onset, and 3) whether this compensation response is crucial for driving for formant adaptation. We asked participants to phonate either the word ‘head’ or ‘hid’ for 1.5 seconds while we applied a real-time shift of the first formant frequency (F1) to participants’ utterance. The shift was applied either at utterance onset (whole-utterance), for only 400 ms after a jittered delay (mid-utterance), or constantly over several trials (constant shift). We found that participants do compensate for mid-utterance formant perturbations, and this response is highly correlated to their responses to whole-utterance formant perturbations. However, their transient compensation responses did not correlate with their adaptation responses, which supports the idea that different mechanisms drive transient compensation and adaptation.

Topic Area: PERCEPTION & ACTION: Motor control

E109 Changes in Functional Connectivity Seeded from M1 after a 12-week Aerobic Exercise Intervention

Keith McGregor^{1,2}, Bruce Crosson^{1,2,3}, Lisa Krishnamurthy^{1,4}, Venkatagiri Krishnamurthy^{1,3}, Javier Omar¹, Kyle Hortman¹, Kaundinya Gopinath³, Joe Nocera^{1,2,5}; ¹Atlanta VA Health Care System, Center for Visual and Neurocognitive Rehabilitation, ²Emory University, Department of Neurology, ³Emory University, Department of Radiology, ⁴Georgia State University, Department of Physics and Astronomy, ⁵Emory University, Department of Physical Therapy

Objective: . Previous work has shown that over a six-month or one-year exercise intervention, older individuals show increased resting state connectivity (rsFC) of the default mode network and the sensorimotor network. However, the effects of shorter-term 12-week exercise interventions on functional connectivity have received less attention. **Method:** Thirty-seven sedentary right-handed older adults were randomized to either a 12-week aerobic, spin cycling exercise group or a 12-week balance-toning exercise group. Resting state functional magnetic resonance images were acquired in sessions PRE/POST interventions. We applied seed-based correlation analysis to left and right primary motor cortices (L-M1 and R-M1) and anterior default mode network (aDMN) to test changes in rsFC between groups after the intervention. **Results:** Seeding from L-M1, we found that participants in the cycling group had a greater PRE/POST change in rsFC in aDMN as compared to the balance group. When accounting for time in aerobic HR zone, we found increased HR workload was positively associated with increased change of rsFC between motor networks and aDMN. Interestingly, L-M1 to aDMN connectivity changes were also related to motor behavior changes in both groups. Comparisons of all participants from PRE to POST showed a reduction in the extent of bilateral M1 connectivity after the interventions with increased connectivity in dominant M1. **Conclusions:** A 12-week physical activity intervention can change rsFC between primary motor regions and default mode network areas, which may be associated with improved motor performance. Decreased connectivity between L-M1 and R-M1 post-intervention may represent a functional consolidation to dominant M1.

Topic Area: PERCEPTION & ACTION: Motor control

E110 Effects of cognitive interference and priming on speech acoustics

Caroline Niziolek¹; ¹University of Wisconsin–Madison

Are there interactions between cognitive interference, priming, and speech production? In a series of experiments, we manipulated the temporal relationship between a visually-presented distractor word and a color to be named verbally. We compared a variant of the Stroop task in which presented words had phonetic properties that partially matched their text color (e.g. “rid” written in red) with a masked priming task in which these same words were presented in a neutral context, then followed by a non-orthographic color stimulus (e.g. “rid” written in white, followed by a red circle). In the Stroop variant, spoken vowels were systematically biased away from the partially-matching text: that is, the inhibition of a competing target was manifest in an accentuation of the acoustic contrast between the spoken and inhibited words. Preliminary data also suggests that the masked priming task preserves this influence, despite the competing word not appearing on the screen at the same time as the color to be produced. This result informs how speech motor plans are influenced by external cues, both relevant and irrelevant.

Topic Area: PERCEPTION & ACTION: Motor control

E111 Measuring Brain Complexity During Neural Motor Resonance

Brandon Hager¹, Albert Yang², Jennifer Gutsell^{1,3}; ¹Department of Psychology, Brandeis University, Waltham, MA, United States, ²Division of Interdisciplinary

Medicine and Biotechnology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States, ³Department of Psychology, Neuroscience Program, and Volen National Center for Complex Systems, Brandeis University, Waltham, MA, United States

Background: EEG mu-desynchronization is an index of motor resonance (MR) and used to study social interaction deficiencies. Unfortunately, finding differences in mu-desynchronization does not reveal how nonlinear brain dynamics are affected. The current study explores how nonlinear dynamics change during MR. We hypothesized that complexity of the mu frequency band (8–13Hz) increases during MR. Additionally, we sought to determine whether baseline complexity would predict MR and changes to network topology. **Methods:** EEG was recorded from healthy participants (n = 45) during rest and observation of videos of hands squeezing stress balls. We used multiscale entropy (MSE) to quantify the complexity of the mu rhythm during MR. We then performed graph theory analysis to explore network topology. **Results:** We found significant mu-desynchronization during the task and that mu entropy was significantly increased during the task compared, while gamma, beta, theta, and delta bands showed decreased entropy. Resting-state entropy was significantly predictive of mu-desynchronization. We also observed a decrease in the clustering coefficient in the mu/alpha band and a significant decrease in global efficiency during action observation. MSE during action observation was strongly correlated with alpha network efficiency. **Conclusions:** The current findings suggest that the desynchronization of the mu wave results in a local increase of mu entropy in sensorimotor areas, potentially reflecting a release from alpha inhibition. This release may be mediated by the baseline MSE in the mu band. The dynamical complexity and network analysis of EEG may prove useful for future studies of MR by incorporating measures of nonlinearity.

Topic Area: PERCEPTION & ACTION: Motor control

E112 Neural correlates of aberrant vocal motor control in Adductor Spasmodic Dysphonia

Hardik Kothare^{1,2}, Sarah Schneider¹, Katherine Yung³, Leighton Hinkley¹, Danielle Mizuiri¹, Susanne Honma¹, Coleman Garrett¹, Molly Naunheim¹, Mark Courey⁴, Srikantan Nagarajan^{1,2}, John Houde¹; ¹University of California, San Francisco, ²UC Berkeley-JCSF Graduate Program in Bioengineering, ³San Francisco Voice & Swallowing, ⁴Mount Sinai Health System

Spasmodic dysphonia (SD) is a debilitating disorder of voicing where the laryngeal muscles are intermittently in spasm and are dystonic. This prevents the vocal folds from vibrating efficiently and results in involuntary interruptions during speech. The underlying causes of SD remain largely unknown. Prior imaging studies have found aberrant activity in the CNS during SD phonation. However, these studies could not resolve whether SD involves impairment of preparatory, feedforward aspects of vocal control or instead involves abnormal processing of sensory feedback during phonation. To investigate this question, we used Magnetoencephalography (MEG) to monitor neural activity and associated behavioural responses time-locked to glottal onset, phonation onset, and onset of pitch feedback perturbations in adductor SD (AdSD) patients and matched controls. MEG scanning was performed in 17 patients and 12 controls. Four additional patients participated only in speech psychophysics studies without imaging. Data from 2 patients and 1 control had to be excluded because of large dental or movement artefacts. During scanning, subjects were prompted to start vocalising the vowel /a/ and hold it for the duration of the prompt (2.4 s). Glottal onset was recorded using surface electromyography of pre-phonatory laryngeal muscular activity. On every trial, between 200ms and 500ms after voice onset, the pitch of their auditory feedback was briefly perturbed by +/- 100 cents for a period of 400ms and vocal responses to this change were recorded. We examined induced beta-band (12-30 Hz) neural oscillations over sensorimotor cortices in patients and controls and performed non-parametric statistical tests to observe group differences. Patients showed an elongated interval between laryngeal movement onset and phonatory onset as well as abnormal pitch perturbation

responses. Prior to glottal onset, patients showed reduced task-induced beta band suppression over the left laryngeal motor cortex, left ventral premotor cortex and left inferior frontal gyrus, and enhanced suppression bilaterally in the parietal lobe, especially around the angular gyrus. This abnormal activity in patients near the angular gyrus persisted after glottal onset. Additionally, after phonation onset, patients had increased bilateral suppression around the postcentral gyrus. Following the onset of an auditory feedback perturbation, patients showed increased bilateral frontal lobe suppression. The results suggest that AdSD patients not only have abnormal responses to sensory feedback during phonation, but also have impaired feedforward, preparatory vocal control prior to phonation.

Topic Area: PERCEPTION & ACTION: Motor control

E113 Stimulus-Elicited Involuntary Imagery in Semi-Automated Driving: Implications for Neuroscience

Anthony G. Velasquez¹, Adam Gazzaley², Heishiro Toyoda³, Ezequiel Morsella^{1,2}; ¹San Francisco State University, ²University of California, San Francisco, ³Toyota Collaborative Safety Research Center

Laboratory tasks in neuroscience (e.g., the flanker task) reveal that incidental stimuli can reliably trigger action tendencies and conscious imagery. Do such effects arise in highly ecologically valid conditions (e.g., simulations of semi-automated driving experiences)? The data from three experiments reveal that the answer is yes. In Experiment 1, participants ($n = 96$) were presented with video footage of the kinds of events that one would observe if one were seated in the driver's seat of a semi-automated vehicle. In the Suppress condition, participants were first trained to respond to street signs according to laboratory techniques that cause stimulus-elicited involuntary imagery. After training, participants were instructed to, when presented with the footage, not respond to the signs. Participants reported more involuntary imagery during Sign-Related trials (MProportion of Trials = .42, SD = .31) than during the control, Sign-Unrelated trials (MProportion of Trials = .32, SD = .25), t one-tailed paired (23) = 2.67, $p < .01$. In Experiment 2 ($n = 84$), such involuntary effects arose even under conditions of multi-tasking (performing the n -back task or psychomotor vigilance task). Experiment 3 ($n = 40$) supported the hypothesis that these effects will decrease (to ~10% of the trials) when the imagery is based on a "conditional discrimination." The present laboratory task, which was designed to be amenable to neuroimaging, has implications for semi-automated driving, because the safe interaction between driver and vehicle requires that the communicative signals from vehicle to driver be effective at activating the appropriate cognitions and behavioral inclinations.

Topic Area: PERCEPTION & ACTION: Motor control

E114 The FACTS model: using state estimation and task-based feedback control to model the speech motor system

John Houde¹, Benjamin Parrell², Vikram Ramanarayanan^{1,3}, Srikantan Nagarajan^{1,4}; ¹University of California, San Francisco, Department of Otolaryngology - Head and Neck Surgery, San Francisco, CA, 94143, USA, ²University of Wisconsin - Madison, Department of Communication Sciences and Disorders, Madison, WI, 53706, USA, ³Educational Testing Service R&D, San Francisco, CA, 94105, USA, ⁴University of California, San Francisco, Department of Radiology, San Francisco, CA, 94143, USA

We present a new computational model of speech motor control: the FACTS model (Feedback-Aware Control of Tasks in Speech). This model employs a hierarchical architecture, with control of high-level speech tasks separate and above the control of speech articulator positions. The task-level controller is modeled as a dynamical system governing the creating of desired constrictions in the vocal tract, drawing from the Task Dynamics model. Critically, this task-level feedback controller uses an estimate of the current state of the vocal tract rather than the true state to generate motor commands.

This state estimate is based on an internal prediction of the state as well as auditory and somatosensory feedback. We show that the FACTS model is able to qualitatively replicate many characteristics of the human speech system: the model is robust to noise in both the sensory and motor pathways, is relatively unaffected by a loss of auditory feedback but impacted to a larger degree by the loss of somatosensory feedback, and responds appropriately to externally-imposed alterations of auditory and somatosensory feedback. The model also replicates previously hypothesized trade-offs between reliance on auditory and somatosensory feedback in speech motor control and shows for the first time how this relationship may be mediated by acuity in each sensory domain. These results have important implications for our understanding of the speech motor control system in humans.

Topic Area: PERCEPTION & ACTION: Motor control

E115 Time-frequency characteristics of neural responses to perturbations during sensorimotor synchronization to auditory and visual rhythms

Daniel Comstock¹, Ramesh Balasubramaniam¹; ¹University of California Merced

Timing mechanisms play a crucial role in detection and correction of errors sensorimotor synchronization (SMS) tasks. Given that existing research suggests there are multiple context dependent neural timing mechanisms, we expect to find different timing mechanisms between auditory and visual SMS and for detecting and correcting errors of different types. We investigated these mechanisms by using time frequency measures, including event related spectral perturbations (ERSP) and inter-trial coherence (ITC) to reanalyze EEG data from a previous event related perturbation (ERP) study looking at auditory and visual error correction (Comstock & Balasubramaniam 2018). In the study, subjects tapped in synchrony to auditory and to visual flashing metronomes with occasional step perturbations, where a tone or flash came either earlier or later than expected. We found measures of error detection most strongly in the theta and alpha bands with strongest responses to auditory late perturbations. Phase coherence over the motor region contralateral to the tapping hand showed a relative increase in the visual condition following a late perturbation and a relative decrease following an early perturbation. The auditory condition showed a double peak in coherence only following an early perturbation, with the peaks corresponding with the timing of the expected tone onset and actual tone onset. Ipsilateral motor phase coherence showed reduced coherence for both perturbations only in the auditory condition. These results show both differences in mechanisms for both error detection and in correction in both modality and in direction, confirming the presence of multiple context dependent timing mechanisms.

Topic Area: PERCEPTION & ACTION: Motor control

E116 Transcranial Direct Current Stimulation to Enhance Laparoscopic Technical Skill Learning: A Preregistered Randomized Controlled Trial

Lawrence Appelbaum¹, Hannah Palmer¹, Zhi-De Deng², Lysianne Beynel¹, Amanda Watts¹, Jonathan Young¹, Sarah Lisanby², John Migaly¹, Morgan Cox¹; ¹Duke University, ²National Institute of Mental Health

Surgical skills are technically challenging and require extensive deliberate practice to master. Because trainees have limited time to learn the complex visual-motor skills necessary for successful passage of board certification, there is a strong need for technologies that can expedite learning. Transcranial direct current stimulation (tDCS) is a non-invasive brain stimulation technique that can modify neuronal excitability, leading to enhanced motor learning, and potentially accelerate surgical skill acquisition. This pre-registered (NCT03083483), double-blinded and controlled study aimed to test whether active tDCS, applied during laparoscopic surgical skill practice, would lead to

larger learning gains relative to sham. Sixty subjects were randomized into three training cohorts: active stimulation to bilateral primary motor cortex (bM1), active stimulation to supplementary motor area (SMA), and sham stimulation. Participants performed 6, 20-minute training blocks of the Fundamental of Laparoscopic Surgery Peg Transfer task over 3 days. For each block, electrical current was ramped up to 2mA over the first 30 seconds and remained constant for active tDCS, while it was immediately ramped off for sham tDCS. Learning curves calculated on scores accounting for timing and errors showed significantly greater improvement for the bM1 group ($t=2.07$, $p=0.039$), achieving the same skill level in 4 sessions compared to 6 sessions for the sham group. While the SMA group also produced greater learning, these data were highly variable and didn't differ significantly from sham ($t=0.85$, $p=0.4$). This study therefore demonstrates the potential for tDCS to enhance manual surgical training, meriting further investigation to replicate and extend these findings.

Topic Area: PERCEPTION & ACTION: Motor control

E117 Bimanual perceptual interactions in the frequency domain differ for flutter and vibration cues

Sripama Sen^{1,2}, Shoaibur Md. Rahman², Jeffrey M. Yau²; ¹Rice University, ²Baylor College of Medicine

Our remarkable ability to interact bimanually with objects in our environment relies on neural processing that coordinates sensorimotor function over the hands. While bimanual motor processing is well-studied, much less is known regarding bimanual touch. We recently showed that the perception of high-frequency vibrations (100-300Hz) on one hand is systematically influenced by distractor vibrations experienced on the other hand even when participants are instructed to ignore the distractors. Distractors biased frequency perception and modulated perceptual thresholds in a frequency-dependent manner, and the strength of bimanual interactions varied inversely with the distance between the hands in peripersonal space. These results imply that somatosensory computations account for hand position when combining vibration frequency cues. Because vibrotactile stimulation spans a wide range of temporal frequencies, with distinct neural representations for low frequency "flutter" and high frequency vibrations, different computations may support bimanual interaction patterns for low versus high frequency stimuli. Here, we tested subjects' ability to discriminate the flutter frequencies (16-36Hz) on their right hand while they ignored distractor cues on their left hand. We manipulated the frequency of the distractors and the separation between the hands. Preliminary results indicate that the distractors induced attractive biases in the perceived flutter frequency, similar to distractor effects at higher frequencies. Unlike interactions at higher frequencies, biasing effects on flutter perception did not differ according to hand positions and effects on perceptual thresholds were inconsistent across participants. These early results imply that distinct somatosensory computations support bimanual interactions in the flutter and vibration frequency domains.

Topic Area: PERCEPTION & ACTION: Other

E118 Consciousness-specific interactions of neural complexity and integration - a spatial and temporal perspective

Andrea I. Luppi^{1,2}, Michael M. Craig², Ioannis Pappas², Paola Finoia², Guy B. Williams², Judith Allanson³, John D. Pickard², Adrian M. Owen⁴, Lorina Naci⁵, David K. Menon², Emmanuel A. Stamatakis²; ¹Harvard University, ²University of Cambridge, ³Cambridge University Hospitals NHS Foundation, Addenbrooke's Hospital, ⁴University of Western Ontario, London, Ontario, Canada, ⁵Trinity College Dublin, Dublin, Ireland

Two remarkable aspects of brain function are its high level of complexity, which is believed to occupy a near-critical point between order and chaos, and its ability to integrate inputs from different modalities into a unified experience

of the world. Recent scientific theories of consciousness have therefore appealed to each of these qualities to explain how the vast repertoire of human conscious experiences arises from brain function. Here, we tested these theories by combining graph theory and dynamic functional connectivity to investigate measures of complexity and integration from resting-state functional magnetic resonance imaging data collected from conscious healthy volunteers ($N = 19$), the same individuals undergoing anaesthesia with the agent propofol, and patients with disorders of consciousness ($N = 22$). Our results revealed consciousness-specific alterations of brain complexity and integration in both the temporal and spatial domains, for both disorders of consciousness and anaesthetic-induced unconsciousness. Spatially, posterior regions of the Default Mode Network exhibited both reduced complexity (quantified by sample entropy) and whole-brain integration during unconsciousness. Temporally, states of high integration appeared particularly vulnerable to loss of consciousness, exhibiting reduced complexity. By combining different biological approaches with diverse analytical methods investigating both spatial and temporal aspects of brain function, the present work demonstrates that consciousness relies on spatio-temporal interactions between brain integration and complexity, whose breakdown may represent a generalisable biomarker for loss of consciousness, with potential relevance for clinical practice.

Topic Area: PERCEPTION & ACTION: Other

E119 Differential parietal activations following remapping in a visuospatial memory task

Jordan Pierce¹, Arnaud Saj², Patrik Vuilleumier¹; ¹University of Geneva, ²University Hospitals of Geneva

Remapping is a process that updates visual information in internal spatial representations across eye movements, allowing for stable perception of the environment. Previous work has demonstrated visual remapping activity in parietal cortex during saccades. Here, we used functional MRI to investigate spatial remapping during two visuospatial memory tasks requiring either overt (accompanied by a saccade) or covert (with central fixation) attention shifts to peripheral distracters. Participants had to remember the position and color of a lateralized dot during a saccade or attention shift, requiring them to update the dot position in memory, and then indicated if a second dot matched the first. Behavioral results indicated that participants generally could answer correctly regardless of where the dots or distracting stimulus appeared. Crucially, however, fMRI data revealed differential activation patterns within parietal cortex as a function of the different visual, motor, and interhemispheric remapping demands in the saccade task, presumably mediating the maintenance of spatial position in perceptual and motor maps. We also observed stronger right parietal activation for left vs. right saccade trials that could reflect a right hemisphere dominance in spatial processing. No differential activation related to remapping was found during the covert attention shift task, indicating that this condition did not necessitate the same remapping processes as the saccade condition. Overall these results further elucidate the mechanisms of spatial remapping in human posterior parietal cortex and their importance to attention processing and ocular motor behavior, with potential implications for understanding visuospatial attention deficits in hemispatial neglect.

Topic Area: PERCEPTION & ACTION: Vision

E120 Evaluating the N170 ERP as an index of reading ability for typically developing and dyslexic students

Karen Froud¹, Lisa Levinson¹, Chaille Maddox¹, Trey Avery², Airey Lau¹, Sushma Narayan¹, SuWon Jung¹, Christina Wusnich¹, Deyrha Mills-Borbon¹, Camila Hasbun-Taveras¹, Sarah Ximena Rojas¹; ¹Teachers College, Columbia University, ²Haskins Laboratories, Yale University

Correspondence between amplitude and lateralization of the N170 event-related potential and reading ability (measured by the Reading Inventory and Phonics Inventory - hmhco.com/assessmentsolutions) was investigated in a group of Typically Developing Readers (TDR, mean age = 10.9) and individuals with dyslexia (DYR, mean age = 11.3). For inclusion, students were screened for hearing and vision and completed the Digit Span (WISC-V subtest). Participants, all monolingual English speakers, completed a one-back task with real word, pseudoword, and symbol stimuli in separate blocks while high-density EEG was recorded. Assessment results revealed no significant differences between groups on Reading Inventory scores ($p = 0.759$) or Digit Span ($p = 0.629$). There was a significant difference in the group means for the Phonics Inventory (TDR mean = 28.91; DYS mean = 12.67; $p = 0.020$). Waveforms obtained over right vs. left hemisphere sensors in the occipito-temporal region showed that the left hemisphere N170 distinguished words vs. pseudowords for the TDR group. Right hemisphere activations for this group showed a greater N170 response to symbols than the left hemisphere, and no difference between words and pseudowords. This finding supports the N170 lateralization hypothesis. For the DYR group, no waveform distinction between words and pseudowords was observed over left hemisphere sensors. Responses to words and pseudowords were slightly differentiated over right-hemisphere sensors, with both word-like conditions associated with greater N170 amplitude than symbols. Findings support the feasibility of using the N170 as a measure of reading intervention effectiveness.

Topic Area: PERCEPTION & ACTION: Vision

E121 Evidence for a hierarchy of prediction errors: Visual mismatch negativity (vMMN) in response to deviance and omission

Robert Woodry¹, Kate Yurgil¹; ¹Loyola University New Orleans

Hierarchical predictive coding models suggest that the brain uses top-down processing of global and local patterns to make predictions of bottom-up sensory information. Previous studies have used electroencephalography (EEG) to detect brain activity associated with predictions in auditory oddball and omission paradigms; errors in prediction elicit an auditory mismatch negativity (MMN), however little is known about this signature in the visual modality. Our goal was to examine hierarchical predictive coding of visual stimuli. We recorded EEG from 20 undergraduate students from Loyola University New Orleans while they viewed a sequence of five shape or face stimuli. Stimuli followed a trajectory around the screen where the fifth either followed, deviated, or was omitted from that trajectory. There were three different blocks: XX (75% followed, 15% deviated, 10% omitted), XY (75% deviated, 15% followed, 10% omitted), and XO (100% omissions). A deviant fifth stimulus generated a visual mismatch negativity (vMMN) response, even in the XY block that frequently finished with a deviant. According to hierarchical models, a higher-order prediction should override a local mismatch response and generate a larger vMMN for rare sequences and rare omissions in block XY than XX. This is because XY omissions violated the expectation of a fifth stimulus as well as the expectation that it will deviate. As hypothesized, XY mismatches and omissions elicited significantly larger mismatch responses than XX ($p < .05$). Additionally, significantly shorter vMMN latencies were elicited by faces vs. shapes ($p < .05$), suggesting a priority in visual prediction processing for facial stimuli.

Topic Area: PERCEPTION & ACTION: Vision

E122 Visually-evoked ERP response differences to motion and color in adults with and without developmental dyslexia.

Lisa Levinson¹, Lauren Shuffrey², Chaille Maddox¹, Heather Green³, Trey Avery⁴, Airey Lau¹, Sushma Narayan¹, SuWon Jung¹, Sarah Ximena-Rojas¹, Karen Froud¹; ¹Teachers College, Columbia University, ²Columbia University Medical Center, ³Children's Hospital of Philadelphia, ⁴Haskins Laboratories, Yale University

High-density electroencephalography (EEG) was used to examine the P1 and N1 event-related potentials (ERPs) as potential neural indices of visual processing differences between adults (aged 18-28 years) with and without dyslexia. Stimuli were tailored to evoke responses from each of two major visual pathways: magnocellular and parvocellular. The P1 component was elicited in response to motion stimuli designed to probe magnocellular pathways, and the N1 component was elicited in response to color stimuli designed for parvocellular processing. Group comparisons revealed statistically significant differences in P1 ERP amplitudes for the motion/magnocellular condition, but no differences in N1 ERP measures for the parvocellular/color condition. Moderate to strong correlations between P1 ERP measures in response to the magnocellular/motion condition were observed in relation to specific behavioral assessments: nonverbal reasoning and memory, orthographic choice, the word identification subtest from the Woodcock Reading Mastery Test (3rd edition: WRMT-III), and the sight word efficiency subtest from the Test of Word Reading Efficiency (2nd edition: TOWRE-2). Findings suggest that literacy-related skills correlate with ERP indices of magnocellular processing, potentially offering a physiological index of dyslexia. These findings demonstrate the feasibility of using high-density EEG to measure differences in early-stage visual processing in two major pathways. With further research, the P1 component in response to a magnocellular-evoking stimulus could serve as a biomarker that either independently or in concert with specific behavioral screenings could help to identify individuals at risk for reading difficulty before they experience reading failure.

Topic Area: PERCEPTION & ACTION: Vision

E123 Examining neural representations of frequency value in decision-making

Hilary J. Don¹, Darrell A. Worthy¹, Astin C. Cornwall¹, Kimberly Ray², Tyler Davis³, David M. Schnyer²; ¹Texas A&M University, ²University of Texas at Austin, ³Texas Tech University

Recent work suggests that expected value, or the average reward value for each alternative during decision-making, can differ from frequency value, which represents how often each alternative provides positive versus negative outcomes. People may base decisions less on the expected magnitude of potential gains and losses than on the frequency with which each alternative provides positive versus negative prediction errors. We investigated the neural representation of frequency value versus expected value by performing model-based fMRI analyses using a Prediction Error (PE) Decay model that computes both expected values and frequency values. Thirty-six young adult participants performed the Soochow Gambling Task, an experience-based decision-making task that dissociates the frequency of gains versus losses from expected value. Model-based fMRI results showed activation in the left dorsolateral prefrontal cortex and caudate that was parametrically modulated by frequency value. However, no regions showed activation that was correlated with expected value. Consistent with previous research, activation in the ventral striatum was correlated with prediction error magnitude. The results provide evidence to suggest that prediction error signals modulate representations of frequency value, and further indicate that decisions may be based on how frequently each option has provided positive versus negative outcomes, rather than the average reward value of each option.

Topic Area: THINKING: Decision making

E124 Keeping Track of 'Alternative Facts': The Neural Correlates of Processing Misinformation Corrections

Andrew Gordon^{1,2}, Susanne Quadflieg², Jonathan Brooks^{2,3}, Ullrich Ecker⁴, Stephan Lewandowsky^{2,4}; ¹University of California, Davis, MIND Institute,

Upon receiving a correction, initially presented misinformation often continues to influence people's judgement and reasoning. Whereas some researchers believe that this so-called continued-influence effect of misinformation (CIEM) simply arises from the insufficient encoding and integration of corrective claims (mental-models account), others assume that it arises from a competition between the correct information and the initial misinformation in memory during retrieval (concurrent-storage account). To examine these possibilities, we conducted two functional magnetic resonance imaging (fMRI) studies. In each study, participants were asked to (a) read a series of brief news reports that contained confirmations or corrections of prior information and (b) evaluate whether subsequently presented memory probes matched the reports' correct facts rather than the initial misinformation. Behavioural results from both studies revealed that following correction-containing news reports, participants struggled to refute mismatching memory probes, especially when they referred to initial misinformation (as opposed to mismatching probes with novel information). In contrast to the mental-models account of the CIEM, we found little evidence that the encoding of confirmations and corrections produced systematic neural processing differences indicative of distinct encoding strategies. Instead, in both studies, we discovered that following corrections, participants exhibited increased activity in the angular gyrus and the precuneus in response to mismatching memory probes that contained prior misinformation, compared to novel mismatch probes. These findings favour the notion that people's susceptibility to the CIEM arises from the concurrent retention of both correct and incorrect information in memory.

Topic Area: THINKING: Decision making

E125 Motor learning informs model-based computations of context-appropriate risk in the genesis of expertise

Neil Dundon¹, Allison Shapiro¹, Viktoriya Babenko¹, Scott Grafton¹; ¹Department of Psychological and Brain Sciences, University of California, Santa Barbara

Risk, in the context of a physical action, is reciprocally related to skill-level. Acquiring expertise correlates in part with a deeper cache of relevant physical abilities. Here, we test whether skill training allows subjects to incorporate expertise-contingent risk reduction into their subjective estimates of an action's value, by requiring them to make context appropriate approach-avoid decisions. Alternatively, approach-avoid decisions could be dominated by the potential for reward irrespective of the risk estimate. Subjects were incentivized to steer a computer cursor, with either a high or low motor-cost, between two points as efficiently as possible. Cost was manipulated by constraining the number of directions the cursor could be steered, requiring more or less redirections and displacement. The optimal cursor choice varied trial to trial, and subjects performed periodical training on the high cost cursor to drive expertise. A generalized linear mixed effects model of the frequency of high cost cursor selection reported an interaction between training and context. As subjects acquired expertise, they chose the high cost cursor more often and were more selective in using it in contexts where it maximized reward. Critically, block-wise measures of the model's precision most strongly correlated with block-wise measures of subjects' motor efficiency, and less so with cumulative and block-wise external reward. We interpret these results as evidence that motor learning informs the deliberative strategy, i.e. model-based computations, of context-appropriate risk in the genesis of expertise.

Topic Area: THINKING: Decision making

E126 Neural correlates of value-based decision making in a cost-benefit integration task

In this study, we set out to replicate the findings of Basten, Biele, Heekeren, and Fiebach (2010). This fMRI study employed a cost-benefit integration task to investigate the neural mechanisms of value integration in 19 participants. While our study with 55 participants confirms important parts of the original investigation, it diverges from the original with respect to the neural representation of monetary loss values. In line with the original study, increases in task difficulty engaged regions of the cognitive control network (e.g., dorsolateral prefrontal cortex, dorsal anterior cingulate cortex), while decreases in task difficulty were associated with activation in regions of the default mode network (e.g., medial prefrontal cortex, posterior cingulate cortex). Moreover, as reported in the original study, activation in the ventral striatum increased parametrically with monetary gain coded in the stimuli. Contrary to the findings of the original study, however, the loss value of the stimulus was not significantly associated with amygdala activity, but negatively correlated with striatal activation. Again, as in the original study, the integrated stimulus value was represented in the ventromedial prefrontal cortex (vmPFC), i.e., BOLD signal in vmPFC was positively correlated with the value difference 'gain - loss'. The striatum simultaneously being activated by gain and deactivated by loss in the current study, resulted in the integrated value of the stimulus already being represented in the striatum as well. The results are discussed with respect to previous findings on the representation of positive and negative stimulus value in the brain.

Topic Area: THINKING: Decision making

E127 Uncertainty in choice policy explains reaction time: toward a unified account of set size, repetition, delay, and learning effects on choice reaction time

Samuel McDougle¹, Anne Collins¹; ¹University of California, Berkeley

Models of RT are useful techniques in psychology and neuroscience, guiding discoveries on decision-making and its neural correlates. Evidence accumulation models (e.g. drift-diffusion) capture the shape of RT distributions across a range of conditions. Such models are primarily used for perceptual discrimination tasks, where sensory evidence is integrated toward a decision bound. Some have used these models to capture "internal" evidence accumulation, such as the retrieval of items in working memory. Others have used accumulation models to capture decision uncertainty in simple reinforcement learning tasks. Taken alone, the above approaches do not capture the full variety of idiosyncratic RT effects. For instance, according to Hick's law, RT increases linearly with the log of set size (i.e., the number of stimulus-response pairs), an effect which has not, to our knowledge, been captured in learning-based RT models. Moreover, repeating trials with identical items facilitates RT, and delays between stimulus presentations slows RT. Practice also affects RT, leading to lower RTs with training, and diminished set size effects. Here we show that a model of choice that includes working memory and reinforcement learning components provides a comprehensive account of RT, where both confidence in current choices and prior choice uncertainty can capture set size, repetition, delay, and practice-related RT effects. We suggest that the fidelity of action-value representations in working memory may explain variance in choices and RTs during instrumental learning. This model effectively reinterprets Hick's law as primarily a function of uncertainty in one's action policy, rather than uncertainty in the world.

Topic Area: THINKING: Decision making

E128 Belief updating in younger and older adults: An ERP study

Bonnie Armstrong¹, Ben Dyson², Julia Spaniol¹; ¹Ryerson University, ²University of Alberta

When prior beliefs about the likelihood of uncertain events must be updated with new information, human decision makers deviate systematically from Bayes' rule by either overweighting the prior (conservatism) or overweighting the new information (representativeness). Normal aging is associated with a general preference for heuristic-based decision making, but little is known about age differences in belief updating. The current experiment examined belief updating in younger (n=23) and older adults (n=24), using behavioral and electrophysiological measures obtained in a virtual urn task (Achtziger et al., 2014). Each of two urns contained different proportions of balls of two colors. Out of the participants' sight, a sample was drawn from one of the urns, and participants were asked to indicate the urn from which the sample was most likely drawn. On each trial, the likelihood of each urn was presented first ("prior"), followed by the sample ("new information"). The degree to which reliance on a heuristic produced response conflicted with Bayes' rule was manipulated across trials, resulting in 3 within-subject conditions (conservatism-conflict, representativeness-conflict, and no-conflict). In both age groups, accuracy was lowest on representativeness-conflict trials and highest on no-conflict trials. In younger adults, but not in older adults, accuracy on representativeness-conflict trials was associated with modulation of the N2 component, an ERP marker of conflict detection, following the sample presentation. These findings are the first to reveal age-related differences in the cognitive processes involved in Bayesian updating.

Topic Area: THINKING: Development & aging

E129 Distinct locus coeruleus and precuneus responses in older adults with cognitive impairment or subjective complaints during value-based choice processing

Yu-Shiang Su^{1,2}, Peter Sheng Yao Hsu³, Yen-Ling Chen¹, Chih-Yi Hsia¹, Ming-Jang Chiu^{1,4}, Isaac Wen-Yih Tseng^{1,4}, Pei-Fang Tang¹, Yu-Ling Chang¹, Charlene Chia-Lin Lee¹, Joshua Oon Soo Goh¹; ¹National Taiwan University, Taipei, Taiwan, ²Academia Sinica, Taipei, Taiwan, ³National Health Research Institutes, Miaoli County, Taiwan, ⁴National Taiwan University Hospital, Taipei, Taiwan

Clinical cognitive impairment (CI) is characterized by mental declines that compromise daily living activities, including shopping and financial management, implicating early pathological neural responses during value-based decisions. However, the neural correlates of value-based decision processing in older patients with CI, and normal individuals with and without subjective complaints (SC) are unclear. 84 older adults (64.5±5.85 yrs old) that were cognitively normal (SC-CI-; N = 20), had SC but minimal CI (SC+CI-; Clinical Dementia Rating ≥ 0.5; N = 24), had no SC but showed objective CI (SC-CI+; performance ≥ 1.5 SD in any cognitive domain; N = 11), or had SC and CI (SC+CI+; N = 29) underwent a lottery choice task functional brain imaging experiment. Participants accepted or rejected stakes with different probabilities of winning and different magnitudes of reward. Neural responses at choice evaluation were submitted to voxel-wise two-way (SC, CI) between-subjects analysis of variance (ANOVA). We found significant SC×CI interaction effects in precuneus responses with higher activation in SC-CI- than SC+CI- and SC+CI+, and lowest activation for SC-CI+ participants. A significant main effect of CI was found in the locus coeruleus (LC) with CI- showing higher activation than CI+. Psychophysiological interaction analysis revealed (p < 0.005 uncorrected) LC reduced functional connectivity to amygdala (cluster size = 7) but increased to lateral prefrontal (cluster size = 16) during choice evaluation in CI+ compared to CI- participant. Overall, we report a novel distinction in LC and precuneus involvement during choice evaluation in CI and SC.

Topic Area: THINKING: Development & aging

E130 Elevation of episodic-based mind-wandering in semantic dementia – evidence for functional reorganisation of the brain's default network

Muireann Irish^{1,2}, Daniel Roquet^{1,2}, Zoë-Lee Goldberg¹, Jessica Andrews-Hanna³, John Hodges^{2,4}; ¹The University of Sydney, Brain and Mind Centre and School of Psychology, Sydney, Australia, ²Australian Research Council Centre of Excellence in Cognition and its Disorders, Sydney, Australia, ³Department of Psychology, University of Arizona, Tucson, Arizona, USA, ⁴The University of Sydney, Central Clinical School, Sydney, Australia

Mind-wandering refers to the quintessentially human capacity to perceptually decouple from the immediate surroundings to consider perspectives distinct from the here and now. Reductions in mind-wandering may constitute an important neurocognitive endophenotype across clinical disorders, reflecting alterations in default and frontoparietal brain networks. Here, we explored mind-wandering in semantic dementia, a neurodegenerative disorder characterised by progressive deterioration of the conceptual knowledge base due to anterior temporal lobe degeneration. Thirteen SD patients were contrasted with 28 healthy older Controls on the Shape Expectations task, a minimally demanding cognitive task which reliably promotes mind-wandering. An episodic-semantic mind-wandering score was derived, representing an individual's tendency to mind-wander in a predominantly episodic versus semantic style. Despite marked semantic deficits, SD patients displayed significantly elevated episodic-based mind-wandering relative to Controls (p < .001). Voxel-based morphometry analyses demonstrated that the co-occurrence of atrophy in the left inferior temporal gyrus and left putamen correlated with mind-wandering in SD. Resting-state functional connectivity analyses further revealed that decreased functional connectivity between inferior parietal regions of the default mode network and the anterior cingulum correlated with SD mind-wandering performance. This study is the first, to our knowledge, to document a striking facilitation of episodic-based mind-wandering in a population characterised by marked cognitive decline and significant neural insult. This increased proclivity for episodic mind-wandering reflects the disconnection between posterior brain regions of the default mode network and prefrontal regions essential for executive control, which may allow intact episodic representations to be harnessed by the SD patient in an unconstrained manner.

Topic Area: THINKING: Development & aging

E131 The Role of Cognitive Reserve and Brain Connectivity in Cognitive Function

Benjamin Dykstra¹, Elizabeth Douglas¹, Brandy Morris¹, Vincent Bryant¹, Jessica Fleck¹; ¹Stockton University

The frontoparietal attention network has been associated with strong cognitive function during aging. We explored the contributions of cognitive reserve (CR) and brain connectivity in predicting cognitive function. CR reflects the ability for sustained cognition despite physical brain changes from aging or disease and is acquired by participating in activities such as education and social engagement. We tested a diverse sample, comprised of different racial and ethnic groups and varied socioeconomic statuses. Participants completed the Cognitive Reserve Index, a measure of CR with education, occupation, and leisure subscales, along with the CANTAB, a computerized assessment of cognitive function. Further, participants had their resting-state brain activity recorded with EEG. We calculated coherence among 32 electrodes in the 10-10 system for each frequency band, delta through gamma. Our analyses focused on beta coherence due to its link to cognitive function in prior research. Coherence was calculated using Nolte's imaginary coherence to reduce effects of volume conduction. Mean local coherence was calculated within frontal and posterior electrode locations, separately for each

hemisphere, and long-distance coherence was calculated between frontal and posterior regions, within and between hemispheres. A standard multiple regression with age, CR, and beta coherence measures significantly predicted composite cognitive function, $F(6, 97) = 4.215$, $p = .001$, $R^2_{Adjusted} = 15.80$. Within the model, age ($p < .001$), CR ($p = .008$), and left frontal-posterior beta coherence ($p = .013$) were significant predictors. Our findings support the unique contributions of CR and brain connectivity in cognitive function in different age groups.

Topic Area: THINKING: Development & aging

E132 Increased creative thinking in narcolepsy

Celia Lacaux^{1,2}, Giuseppe Plazzi³, Isabelle Arnulf^{1,2}, Delphine Oudiette^{1,2}; ¹Sorbonne University, IHU@ICM, INSERM, CNRS UMR7225, F-75013 Paris, France, ²AP-HP, Hôpital Pitié-Salpêtrière, Service des Pathologies du Sommeil, F-75013 Paris, France, ³University of Bologna, Bologna, Italy

Rapid eye movement (REM) sleep and dreams have been linked to creativity. However, most studies relied on simple associative tasks and did not assess creativity per se, a process that is unlikely to be achieved in a single nap. To tackle this methodological hurdle, we called upon experts of REM sleep and dreams: subjects with narcolepsy, who present excessive daytime sleepiness, symptoms of dissociated wakefulness and REM sleep (e.g., lucid dreams), and a high dream recall frequency. Given their life-long privileged access to REM sleep and dreams, we hypothesised that subjects with narcolepsy have developed high creative abilities. To test this assumption, we evaluated, with two questionnaires, the creative achievements and the creative profiles of 185 subjects with narcolepsy and of 126 healthy matched-controls. Then, we objectively tested the creative performance of 30 subjects with narcolepsy and of 30 matched-controls. This test assesses the two key modes of creative thinking, namely divergent-exploratory thinking (i.e., finding the greatest number of solutions based on a given stimulus) and convergent-integrative thinking (i.e., integrating several elements into a coherent and original synthesis) on two different domains of expression (graphic and verbal). Subjects with narcolepsy obtained higher scores than controls on the two questionnaires of creativity and on the objective test of creative performance in all the dimensions tested. Additionally, most symptoms of narcolepsy (but not treatments) were associated with higher scores of creativity. These results highlight a higher creative potential in subjects with narcolepsy and further support a role of REM sleep in creativity.

Topic Area: THINKING: Problem solving

E133 Neural basis of functional fixedness during creative ideas generation: an EEG study

Anaëlle Camarda¹, Émilie Salvia², Julie Vidal², Benoit Weil¹, Nicolas Poiré^{2,3}, Olivier Houdé^{2,3}, Grégoire Borst^{2,3}, Mathieu Cassotti^{2,3}; ¹Mines ParisTech, CGS, ²Paris Descartes University, LaPsyDÉ, ³Institut universitaire de France

The present study aimed at investigating the neural bases of the processes involved in overcoming fixation effects during creative ideas generation. Using the AUT adapted for EEG recording, we examined whether participant's ability to provide original ideas was related to alpha power changes in both frontal and temporo-parietal regions. Critically, for half of the objects, the classical uses of the objects were primed orally and a picture of the classical uses were presented visually to increase functional fixedness (Fixation Priming condition). For the other half, only the name of the objects and a picture of the objects was provided to the participants (control condition). As expected, priming the classical use of an object before the generation of creative alternative uses of this object impeded participant's performances in terms of expansivity. In the control condition, while the frontal alpha synchronization was maintained across all the successive time windows in high expansive participants, the frontal alpha synchronization decreased in weak expansive

participants. In the Fixation Priming condition in which functional fixedness is maximal both high and weak expansive participants maintain frontal alpha synchronization throughout the period preceding their answer. Whereas high expansive participants maintained alpha synchronization in the temporo-parietal regions throughout the creative ideas generation period, weak expansive participants displayed alpha desynchronization in the same regions during this period. Taken together these results suggest that high expansive individuals might generate more creative ideas than weak expansive ones because they rely to greater on internal semantic association and selection processes.

Topic Area: THINKING: Problem solving

E134 Neural Rule Based Systems

Dainius Kreivenas¹, Christian Huyck¹; ¹Middlesex University

The brain is a vast parallel system of neurons, but researchers often find it difficult to use neural systems to develop, among other things, neurocognitive models. Rule based systems (RBSs) allow people to solve difficult real-world problems, and are often used for, among other things, developing cognitive models. Implementing RBSs in simulated neurons enables huge parallel RBSs that can be run in neuromorphic hardware, like SpiNNaker, or on standard hardware using neural simulators like NEST. A system has been developed that translates an RBS into a neural system specified in PyNN. The rules and initial facts are specified by the user. The system converts these rules and facts into binary cell assemblies, which are made of Leaky Integrate-and-Fire Neurons. The rules and their associated facts, are mapped to finite state automaton, which are then converted into cell assemblies instantiated as a network of neurons with static synaptic connections that either ignite or extinguish cell assemblies. For example, a rule configuration of a 6x6 Sudoku puzzle is solved using almost fifty thousand neurons and seven hundred fifty thousand synapses. The system executes around 1000 rules at one time, and about 8400 rules in total over 197ms of simulated time to solve the puzzle. While it is extremely unlikely that the artificial neural topology is a direct copy of the associated biological neural topology, this provides a mechanism for supporting improved development of neural systems. This work is a plank for a proto neural cognitive architecture implemented in artificial neurons.

Topic Area: THINKING: Problem solving

E135 The Neural Underpinnings of Creative Design

Laura Hay¹, Alex Duffy¹, Sam Gilbert², Laura Lyall³, Gerard Campbell¹, Damien Coyle⁴, Madeleine Grealy¹; ¹University of Strathclyde, ²University College London, ³University of Glasgow, ⁴Ulster University

Neuroimaging investigations of creativity aimed towards uncovering its precise neural underpinnings have thus far been unable to reach firm conclusions. A systematic review and meta-analysis of fMRI visual creativity studies (Pidgeon et al., 2016) showed activation of the right PFC including right middle and inferior frontal gyri and right precentral gyrus, thalamocortical nucleus and left middle frontal gyrus. However, substantial variance in the regions engaged across studies suggests that activation differs according to task-specific factors, such as whether tasks emphasise novelty, function or aesthetics of generated solutions. Furthermore, no study to date has examined creative idea generation in professional designers. In the present fMRI study we recorded the neural activity of 29 professional engineering designers while they generated ideas in response to creative (open-ended) and innovative (constrained) design tasks. Performance on both tasks was found to be associated with greater activity in the left cingulate gyrus and right superior temporal gyrus compared with a design manipulation control task. Furthermore, region of interest analysis restricted to pre-frontal regions revealed no significant differences in brain activity between the creative and innovative tasks. These findings are consistent with previous studies

highlighting the role of left pre-frontal regions in supporting controlled semantic retrieval processes as well as the inhibition of unoriginal or irrelevant ideas during creative tasks. The results also align with previous studies suggesting that the right superior temporal gyrus facilitates insight during creative problem solving. Finally, the results show that creative and innovative design tasks recruit similar brain regions in professional designers.

Topic Area: THINKING: Problem solving

E136 The shape of the ACC contributes to both inhibitory control efficiency and the ability to generate creative idea in adolescents

Mathieu Cassotti^{1,4}, Anaëlle Camarda², Cloélia Tissier¹, Sylvain Charon³, Catherine Oppenheim³, Olivier Houdé^{1,4}, Grégoire Borst^{1,4}, Arnaud Cachia^{1,3,4}; ¹Université Paris Descartes, ²Mines ParisTech, ³Center of Psychiatry and Neurosciences, ⁴Institut Universitaire de France

The ability to inhibit common and dominant paths of solutions to a problem seems to be a critical process for generating creative ideas. Some of the strongest evidence linking inhibitory control to creative thinking has been provided by functional neuroimaging studies that have shown a positive relationship between the ability to generate creative solutions to a problem and activation of specific prefrontal brain regions, including the dorsal anterior cingulate cortex (ACC), known to be implicated in executive function and inhibitory control in particular. Of note, the ACC sulcal pattern, a qualitative feature of the brain determined in utero and not affected by brain maturation and learning, have been shown to influence inhibitory control efficiency in both children and adults. Using anatomical MRI and three-dimensional reconstruction of cortical folds, the aim of the present study was to determine whether ACC sulcal pattern influence inhibitory control performance and the ability to generate creative ideas in adolescents. Analyses confirmed that 1) inhibitory control performance, assessed using a standard inhibitory control task, is positively related to creativity in adolescents and 2) ACC sulcal pattern affects both inhibitory control efficiency and creative ideation. Taken together, these results support that inhibitory control is a core process to generate original solutions in a creative task.

Topic Area: THINKING: Problem solving

E137 Dynamic Functional Connectivity Measures Fail to Predict “Real World” Classroom Learning

Adam Weinberger¹, Robert Cortes¹, Adam Green¹; ¹Georgetown University

Learning is a complex process of adaptation, adjustment, and regulative change. In recent years, dynamic functional connectivity analyses have been used to examine brief changes in patterns of connectivity. Because the brain exists in a constant state of reconfigurations – and how and when these reconfigurations take place are likely to have behavioral ramifications – some have hypothesized that dynamic, short-term modulations of functional connectivity may be used to predict and assess learning. Notably, the majority of research within this burgeoning field has examined learning over short periods of time following brief training periods conducted in the laboratory environment. Thus, it is currently unknown whether dynamic functional connectivity can be used to better understand “real world” and/or classroom-based learning. Here, we recruited a group of high school students before and after participation in a year-long high school course (the GeoSpatial Semester; GSS) designed to build spatial thinking and project management skills through the use of geospatial technology. Students came to Georgetown University to complete an fMRI scanning session before and after the course. Dynamic functional connectivity metrics were calculated at rest and as students completed a number of spatially-based tasks. In contrast to the current literature, dynamic functional connectivity metrics were not able to effectively predict learning during the year-long course.

Topic Area: THINKING: Reasoning

E138 Minding the eye: an Aphantasia case study

Natalie Halloran¹, Abigail Beck¹, Carole Scherling¹; ¹Department of Psychological Science, Belmont University, Nashville, TN, USA

Aphantasia, a condition in which an individual is not able to conjure images within the “mind’s eye,” reveals deficits in the ability to mentally picture people, places, or events (Zeman, 2018). Hence, these individuals may have differences in their ability to learn, mentally modulate as well as recognize and remember items. Deficit diagnosis is uncommon due to a lack of awareness for affected individuals and clinicians alike. Case studies are essential to advance our understanding. The current study examined 2 patients (23; 1M) with aphantasia. They completed a battery of visuospatial and memory tasks: mental rotation, change blindness, abstract word recognition, spatial reasoning, and memory load (Jacobs, 2017). Such tests measure the capacity for internal representation of objects. Healthy controls demonstrate higher capacity to fulfill visual tasks, while being even with aphantasia patients on spatial tasks (Keogh & Pearson, 2017). Results indicate that aphantasia subjects demonstrate expected task reaction times and error rates compared to healthy controls (ex: Rey-Osterrieth reaction time: 102 seconds; scores: 20/36 and 22/36). However, subjects were unique in approaching the tasks and self-reported high levels of frustration and fatigue. In addition, they demonstrated higher-than-expected verbalization of task actions. Concluding, aphantasia individuals have likely acquired compensatory skills to overcome internal representation short-comings, but deficits lead to increased cognitive load. Continued study of cases, adding neuroimaging and increasing sample sizes will lead to a better understanding. It will also grant a better understanding of the practical role that the mind’s eye plays in daily life.

Topic Area: THINKING: Reasoning

E139 The Influence of Reasoning Ability and Relational Cueing in Solving Relational Match-to-Sample Problems

Matthew J. Kmiecik¹, Alex D. Martin¹, Lauren M. Kim¹, Rudy Perez¹, David M. Martinez¹, Ekarin E. Pongpipat¹, Daniel C. Krawczyk^{1,2}; ¹The University of Texas at Dallas, ²The University of Texas Southwestern Medical Center

Performing relational comparisons is considered among the most intelligent cognitive capacities. Animal studies have demonstrated that chimpanzees and crows are capable of relational reasoning with second-order relationships (e.g., analogies); however, it has been hypothesized that only humans are capable of reasoning with third-order relationships. Exploring this process in humans, we were interested in understanding the relationship between relational reasoning performance in varying performers given different instructions. To investigate this, participants were presented relational match-to-sample problems that varied in relational complexity: perceptual, analogical, and system mappings. Problem types were presented with minimal instruction, no practice, and randomly across four blocks. The participants received feedback after each attempt and an instructional manipulation was given to facilitate relational thinking. Performance types (high vs. low) were defined to understand individual differences in reasoning ability. Results showed that performance decreased with greater relational complexity; however, the participants’ rate of learning the three relational structures depended on performance level and whether the instructional manipulation was given. Specifically, high performers more accurately solved analogical mappings and demonstrated a curvilinear learning rate across block, such that system mapping performance decreased before increasing across the experiment. High performers also had higher visual working memory scores and better verbal and scene analogy performance. The instructional manipulation was a much weaker effect than performance type but resulted in participants learning the analogical mapping structure at a faster rate. Humans’ ability to learn

complex relational comparisons with minimal instruction/feedback is associated with working memory ability and improved by relational cueing.

Topic Area: THINKING: Reasoning

Poster Session F

Tuesday, March 26, 8:00–10:00 am, Pacific Concourse

F1 Attention Control and Inhibition in ADHD Using a Comprehensive, Case Study Approach

Maria Stacy¹, Emily Caminiti¹, Zsafia Imre¹, Hannah Travis¹, Audreyana Jagger-Rickels¹, Sarah Vadnais¹, Jennifer Schlak¹, Genni Newsham¹, Michelle Y. Kibby¹; ¹Southern Illinois University- Carbondale

Although various researchers have investigated attentional control in adolescents with ADHD using ERP, no studies were found utilizing either a visual 3-stimulus oddball or a directional Stroop task. Both paradigms were utilized in the present case study, along with neuropsychological testing and MRI data. Participants included two adolescents with ADHD and two controls, ages 14-16 years. Neither ADHD adolescent had a P3a during the oddball task, whereas controls did, commensurate with a prior study using an auditory odd-ball task (Tang et al., 2015). Similarly, both ADHD adolescents had high inattention scores on the BASC relative to controls. On the directional Stroop task ADHD and controls had comparable N2 latencies during the incongruent condition measuring response inhibition (268 versus 262 milliseconds), but ADHD had slightly longer N2 latency than controls on the more difficult mixed condition (367 versus 267 milliseconds) measuring inhibition and attention control. ADHD's N4 latencies were slightly longer in both conditions. Controls' peak N2 activation during the mixed condition was in right prefrontal, whereas it was in right fusiform for ADHD. For the N4, controls' peak activation was in left fusiform, whereas it was in right inferior temporal for ADHD. Consistent with their differing activation, ADHD displayed worse inhibition and working memory on the BRIEF than controls. Similarly, ADHD had smaller right prefrontal volumes than controls when using voxel-based morphometry (VBM). Taken together, youth with ADHD have worse attentional control than controls which may be related to worse anterior functioning based upon P3a, N2, and MRI data.

Topic Area: ATTENTION: Other

F2 Brain imaging of ADHD with a real-world condition

Juha Salmi^{1,2,3,4,5}, Mostafa Metwaly⁴, Kimmo Alho⁴, Sami Leppämäki⁶, Pekka Tani⁶, Anniina Koski⁶, Mika Määttä⁶, Susanne Jaeggi^{7,8}, Jussi Tohka⁹, Matti Laine¹⁰; ¹Department of Psychology and Speech-Language Pathology, University of Turku, Turku, Finland, ²Turku Institute for Advanced Studies, University of Turku, Turku Finland, ³Department of Psychology, Åbo Akademi University, Turku, Finland, ⁴Department of Psychology and Logopedics, University of Helsinki, Helsinki, Finland, ⁵AMI Centre, Aalto Neuroimaging, Aalto University, Espoo, Finland, ⁶Department of Psychiatry, Helsinki University Hospital, Helsinki, Finland, ⁷School of Education, University of California, Irvine, USA, ⁸Department of Cognitive Sciences, University of California, Irvine, USA, ⁹AI Virtanen Institute for Molecular Sciences, University of Eastern Finland, Kuopio, Finland, ¹⁰Brain and Mind Center, University of Turku, Turku, Finland

Here we suggest a new avenue for brain imaging of ADHD using a real-world condition where participants watch a film excerpt with added irrelevant background noises (speech, music, white noise). Using fMRI, we compared 52 adults with ADHD and 29 healthy controls for their brain response amplitudes, inter-subject correlations, and functional connectivity on this condition. We also compared the brain activity during real-world condition with

conventional strictly controlled tasks and resting state analyses, and examined its use in assessing the efficacy of a cognitive training intervention in ADHD. Film episodes without irrelevant distractors elicited similar, robust responses in the frontoparietal networks in the ADHD participants and the controls. The distractors caused increased activations in the auditory and visual areas, as well as in the default-mode network, with significantly stronger responses in the ADHD participants as compared with the controls. A randomized controlled trial within the ADHD group showed that the distractor-related responses in the visual cortex were partially normalized through cognitive training. The data-driven analysis of inter-individual brain response variability showed altered activations in ADHD participants in brain areas overlapping with those showing amplitude differences. Inter-individual variability of the brain responses was also related to the ADHD symptom severity. Finally, our results suggest that during film viewing altered functional connectivity is observed beyond areas showing group differences during resting state. The results highlight the potential of real-world conditions in advancing our understanding on the neurocognitive mechanisms of ADHD and its treatment.

Topic Area: ATTENTION: Other

F3 Fluctuations in pupil size reflect lack of external attention

Jaana Simola¹, Mahiko Konishi², Satu Palva^{1,3}, Jonathan Smallwood², Matias Palva^{1,3}; ¹Helsinki Institute of Life Science (HiLIFE), Neuroscience Center, University of Helsinki, Finland, ²Department of Psychology / York Neuroimaging Centre, University of York, UK, ³Centre for Cognitive Neuroimaging, Institute of Neuroscience and Psychology University of Glasgow, UK

Unusually small or large pupil dilations are associated with momentary lapses in attention. Here, we examined whether scale-free fluctuations as evidenced by long range temporal correlations (LRTCs) in pupil size time-series are affected by the external task focus. Participants (N=24) saw pairs of shapes (Non-Targets, NTs) followed by a target stimulus. In the 0-back task, they responded which shape matched the presently perceived shape, while the NTs were irrelevant for the task. In the 1-back task, participants responded depending on which side the target was on the previous trial, and they must attend on the NTs. Pupil size were recorded in two sessions consisting of alternating task blocks. Focus of attention was measured by task performance and self-reports collected at the end of the sessions. We used detrended fluctuation analysis (DFA) to obtain the LRTC scaling exponents that quantify the strength of long-range correlations of pupil size time-series. The LRTC scaling exponents were stronger in the 0-back relative to the 1-back task and correlated negatively with the reported levels of detail in thought. Slower response times were further associated with increased levels of self-referential thinking. Our data indicated stronger LRTCs in pupil size when attention was less constrained by the task as well as an association between scale-free pupil size fluctuations and the form of self-generated thought. These results suggest that pupil size fluctuations could be used as an objective marker of the degree of task focus.

Topic Area: ATTENTION: Other

F4 Passive Implicit Learning in a Complex Task Environment

Gregory Gill¹, Stephen Luehr¹, Olave Krigolson¹; ¹University of Victoria, Centre for Biomedical Research

In professions where focus and concentration are imperative, it is important to have measures of cognitive ability without drawing attention away from the primary task. The concept of attention is often measured within electroencephalography research using the P300. This component is generally accepted to reflect stimulus evaluation. Here, we tested the degree to which participants are subconsciously attending to their peripheral environment when they should be focusing on the task at hand. EEG data was

recorded from participants as they performed a simple reward learning task followed by a visual acuity task as the primary focus of the experiment. To determine the extent to which humans allocate attention to extraneous information in their surrounding environment, we overlaid an auditory acuity task on top of the two primary tasks. Indeed, the irrelevant auditory acuity task elicited a P300 response, illustrating that even when focused on specific tasks, humans are continuously moderating their peripheral environment. These results show promise for the potential use of unattended, non-intrusive stimuli to probe various aspects of brain function and ability in crucial lines of work such as medical and transport environments.

Topic Area: ATTENTION: Other

F5 Separable attention processes constrain multidimensional reinforcement learning

Angela Radulescu^{1,2}, Yael Niv^{1,2}; ¹Princeton University Department of Psychology, ²Princeton Neuroscience Institute

Two prominent theories suggest different targets for selective attention in reinforcement learning: according to one theory, attention should be directed towards stimulus features that are most predictive of reward (Mackintosh, 1975). An alternative view suggests instead that attention should be directed towards features that we are most uncertain about (Pearce and Hall, 1980). Dayan et al. (2000) offered a resolution to this seeming contradiction by suggesting that when making choices, one should attend to the most predictive features, whereas when learning one should attend to the most uncertain features. Here we combine eye tracking with a multidimensional reinforcement learning task in order to simultaneously measure attention for choice and attention for learning. In each trial of the task, human participants select one of 3 stimuli that differ along 3 dimensions: faces, houses and tools. Choosing the stimulus containing a "target" feature yields 1 point 75% of the time. Choosing stimuli that do not contain the target feature yields 1 point 25% of the time. To do well, participants must learn from trial and error the identity of the target feature. We measured participants' focus of attention by monitoring their eye movements during the choice and learning phases of each trial. Using trial-by-trial computational modeling in combination with an empirically derived index of attention, we show that attention for choice and attention for learning are separable cognitive processes, and that this separation is predictive of choice behavior.

Topic Area: ATTENTION: Other

F6 Signal Complexity of the Whole Brain Connectome is related to Fluctuations in Attention

Agnieszka Zuberer^{1,2}, Eve M. Valera^{5,6}, Aaron Kucyi^{4,5,6}, David Rothlein^{1,2}, Michael Esterman^{1,2,3}; ¹Department of Psychiatry, Boston University School of Medicine, ²Boston Attention and Learning Laboratory, Veterans Administration, Boston Healthcare System, Boston, MA 02130, ³Neuroimaging Research for Veterans Center (NeRve), Veterans Administration, Boston Healthcare System, Boston, MA 02130, ⁴Department of Neurology & Neurological Sciences, Stanford University, Stanford, ⁵Department of Psychiatry, Harvard Medical School, ⁶Department of Psychiatry, Massachusetts General Hospital, Charlestown

Attention fluctuates from moment to moment between different degrees of on/off-task focus. While these fluctuations have been associated with activity and connectivity in a variety of specific brain regions, less work has been done to relate these fluctuations to a meaningful and reliable measure of global brain functioning. A body of research suggests that brain signal variability is a functional property rather than mere noise: higher brain signal variability has been related to more accurate and stable task performance and a marker for brain maturation. While these findings are based on voxel-wise signal variability calculations of activation over time, we propose an alternative

approach, exploring variability of connectivity patterns across the whole-brain (connectome) over time, or graph spectral entropy (GSE). In contrast to activation variability, we predicted that lower connectome-based signal variability would be a marker of greater attentional stability, or on-task focus. To address this question, 26 healthy adults underwent 4 sessions of the gradCPT, a well-validated continuous performance task (Esterman et al., 2013). During the gradCPT, thought probes appeared pseudo-randomly instructing subjects to rate the degree of their task focus in the previous trial. For each pre-thought probe 30s epoch, GSE was calculated across the whole-brain using a 351-region parcellation (Craddock et al., 2012). Higher GSE was significantly associated with poorer states of attention, using both objective (greater RT variability) and subjective (lower on-task focus) measures. These findings suggest that signal complexity of the whole-brain connectome may constitute a functional property of the brain which tracks attentional fluctuations.

Topic Area: ATTENTION: Other

F7 The Effects of Delta Transcranial Alternating Current Stimulation on Dynamic Attending are Phase and Context Dependent

Adam K. Shelp¹, Martin Wiener¹; ¹George Mason University

Attention requires the allocation of limited resources to properly interpret our environment, making it ultimately unsustainable. Dynamic Attending Theory suggests that, in order to realistically maintain vigilance to our surroundings, attention likely fluctuates between high and low energetic states, such that information can be processed more quickly and accurately during attentional peaks and vice versa. Additionally, prior studies have suggested that the phase of delta oscillations (1-4 Hz) are critically involved in the entrainment of attention. We investigated the physiological and behavioral entrainment of attention and the role that delta phase plays to moderate the benefits of this attending. Participants (N=28) passively experienced a background auditory rhythm and were required to complete a visual discrimination task while undergoing 2 Hz transcranial alternating current stimulation (tACS). The task involved identifying an image, either upright or inverted, presented either on or before the beat, while receiving delta stimulation that was either aligned or unaligned with image presentation. As expected, reaction times (RTs) were faster for on-beat than off-beat stimuli, and for upright images than inverted. Crucially, tACS in phase with the beat led to improved RTs over out-of-phase stimulation, but only for upright images; remarkably, this pattern was reversed for out-of-phase stimulation during inverted images, with faster RTs for inverted stimuli presented on-beat. These results suggest that the effects of delta tACS are both phase and context dependent, and mediate a potential form of speed-accuracy tradeoff in the allocation of attentional resources during rhythmic entrainment.

Topic Area: ATTENTION: Other

F8 Brain and cognitive mechanisms of top-down attentional control in a naturalistic settings: Benefits of multi-variate electrical analyses

Pawel J. Matusz^{1,2,3}, Nora Turoman², Ruxandra I. Tivadar², Chrysa Retsa², Micah M. Murray^{2,3,4,5}; ¹Information Systems Institute at the University of Applied Sciences Western Switzerland (HES-SO Valais), 3960 Sierre, Switzerland, ²The LINE (Laboratory for Investigative Neurophysiology), Department of Radiology, University Hospital Centre and University of Lausanne, 1011 Lausanne, Switzerland, ³Department of Hearing and Speech Sciences, Vanderbilt University, Nashville, TN 37203- 5721, USA, ⁴The EEG Brain Mapping Core, Center for Biomedical Imaging (CIBM), University Hospital Center and University of Lausanne, 1011 Lausanne, Switzerland, ⁵Department of Ophthalmology, University of Lausanne and Fondation Asile des Aveugles, Lausanne, Switzerland

In real-world environments, information is typically multisensory, and objects are a primary unit of information processing. Object recognition and action necessitates attentional selection of task-relevant from among task-irrelevant objects. However, brain and cognitive mechanisms governing attentional selection of multisensory objects remain poorly understood. In multi-stimulus (visual) arrays, attentional selection of objects in humans and animal models is traditionally quantified via “the N2pc component”: spatially-selective enhancements of neural processing of objects within ventral visual cortices app. 150–300ms post-stimulus. We tested whether N2pc is a viable marker of attentional control in naturalistic, multisensory contexts. Participants searched for coloured targets while colour and/or colour-sound distractors preceded search array. Across several datasets, behavioural spatial-cueing effects reflected well control of visual attentional selection by multisensory processes. Contrastingly, traditional analyses of mean N2pc amplitudes over PO7/8 across app. 150–300ms post-cue did not reflect or correlate with multisensory effects observed behaviourally. To provide more direct evidence for brain and cognitive mechanisms underlying attention control in naturalistic, multisensory settings, we analysed lateralised ERPs across N2pc time-windows with electrical neuroimaging and multi-variate pattern analyses. These analyses revealed that multisensory processes control attentional object selection by altering strength of response within the same brain networks and/or altering the engaged brain networks across unisensory and multisensory contexts. We discuss how an approach combining rigorous tasks emulating (multi-sensory/task-demand) variabilities of real-world environments with cost-effectiveness of EEG and robust analyses of rich spatio-temporal data provided by EEG can offer new insights how neurocognitive functions, like attention control, operate in everyday situations.

Topic Area: ATTENTION: Spatial

F9 Dissociating retinal eccentricity and covert spatial attention effects on visual evoked potentials: a gaze-controlled ERP study

Juliane Britz¹, Doron Ariav², Pnina Rappel², Leon Y Deouell²; ¹University of Fribourg, Switzerland, ²The Hebrew University of Jerusalem, Israel

Central support for early attentional selection comes from the finding that stimuli appearing at attended locations elicit early visual evoked potentials (VEPs; < 200 ms) with larger amplitudes than do stimuli at unattended locations. In a typical experiment demonstrating this phenomenon, observers are asked to fixate their gaze on a central marker and respond to lateral stimuli that follow a cue to attend left or right. The difference between responses to stimuli at attended and unattended locations is taken as a signature of covert spatial attention. However, it was recently shown that following the cue, involuntary microsaccades tend to be biased toward the cued location. Thus, attended stimuli may have reduced retinal eccentricity relative to the unattended stimuli. In an experiment using simultaneous high resolution eye tracking and EEG in 14 subjects, we asked whether this eccentricity difference, instead of genuine covert spatial attention, could explain the enhanced VEPs for stimuli in the cued side. Replicating previous studies, subjects indeed biased their microsaccades toward the cued side. However, the classic VEP spatial attention effects were replicated even when the bias was accounted for by removing trials with deviation from central fixation. Moreover, the effects persisted even when eccentricity was strictly controlled using gaze-contingent display. Thus, we conclude that spatial attention effects on VEPs are not attributable to differences in stimulus retinal eccentricity.

Topic Area: ATTENTION: Spatial

F10 Hodological correlates of human visuo-spatial attention and its disorders based on coalitional game theory-derived contributions of white matter bundles

Melissa Zavaglia^{1,2}, Monica N. Toba^{3,4}, Tristan Moreau³, Federica Rastelli^{3,5}, Anna Kaglik^{3,5}, Romain Valabregue⁶, Pascale Pradat-Diehl^{5,7}, Claus C. Hilgetag^{1,8}, Antoni Valero-Cabré^{3,5,9}; ¹Department of Computational Neuroscience, University Medical Center Hamburg-Eppendorf, Hamburg, Germany., ²Jacobs University, Focus Area Health, Bremen, Germany, ³Cerebral Dynamics, Plasticity and Rehabilitation Team, Frontlab, Brain and Spine Institute, ICM, Paris, France, Sorbonne Universités, UPMC Paris 06, Inserm UMR S 1127, CNRS UMR 7225, F-75013, & IHU-A-ICM, Paris, France., ⁴Laboratory of Functional Neurosciences (EA 4559), University Hospital of Amiens and University of Picardy Jules Verne, Amiens, France., ⁵AP-HP, HxU Pitié-Salpêtrière-Charles-Foix, service de Médecine Physique et de Réadaptation & PHRC Régional NEGLECT, Paris, France., ⁶Centre for Neuroimaging Research - CENIR, Brain and Spine Institute, ICM, Paris, France, Sorbonne Universités, Inserm UMR S 1127, CNRS UMR 7225, F-75013 Paris, France., ⁷GRC-UPMC n° 18- Handicap cognitif et réadaptation, ⁸Department of Health Sciences, Boston University, 635 Commonwealth Ave. Boston, MA 02215, USA., ⁹Laboratory for Cerebral Dynamics, Plasticity & Rehabilitation, Boston University School of Medicine, Boston, MA 02118, USA.

The disconnection paradigm revived by Geschwind et al. (1965) and recently revisited by Catani & ffytche (2005) assumes that the integrity of white matter (WM) bundles is essential in characterizing brain structures and functions relationships. By taking advantage of this framework, here we used the Multi-perturbation Shapley value Analysis (MSA) based on coalitional game theory and inferred causal patterns of contributions of WM bundles in the visuospatial attention function on the basis of lesion volume and behavioral performance datasets (line bisection and cancellation tasks) from 25 right hemisphere stroke patients. Results showed that optical radiations (OR) always exerted positive contributions whereas the anterior cingulum (CA) contributed always negatively. Alternating task-dependent contributions were observed for the second and third branches of the superior longitudinal fasciculus (SLF II and SLF III, both having positive contributions for the bells cancellation and negative contributions to the other tests), the posterior cingulum (CP) (negative contribution to bells cancellation test and positive contribution to the other tests), and the inferior fronto-occipital fasciculus (IFOF) (negative contribution to letter cancellation, and positive contribution to the other tests). These results characterize and specify the role of disconnection in visuospatial attention disorders and pave the way to non-invasive stimulation studies to rehabilitate related disorders.

Topic Area: ATTENTION: Spatial

F11 Hunger potentiates the unconscious capture of attention by food-related images

Arne Ilse¹, Mircea Ariel Schoenfeld³, Sarah Donohue^{1,2}, Jens-Max Hopf^{1,2}, Hans-Jochen Heinze¹, Joseph Harris^{1,2}; ¹Otto-von-Guericke University, Magdeburg, ²Leibniz Institute for Neurobiology, Magdeburg, ³Klinikum Schmierer Heidelberg, Heidelberg

Visual targets containing reward-associated features or objects appear to capture attention. This capture is evident behaviorally as faster and more accurate responses, and neurally as an enhanced-amplitude N2pc index of spatial attention allocation, which occurs even when the targets are presented outside of awareness. In the case of reinforcers such as food or substances of dependence, it is likely that the motivational state of craving accompanying deprivation potentiates this capture. The automaticity of such attentional capture by reward-associated stimuli, as well as its possible interaction with craving, is as yet not completely understood, though it is likely a major explanatory factor in motivated behaviors. For the present experiment, participants completed two EEG recording sessions: one just after eating lunch (sated / non-craving), and the other following a minimum 12-hour period of fasting (hungry/craving). For both sessions, participants identified food- and clothing- related targets embedded in a substitution masking paradigm, which yielded trials of full target visibility, as well as trials for which targets were

present but undetected. Although masking equally disrupted visual awareness of both classes of targets, a three-way session by visibility by target interaction was observed, with unseen food targets eliciting relative N2pc enhancement, but only during the “hungry” session. No such capture was evident under conditions of full visibility. These findings indicate that attentional capture by food-related images, and reflected in enhancements of the N2pc, is spurred by hunger, and that this effect only takes place in the absence of awareness.

Topic Area: ATTENTION: Spatial

F12 Inhibitory control training induces cortical thickness changes linked to global/local visual abilities in children

Nicolas Poirrel^{1,2}, Arnaud Cachia^{1,2}, Marine Moyon¹, Lisa Delalande¹, Valérie Datin-Dorrière¹, Katell Mevel¹, Grégory Simon³, François Orliac¹, Bernard Guillois⁴, Olivier Houdé^{1,2}, Grégoire Borst^{1,2}; ¹LaPsyDÉ, UMR 8240, CNRS, Université Paris Descartes, Université de Caen Normandie, France, ²Institut Universitaire de France (IUF), Paris, ³ISTS, UMR 6301, CNRS, CEA, Caen, France, ⁴LPCN, Université de Caen Normandie, France

Visual environments are composed of global shapes and local details that compete for attentional resources. Children, who present a weaker bias toward global visual information than adults, have to inhibit the local information to correctly consider global information, and vice-versa. The present work used for the first time a longitudinal design to test the effect of an inhibitory control training on cortical thickness changes linked to global/local abilities in ten years-old children. Participants were randomly assigned to an inhibitory control (stroop/stop-signal tasks) or a control (knowledge based task) training group. In the pre- and post-training sessions, children performed a classic global/local visual task and a 3-Tesla MRI session. Performances during global/local visual task improved more in the inhibitory control group than in the control group. Moreover, in comparison to the control group, better abilities to deal with interference from local information after inhibitory control training was associated with changes in cortical thickness in prefrontal regions (insula, inferior, middle and orbital). On the other hand, inhibitory training group presented better abilities to deal with interference from global information associated with thickness changes in postcentral, superior temporal and occipital regions. Altogether, the present study is the first to evidenced the beneficial impact of inhibitory control training on both behavioral and neural levels for visuo-spatial abilities in children, with a posterior neural plasticity linked to the ability to deal with conflicting global information, and an anterior neural plasticity linked to the ability to deal with conflicting local visual information.

Topic Area: ATTENTION: Spatial

F13 Successful classification of attentional tasks by power modulations in the alpha frequency bandwidth

Jonathan Silas¹, Irene Varela Leniz², Eris Chinellato¹, Bettina Forster³, Alexander Jones¹; ¹Middlesex University London, UK, ²Mondragon Unibertsitatea, Mondragón, Spain, ³City University London, London, UK

Power modulations at the alpha frequency recorded over the somatosensory cortex have been shown to systematically vary depending upon attention to tactile stimuli. When attention is orientated endogenously to the left or right, alpha power has been shown to be heavily lateralised in the brain. However, when attention is cued exogenously, somatosensory alpha lateralisation decreases. We sought to ask whether alpha power measured at electrodes over the somatosensory cortex contained sufficient information to categorise the attentional processes engaged in by the participant. Participants completed three attentional tasks whilst we recorded their electroencephalography (EEG). Each task included a lateralised cue to the left or right index finger followed by a target (after 1000 ms) to the same or opposite hand. In the exogenous task, the cue provided no information about

the location of the upcoming target. In the endogenous predictive task, the cue was predictive of the target to the same hand (80%) and in a counter-predictive task, to the opposite hand. Using a machine classifier (random forest) trained on 90% of the data during the cue-target interval we show that central alpha power is sufficient to categorise the tasks above chance in the remaining 10% of data. Further, we find that categorisation is best in the 300-400ms time window and that the contribution by the hemisphere contralateral to the stimuli is better early in the cue-target interval, whilst ipsilateral hemispheric contribution is best late, just before target onset. These findings suggest a necessary role of alpha power in attentional mechanisms.

Topic Area: ATTENTION: Spatial

F14 A Pilot Study on Mirror Neuron Functioning and the Social Impairments Observed in Depression

Michael Widdowson¹, Christina Kim¹, Yuzhou Tong¹, Crystal Inacay¹, Fiza Singh², Jaime A. Pineda¹; ¹Department of Cognitive Science, University of California, San Diego, ²Department of Psychiatry, University of California, San Diego

The discovery of mirror neurons in primates and the mirror neuron system (MNS) in humans has provided the basis for how biological agents might understand the emotions of others by integrating action and perceptual networks in the brain. In particular, social “mirroring” has been shown to be abnormal in certain psychiatric disorders, including autism and schizophrenia. There is growing evidence to suggest that MNS abnormalities might exist in depressive disorders. Our pilot study explored the relationship between social functioning (empathy, theory of mind, and emotion recognition) and MNS activity, as indexed by the suppression of mu rhythms (MS), in depressive symptoms. We hypothesized that symptom severity would correlate with reduced social functioning, and decreased MS, implying reduced MNS function. Thirty-two subjects, 18-25 years old, from the University of California, San Diego were recruited. Subjects completed Beck’s Depression Inventory (BDI) and were assigned to two groups, non-depressed (ND, BDI score: 0-13) or depressed (D, BDI score: 14-28). Subjects completed self-report questionnaires (STAI, IRI, ECR-R), tasks (Dot Probe, TASIT), and performed a modified version of the Reading the Mind in the Eyes Test (RMET). Scalp EEG was recorded during RMET and resting state (RS). Depressive symptoms negatively correlated with social cognition (TASIT: $r=-0.52$, $p=0.005$), empathy (IRI-EC: $r=-0.37$, $p=0.049$) and perspective taking (IRI-PT: $R=-0.37$, $p=0.048$). In addition, a correlation was found between depressive symptoms and interhemispheric midbrain mu wave asymmetry during RS eyes-closed. This implies there is aberrant somatosensory mu rhythm activity with greater depressive symptoms, implicating abnormal MNS functioning in depression.

Topic Area: EMOTION & SOCIAL: Other

F15 Neural Synchronization in lovers

Yuhang Long¹, Lifan Zheng¹, Xialu Bai¹, Hui Zhao¹, Wenda Liu¹, Chunming Lu¹; ¹Beijing Normal University

Romantic relationship is one of the basic bonds which can facilitate foundation and development of the society. People in romantic relationships have unique performances in behavior, biochemistry and brain functional imaging. Most of the previous studies explored romantic relationship from a single-person perspective. However, it is necessary to examine the mechanism from a two-person perspective due to the interactive nature of this interpersonal connection. Recently, many studies based on dual-brain suggested that interpersonal brain synchronization can be used as an indicator of the quality of communication. The purpose of this study is to reveal whether there will be brain synchronization mechanisms that are differing from other types of interpersonal relationships, such as cross-sex friendship; and whether the

brain synchronization will be affected by social interaction scenarios and whether it is associated with the intensity of the relationship. Here, we used three categories of topics consisting of a neutral topic, a supportive topic and a conflicting topic. By analyzing the brain activity synchronization under the three different topics, we found that lover group shows higher brain synchronization between the somatomotor cortex of male and temporal pole of female than friend group regardless of interaction scenarios. And the compassionate love score is associated with this brain synchronization. These findings suggest that brain synchronization underlies the communication between lovers. This study showed important theoretical significance to reveal the basic law of romantic relationship.

Topic Area: EMOTION & SOCIAL: Other

F16 Probability of Reward modulates Reward-related Activation and Sex differences in the medial Prefrontal Cortex and striatum in youth with ADHD

Prerona Mukherjee¹, Maria B. Menor¹, Shannon L. Hoffman¹, Tadeus A. Hartanto¹, J. Faye Dixon¹, Wouter van den Bos^{2,3}, Julie B. Schweitzer¹, Catherine Fassbender¹; ¹MIND. Institute, UC Davis, CA, ²Max-Planck-Institut für Bildungsforschung, ³The University of Amsterdam

Altered reward processing in ADHD is linked with hypoactivity in the striatum. However, sensitivity to reward and activity in striatum in ADHD may be impacted by the probability of reward. Using a reward paradigm involving fixed probabilities of reward, we examined brain regions associated with wins and losses, with and without modulation by reward probability with MRI (N 130; ADHD 65; aged 12-22; Female 55). We used a-priori regions of interest (ROI) derived from the Neurosynth database for regions associated with reward and loss including the orbitofrontal cortex (OFC) and basal ganglia (BG). We used repeated measures ANOVAs with Condition (Win vs. Loss) as a within subjects factor and Group (TD vs. ADHD) and Sex (Female vs. Male) as between groups factors, co-varying for age. We found a Condition x Group x Sex effect in reward-derived ROIs in the vmPFC and a Group x Sex effect in the left OFC. Factoring in probability resulted in a main effect of Group and a Condition x Group interaction in the OFC and a marginal effect of Group ($p=0.07$) in the vmPFC. In Loss-derived ROIs we found a marginal Condition x Sex interaction ($p=0.09$) in the right BG. However, factoring in probability a Condition x Group interaction in the left BG and a marginal Condition x Group interaction in right BG emerged. Studies suggest minimal ADHD impairment during reward receipt; we suggest that differences maybe more appreciable when accounting for reward probability. Furthermore males and females with ADHD experience differential reward responsivity.

Topic Area: EMOTION & SOCIAL: Other

F17 Revelation of a protagonist as homosexual causes divergence of neural synchrony among heterosexual and homosexual spectators

Afadila Mamdooh¹, Mikko Sams¹, Iiro Jääskeläinen¹, Janne Kauttonen^{1,2}; ¹Brain and Mind Laboratory, Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland, ²Advanced Magnetic Imaging (AMI) Centre, Aalto NeuroImaging, Aalto University, Espoo, Finland

We perceive individuals belonging to our in-group vs. out-group differently. However, it is still unclear how contextual knowledge, not visible e.g. in facial characteristics, about the in-group of a given person modulates our social perception. Here, 29 participants (14 homosexuals and 15 heterosexuals) watched a short movie about a homosexual character whose sexual orientation is disclosed in the middle of the movie during functional magnetic resonance imaging of brain activity. We analyzed the data using data-driven inter-subject correlation (ISC) method. Significant between-group differences in ISC emerged in a number of brain regions as the protagonist's sexual orientation was revealed, positioning him to in-group of the homosexual

subjects and to out-group of the heterosexual ones. The homosexual subjects showed increased ISC in superior temporal sulcus, visual cortex, and right dorsolateral prefrontal cortex. The heterosexual subjects showed increased ISC in more extensive set of brain areas, including the right fusiform gyrus, right temporoparietal junction, bilateral somatosensory cortex, left prefrontal cortex, bilateral frontal gyrus, left temporal pole, anterior cingulate cortex, precuneus, and the cerebellum. It is possible that our results reflect more idiosyncratic in-group than out-group perspective. To our knowledge this is the first study to use complex movie narrative to investigate neural mechanisms involved with in/out-group social perspectives under naturalistic conditions.

Topic Area: EMOTION & SOCIAL: Other

F18 The psychophysiology of guilt

Chloe A. Stewart¹, Penny A. MacDonald¹, R.W.J. Neufeld¹, Derek G.V. Mitchell¹, Elizabeth C. Finger¹; ¹University of Western Ontario

The autonomic nervous system (ANS), which is responsible for the regulation of bodily functions, has been shown to play a role in the experience of emotions. Previous research has established physiological patterns of activation for numerous basic emotions. One emotion that has not yet been characterized, despite an anecdotally visceral experience, is guilt, an emotion that is elicited by realizing that one has caused actual or perceived harm to another. This study sought to identify the specific ANS patterns elicited during the experience of guilt. Fifty healthy individuals (25 female) completed a novel task, which involved viewing videos designed to elicit guilt and the comparison emotions of amusement, disgust, sadness, pride, and neutral affect. Participants' swallowing, heart, and respiration rates were continuously monitored. Preliminary analysis identified a significant interaction between emotion and physiological states ($F(9.782, 459.769)= 2.070, p=.027$). Post-hoc analyses found specific patterns of activation distinct from neutral affect for each of the comparison emotions, with guilt eliciting a unique pattern of increased swallowing ($t(42)=3.828, p<.001$) and increased sympathetic heart rate activation ($t(41)=3.246, p=.002$). There was no significant effect of guilt on respiratory sinus arrhythmia, ($t(41)=.473, p=.639$) or on respiration rate ($t(42)=.952, p=.347$). These results suggest that there is a distinguishable autonomic output representing guilt that is characterized by enhanced sympathetic outflow. Future studies will aim to identify whether alterations in these physiological responses may have implications for emotional abnormalities in disorders known to have altered levels of guilt, such as psychopathy and frontotemporal dementia.

Topic Area: EMOTION & SOCIAL: Other

F19 Acoustic Cues Used for Perceiving Race in the Human Voice

Tedra James¹, Psyche Loui^{1,2}; ¹Wesleyan University, ²Northeastern University

The ability to discern a person's racial identity from their voice has been reported in numerous studies, yet it remains unclear what auditory cues are utilized to inform these judgments. Here we present three experiments to clarify whether two potential cues – fundamental frequency (F0) and vocal tract length – are used to identify whether a speaker is Black or White. Two identical read sentences from 17 Black and 17 White speakers were selected from the TIMIT Corpus and analyzed using Tandem-STRAIGHT (Kawahara 2009). Acoustic features were either kept the same (Experiment 1), modified to be 1, 2, and 3 semitones higher or lower in F0 (Experiment 2), or modified to be 5, 10, and 15% larger or smaller in vocal tract length (Experiment 3). Amazon Mechanical Turk listeners (N = 210) used a 6-point scale to rate whether they thought the voice was 1-most likely, 2-probably, or 3-possibly Black, or 4-possibly, 5-probably, or 6-most likely White. Listeners rated White voices higher (closer to 6) than Black voices (T-Test, $p<.001$), indicating that listeners could reliably differentiate Black and White speakers. Ratings for speech with modified F0 did not differ across manipulations; however, speech

produced by smaller vocal tracts were rated higher than speech produced by larger vocal tracts (linear contrast ANOVA, $p < .001$). These results show that vocal tract length, and not F0, is a cue used when identifying the race of a speaker.

Topic Area: EMOTION & SOCIAL: Person perception

F20 Cartoons, Animals, and Autistic Traits: An Eye Tracking Study

Nicole L. Dalasio¹, Jenifer Joseph¹, Jennifer L. Stevenson¹; ¹Ursinus College

Autistic individuals often exhibit reduced attention to the eye region compared to non-autistic individuals while viewing facial stimuli. However, differences in the types of face stimuli presented, such as their level of realism (e.g., photographs versus cartoons) and types of faces (e.g., human or animal faces), have led to conflicting conclusions about the nature and extent of such differences between autistic and non-autistic individuals. Few facial processing studies have explored differences associated with varying levels of autistic traits. This study investigated the relationship between autistic traits and eye movements while passively viewing facial stimuli. Thirty-eight college-aged students ($M = 19.66$, $SD = 1.21$) viewed 105 randomized stimuli, during which eye fixation data were collected. Stimuli included human and animal faces with three levels of realistic depiction (i.e., cartoons, semi-cartooned, or photographs). Participants were subdivided into high and low autistic trait groups using a median split ($Mdn = 114.5$) on the Autism-Spectrum Quotient. As predicted, this study found no correlations, main effects, or interactions (all $p > .05$) involving autistic traits and eye fixation. Significant differences in fixation duration and count appeared to be driven by stimulus design. The novel task, stimulus design, and fixation cross placement in this study potentially mitigate effects of autistic traits in previous eye-tracking studies. These findings suggest that underlying differences in autistic facial processing, as measured by eye fixation, may not be a function of autistic traits and are more nuanced than previously believed.

Topic Area: EMOTION & SOCIAL: Person perception

F21 Embodied emotions in Autism Spectrum Disorder: Somatosensory Evoked Potentials reveal atypical patterns of neural activity during perception of emotional expressions in ASD

Martina Fanghella^{1,2}, Sebastian Gaigg², Matteo Candidi¹, Bettina Forster², Beatriz Calvo-Merino²; ¹Sapienza, Rome, ²City, University of London

Recent research has shown the independent contribution of the Somatosensory Cortex (SCx) to emotion recognition, supporting the embodied emotion hypothesis. Atypical patterns of responses to emotions in Autism Spectrum Disorder (ASD) has been investigated only at a visual level, here we aim to investigate if ASD individuals show atypical patterns of embodiment during emotion perception beyond the established visual differences. We investigate embodied responses during emotion perception in ASD in 2 groups (typically developed (TD) and Autism Spectrum Disorder (ASD) individuals). We presented neutral, afraid and happy faces to our participants while recording their brain activity with EEG. We measured the visual evoked potentials (VEPs) over the occipital lobe and the somatosensory evoked potentials (SEPs) over the SCx. SEPs were evoked by applying a tactile stimulation on their index finger during the visual processing. To isolate the pure somatosensory responses related to emotional processing from visual carryover effects, we subtracted the neural activity recorded in the visual condition from activity in the tactile condition (following Sel et al., 2014). We found a significant main effect of emotion on 60-80 ms time window in both groups, suggesting embodied representations of emotional expressions in TD and in ASD individuals. Interestingly, we found a significant emotion and group interaction between 140-220ms, suggesting atypical modulation of embodied responses to emotional expressions in ASD compared to TD. Our study provides novel evidence of atypical pattern of neural responses during

perception of emotional expressions in the Somatosensory Cortex in individuals with ASD.

Topic Area: EMOTION & SOCIAL: Person perception

F22 Emotional expression accounts for the effects of head posture on perceived personality.

David Perrett¹, Hongfei Lin², Dongyu Zhang²; ¹University of St Andrews, ²Dalian University of Technology

Interpreting the personality and the disposition of people is important for social interaction. Both emotional expression and facial width are known to affect personality perception. Moreover, both the apparent emotional expression and the apparent width to height ratio of the face change with head tilt. We investigated how head tilt affects judgements of trustworthiness and dominance and whether such trait judgements reflect apparent emotion or facial width. We asked 80 participants to rate the dominance, emotion and trustworthiness of 24 faces posing with different head tilts while maintaining eye gaze at the camera. Both a 30° up and a 20° down head tilt were perceived as less trustworthy and more dominant than the head-level posture. Change in perceived trustworthiness and dominance with head tilt correlated with change in apparent emotional positivity but not change in facial width. While a large downward tilt induced a negative expression we found that the most positive expression arose on average with a small downward tilt (8°). Similarly the most trustworthy appearance occurred for a small downward tilt (4°). The least dominant appearance occurred for a small upward tilt (5°) showing differentiation of visual cues to dominance and trustworthiness. Variation in head tilt maximising trustworthiness and submissive appearance across faces was related to the variation in head posture maximising emotional positivity of the same faces but was unrelated to the facial width. Hence, our analysis suggests that apparent emotional expression provides a better explanation of perceived personality compared with cues to facial structure.

Topic Area: EMOTION & SOCIAL: Person perception

F23 Experience influences hemisphere differences in approach-avoidance responses to the perception of race, gender and emotional expression

Paul Moes¹, Maame Adwoa Brantuo¹, Nathan LeFebre¹, Mikaela Hager¹, Kalyn Carley¹, Blake Riek¹; ¹Calvin College

Faces contain a wealth of social information requiring rapid recognition and the preparation of an appropriate response. While exceptions exist, Richard Davidson and colleagues have shown a pattern of hemisphere specialization for responses to stimuli that follow a left-hemisphere-approach and right-hemisphere-avoidance motivational pattern. The present study explored the interaction of several facial features, including emotional expression, gender, and race with hemisphere response using both reaction time (RT) and EEG/ERP-P300 amplitude measures. Participants viewed lateralized (RT study), or central (ERP study) presentations of faces that varied by gender, emotion (happy/angry), and racial category (white/black). Consistent with the hypothesis, faces belonging to the racial out-group produced a significant right hemisphere advantage for RT and P300 amplitude, while faces from the in-group produced a significant left hemisphere advantage for P300. Gender of the face, emotion, and gender of the participant also interacted with racial category, but only the 5-way interaction for P300 amplitude was significant and only for posterior areas. The essential pattern of these interactions was such that angry-male-out-group faces produced the strongest right hemisphere advantage while happy-female-in-group faces produced the strongest left hemisphere advantage. Finally, these measures showed a significant relationship to scores from an "out-group experiences" questionnaire (P300 only) as well as a test of implicit association (for RT only). Taken together the

results suggest that facial features prompt rapid hemisphere-specific motivational responses that are associated with social experience and implicit bias.

Topic Area: EMOTION & SOCIAL: Person perception

F24 Extracting actions associated with specific personality traits for modeling of the social knowledge

Masahiro Okamoto¹, Satoshi Eifuku¹; ¹Fukushima Medical University

We make inferences about others' behaviors based on what we know about them. Inability to make such inferences may cause serious difficulties when interacting with other people. A recent study revealed that personality traits were correlated with the prediction of others' actions, and that brain activity during prediction was partially explained by the perceived traits of third-party targets by study participants. Conversely, how we "know" about others' traits remains unclear. When reading a novel, we make inferences about the characters based on their behaviors. Such an experience raises important questions about what kind of behaviors and speeches lead us to identify a specific trait not only when reading novels but in a real life. In the present study, participants were asked to rate eight people close to them on 20 personality traits, such as good-naturedness and impudence. In addition, the participants provided reasons for rating each personality trait, with concrete episodes. As a result, principal component analysis on the ratings revealed three components (approachableness, extraversion, gentleness). Correspondence analysis identified verbs characterizing each component: talking, listening, and seeing for the "approachableness" component; drinking, participating, and connecting for the "extraversion" component; and thinking, working, and acting for the third component. Document classification successfully classified each episode into one of the three components based on the frequency of the listed verbs. Taken together, these results suggest that specific verbs are associated with specific traits. In our next study, we are going to investigate how these verbs are represented in the human brain.

Topic Area: EMOTION & SOCIAL: Person perception

F25 Loneliness Modulates Automatic Attention to Warm and Competent People: Preliminary Evidence from an Eye-Tracking Study

Toshiki Saito¹, Kosuke Motoki^{1,2}, Rui Nouchi¹, Ryuta Kawashima¹, Motoaki Sugiura¹; ¹Tohoku University, ²Japan Society for the Promotion of Science

Social connections are essential for human survival. Loneliness can be considered a motivational factor for building and maintaining social connections. Although previous studies have investigated the effect of loneliness on social behavior, the effect of loneliness on automatic attention to human faces remain largely unknown. Automatic attention occurs with little cognitive effort and has a key role in detecting biologically salient events such as human faces. In the current study, we investigated the effect of loneliness on automatic visual attention to warmth and competence facial information which determine facial attraction. Thirty-seven participants rated the facial information, warmth and competence. Then they engaged with the target-distractor paradigm in which they saw 2 images of houses at the top and bottom and indicated whether the images were identical or not. During the task, we presented 2 faces as distractors and measured visual attention toward faces as automatic attention because the participants did not have to attend to them. The results showed that there is an interaction effect between subjective loneliness and facial information on automatic attention. Warm targets automatically captured attention from lonely people, whereas competent targets automatically captured attention from less lonely people. These results suggest that loneliness adaptively influences automatic processing of social information.

Topic Area: EMOTION & SOCIAL: Person perception

F26 Neural correlates of guilty feelings in young adults

Seishu Nakagawa^{1,2}, Hikaru Takeuchi², Yasuyuki Taki², Rui Nouchi², Yuka Kotozaki², Takamitsu Shinada², Tsukasa Maruyama², Atsushi Sekiguchi^{2,3}, Kunio Iizuka², Ryoichi Yokoyama⁴, Yuki Yamamoto², Ryuta Kawashima²; ¹Tohoku Medical and Pharmaceutical University, Sendai, Japan, ²Tohoku University, ³National Center of Neurology and Psychiatry, Kodaira, Tokyo, Japan, ⁴Kobe University

Feelings of guilt are associated with self and social cognitions. Deontological guilt is derived from the transgression of social and moral norms according to inner values, whereas altruistic guilt arises from the appraisal of altruistic situations. We hypothesized that the brain structures involved in feelings of guilt are also associated with regions related to self and social cognitions. We investigated the association between regional gray matter density (rGMD) or regional mean diffusivity (MD) using MRI and the guilty feeling scale (GFS) which comprises interpersonal situation (IPS; references altruistic guilt) and rule-breaking situation (RBS; references deontological guilt) scores in healthy young students (20.7 ± 1.8 years; rGMD: 422 males, 342 females; MD: 686 males, 510 females). Importantly, there were two novel findings. One is that both the IPS and RBS were negatively related to the rGMD in the right posterior insula (PI) as a common region for feelings of guilt. The other is that MD in the right somatosensory and motor cortices from arm to hand were positively correlated with RBS scores, as would be predicted by the Macbeth effect. Further, the IPS scores were negatively correlated with rGMD in the left anterior insula (AI), and right inferior parietal lobule (IPL). Moreover, the RBS scores were positively correlated with MD in the bilateral IPL, the right prefrontal regions, and the left posterior cingulate region, in accordance with our hypothesis.

Topic Area: EMOTION & SOCIAL: Person perception

F27 Preconscious and conscious stages of stimulus processing depend on whom we are with: a within- and a between subject study

J. Bruno Debrulle¹, Emma Pietri¹, Tarlan Daryoush¹, Natalie Frye¹, Louise Barlet¹; ¹McGill University

In order to be prepared to whatever could happen with unknown people, we could be in a particular mode of processing when we are in the presence of strangers. This would explain why we previously found that the mere presence of a stranger next to participants had a major impact on their event-related brain potentials (ERPs). These ERPs were evoked by images presented for simple memorization. They depended to a large extent on whether participants were alone or sitting side by side with a stranger. Alone participants had larger N300s and N400s and smaller late posterior positivities than participants with strangers. In this new study, participants went through the same task in the two different social contexts. The analysis of the results of this within-subjects study led to suggest that stimulus processing could initially be systematically performed in all the perspectives learned from our experiences of the behavior of close others. All these perspectives would be kept when in the presence of a stranger, in order to be prepared to anything. When alone, only a few would be kept: those that fits our own personality.

Topic Area: EMOTION & SOCIAL: Person perception

F28 Salience-Driven Attention is Pivotal to Understanding Others' Intentions

Myrthe G. Rijpma¹, Suzanne M. Shdo¹, Gianina Toller¹, Joel H. Kramer¹, Bruce L. Miller¹, Katherine P. Rankin¹; ¹Memory and Aging Center, University of California, San Francisco, 675 Nelson Rising Ln, Suite 190

A large body of research has been generated to explain the cognitive and neural processes related to inferring other people's mental states, often called Theory of Mind (ToM). However, most research does not use ecologically realistic test paradigms that can address how an individual selects socially important stimuli to process, and only a subset has focused on practical ToM-related constructs, such as understanding other people's intentions. In this study, we investigated the structural neuroanatomic contributions to understanding intentions in complex social situations, using the realistic video vignette-based Awareness of Social Inference Test (TASIT) enriched version (SI-E) in 179 participants, including 102 patients with known neurodegenerative diagnoses and 77 older neurologically healthy controls. Statistical Parametric Mapping (SPM12) was used for voxel-based morphometry and structural regions of interest (ROIs) were derived to correspond with key nodes in three functional intrinsically connected networks (ICNs). In concordance with previous ToM studies, distinct neural correlates for understanding others' intentions included ICN ROIs known to mediate executive functioning (i.e., frontoparietal network, FPN), and memory manipulation (i.e., default mode network, DMN). However, when regions related to salience-driven attention (i.e., salience network, SN) were included in the models, only the SN ROIs independently predicted the ability to infer intentions ($p < 0.001$), suggesting the FPN and DMN regions may only play a secondary role. Thus, online attention-attribution and selection of socially important information were found to be vital to correctly infer other people's intentions from realistically complex stimuli, supporting the essential role of attention for normal social cognition.

Topic Area: EMOTION & SOCIAL: Person perception

F29 The Irony of Racial Colorblindness: Behavioral and Physiological Effects

Alejandro Heredia Cedillo¹, Javier Baltazar¹, Andre Oliver¹, Avi Ben-Zeev¹, Mark W. Geisler¹; ¹San Francisco State University

We ask whether endorsing a racial colorblindness ideology – a belief system that holds that race should not and does matter when interacting with others (Wolsko, et. al., 2000) – leads, ironically, to an increased attention to race. To examine participants' extent of racial colorblindness, we employed the Colorblind Racial Attitudes Scale (CoBRAS) (Neville et. al., 2000). Using a modified visual dot-probe task, we provided evidence for an ironic effect (study 1), such that individuals with higher (versus lower) CoBRAS scores showed a statistically significant heightened attention to racial stimuli (Black and White male faces), $F(1, 85) = 5.72, p < .02, \eta^2 = .063$. This ironic effect was replicated and found to be specific to racial versus to neutral stimuli, $F(1, 76) = 8.55, p < .01, \eta^2 = .1$ (Study 2). We discuss a preliminary study with event-related potential (ERP) data recorded during a speeded racial categorization task (Study 3) that support the behavioral findings.

Topic Area: EMOTION & SOCIAL: Person perception

F30 The Utility of the Dynamic Facial Expression Task in Real-Time fMRI Neurofeedback Training of Amygdala Signal

Tim Varkevisser^{1,2,3}, Jack van Honk^{3,4}, Elbert Geuze^{1,2}; ¹University Medical Center, Utrecht, The Netherlands, ²Expertise Center Military Mental Health Care, Utrecht, The Netherlands, ³Utrecht University, Utrecht, The Netherlands, ⁴University of Cape Town, Cape Town, South Africa

Research indicates that the amygdala of individuals with impulsive aggression problems may be overly responsive to the presentation of negative emotional (e.g., angry or fearful) facial stimuli. Here, we present preliminary results for the use of the dynamic facial expression task (DFET) in a real-time fMRI neurofeedback paradigm that aims to teach combat veterans with impulsive

aggression problems to self-regulate their amygdala signal. Blocks of facial stimuli that (rapidly) change from a neutral expression to an angry or fearful one were presented to a sample of non-aggressive healthy volunteers ($N = 10$). A number of variations in task design and stimulus presentation were tested in order to elicit a maximum amygdala response, and to be used in the follow-up neurofeedback experiment. Preliminary results indicate that within-subject t-values in the range of 3-5 can be reached with the DFET, i.e., when blocks of (emotional) facial expression are compared to blocks of rest. Little to no contrast in amygdala signal was observed when the dynamic expression (angry or fearful) blocks were compared to blocks of the static neutral expression. These findings suggest that facial stimuli that rapidly change from a neutral expression to an angry or fearful one may elicit no amygdala response over and beyond that of static neutral facial stimuli, i.e., when measured at a within-subject level. Experiments are ongoing to determine if the DFET may still be suitable for use in real-time fMRI neurofeedback training of amygdala signal, e.g., in combat veterans with impulsive aggression problems.

Topic Area: EMOTION & SOCIAL: Person perception

F31 Dissociating the neural representations of tactile and hedonic information.

James H. Kryklywy¹, Mana R. Ehlers¹, Andre O. Beukers², Sarah M. Moore¹, Rebecca M. Todd¹, Adam K. Anderson³; ¹University of British Columbia, ²Princeton University, ³Cornell University

With the increasing development of multivariate analyses for neuroimaging data, we are beginning to get a deeper and more intricate understanding of how mental states manifest as specific patterns of neural activation. Recent work has outlined activation patterns associated with hedonic and tactile pain representation, yet the degree to which this is overlapping or independent of positive hedonic value and stimulation remains unknown. In the current study, functional magnetic resonance imaging data was collected from 67 participants from Cornell University, who received tactile stimulation to induce painful or pleasurable experience. Representational similarity analyses conducted on BOLD signal from six regions of interest identified the similarity of neural representation across pressure-pain, appetitive brushing and null trials. The resulting similarity matrices were tested against 9 unique theoretical models of potential hedonic and tactile responding to determine the contribution of each area to phenomenological mental states. Of particular note, by individually titrating pain-pressure to a constant hedonic value across participants, while holding appetitive tactile stimulation consistent (with varied hedonic liking), we are able to disembed tactile and hedonic value with unprecedented accuracy. Results demonstrate unique contributions from primary somatosensory cortex, ventromedial prefrontal cortex and insula to both modeled factors. This work gives unique insight into the integration of sensory and affective experience and suggests that while dissociable brain areas may contribute to each experiential feature, there is also great deal of interaction and codependence within these systems.

Topic Area: EMOTION & SOCIAL: Self perception

F32 Emotional lability in focal hippocampal damage

Christopher Butler¹, Georgios P. D. Argyropoulos¹, Lauren Moore^{1,2}, Clare Loane^{1,3}, Adriana Roca-Fernandez¹, Carmen Lage-Martinez^{1,4}; ¹University of Oxford, ²University of Bath, ³University College London, ⁴University Hospital Marqués de Valdecilla

A sizeable literature on animal models suggests that the primate anterior hippocampus (homologous to the rodent ventral hippocampus) is embedded within networks regulating emotion and affect. However, very little is known on emotional dysregulation in patients with hippocampal damage. We thus aimed to assess the negative emotional sequelae in focal hippocampal atrophy

following autoimmune limbic encephalitis, a neurological disease typically associated with hippocampal damage and residual cognitive and emotional impairment. We focused on emotional lability, i.e. the fluctuating and inappropriate levels of emotional arousal, manifested with labile crying or laughter. We analyzed acute neuroradiological reports, clinical notes, post-acute neuropsychological scores, along with structural MRI and resting-state fMRI datasets in relation to emotional lability in a large cohort of patients ($n = 36$) that had been treated for limbic encephalitis. Emotional lability was present in 50% of the patients, yet selectively in the form of tearfulness. It was not associated with depression, impulsiveness, memory impairment, or executive dysfunction. While patients showed focal hippocampal atrophy within the medial temporal lobe, hippocampal volumes did not reliably predict tearfulness. Instead, it was the abnormalities in the resting-state hemodynamic activity in and hippocampal functional connectivity with regions in the inferior and superior parietal lobules that were associated with tearfulness. Residual tearfulness is highly common, and it is not a manifestation of depression, pseudobulbar affect, impulsiveness, or executive dysfunction. Functional abnormalities in parietal regions supporting perspective taking and social-affective processing may compromise patients' emotion regulation following focal hippocampal damage.

Topic Area: EMOTION & SOCIAL: Self perception

F33 Resting State Functional Connectivity Neural Correlates of Self-Reported Anxiety and Depression

Yush Kukreja¹, Lauren Goodes², Jeremy Cohen², Jeffrey Rouse¹; ¹Tulane University of New Orleans, Louisiana, ²Xavier University of Louisiana

Our study investigated whether the degree of trauma-related anxiety and depression is associated with unique resting-state functional connectivity patterns. 50 subjects were randomly selected from the Nathan-Kline Institute Rockland Sample: 30 females and 20 males, with an average age of 31.2 (SD=7.87). All of these subjects were administered the Trauma Symptom Checklist (TSC), a self-reported survey of traumatic experiences, and included multiple subscales. Our study focused on two subscales, anxiety and depression, which were used as covariates in resting-state functional connectivity analysis using SPM12 and CONN toolboxes within MATLAB. CONN was used to conduct preprocessing and correct for multiple comparisons prior to obtaining connectivity maps. On the anxiety subscale, there was statistically significant positive correlation in resting state scans with the amygdala and medial frontal cortex as the predominant seeds. As for depression, the Vermis 3 was a highly active seed for a positively correlated connectivity with multiple other regions in the brain. Overlapping connectivity was observed between the anxiety and depression subscales. CONN was able to obtain a connectivity map that represented activity as a correlation with both anxiety and depression scores. This connectivity included a three-way connection between the medial frontal cortex, the amygdala, and the right temporal pole. This was consistent with previous research which elucidated a high level of connectivity between the medial frontal cortex and the amygdala in subjects with anxious and depressive tendencies. These results offer preliminary insight into the differing neural substrates within self-reported anxious and depressive symptoms post-trauma.

Topic Area: EMOTION & SOCIAL: Self perception

F34 A better understanding of impulsivity in children with Attention Deficit Hyperactivity Disorder : an electromyographic approach

Aurélien Grandjean^{1,2}, Isabel Suarez⁴, Elisa Diaz⁴, Laure Spieser^{1,2}, Boris Burle^{1,2}, Agnès Blaye^{1,3}, Laurence Casini^{1,2}; ¹Aix-Marseille Université, ²Laboratoire de Neurosciences Cognitives, ³Laboratoire de Psychologie Cognitives, ⁴Universidad del Norte de Barranquilla

Attention deficit/hyperactivity disorder (ADHD) is considered to be one of the most common developmental disorders diagnosed in childhood. It is characterized by symptoms of inattention, hyperactivity and impulsivity. Impulsivity refers both to the susceptibility to activate inappropriate automatic responses and to a deficit in the ability to inhibit them. Whether these two aspects are involved in ADHD remains to be deciphered. In this aim, we used a novel approach based on behavioral analyses extended with Electromyographic activity recording to decipher the effects of ADHD on the expression and suppression of erroneous automatic actions. We compared performance of 24 children with ADHD and 24 typically developing children when performing a Simon reaction time task, which is well-known to elicit automatic response tendencies. Electromyographic activity was recorded from the flexor pollicis brevis of each thumb. The behavioral results have shown that children with ADHD were slower and presented a larger interference effect compared with control children suggesting that children with ADHD present difficulties in interference control. Moreover, the preliminary Electromyographic data analysis has revealed two main effects: 1/ the incorrect activation rate, measuring the strength of the susceptibility to trigger automatic responses, was similar in both groups, 2/ the correction rate, measuring the ability to suppress automatic actions was lower in children with ADHD, suggesting a deficit in inhibition of automatic actions. In conclusion, our data suggest that the difficulties in the interference control would be due to a deficit in inhibiting automatic responses rather to a larger susceptibility to activate them.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F35 Cognitive Control Connectivity in Adolescents and Young Adults with Autism Spectrum Disorder

Rachel A. Wulff¹, Marie K. Krug¹, Cory C. Coleman¹, Matthew V. Elliott², Jeremy Hogeveen³, Tyler A. Lesh¹, Tara A. Niendam¹, J. Daniel Ragland¹, Cameron S. Carter¹, Marjorie Solomon¹; ¹University of California, Davis, ²University of California, Berkeley, ³The University of New Mexico

Many adolescents with autism spectrum disorder (ASD) rely on different neural networks to implement cognitive control than individuals with typical development (TD) (Solomon et al., 2014). It is unclear how these networks develop over adolescence. During fMRI scanning, 70 individuals with TD (mean age = 17.5) and 56 with ASD (mean age = 17.9) completed a rapid event-related version of the Preparing to Overcome Prepotency task. On 50% of trials a red cue required a button response on the opposite side as the subsequent arrow probe. On the other 50%, a green cue signaled a response on the same side. Both ASD and TD took longer to respond to red trials. The difference in response time (RT) between red and green trials was larger in ASD versus the TD group ($F(1, 123) = 4.2, p < .05$). Whole brain analysis revealed that there were no differences between groups on red - green cue or probe contrasts. Functional connectivity analysis showed that at the cue, TD exhibited greater anterior cingulate cortex (ACC) to parietal cortex connectivity than ASD, perhaps indicative of increased preparatory control processes. At the probe, TD showed increased dorsolateral prefrontal cortex (DLPFC) connectivity with the insula and left inferior frontal gyrus, and higher ACC to right insula connectivity, indicating more recruitment of response inhibition networks. Individuals with ASD showed greater DLPFC to occipital cortex connectivity compared to TD at the probe. Future analyses will investigate behavioral and connectivity correlates and differences in ASD subsets with and without cognitive control impairments.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F36 Developing a new behavioral paradigm for testing an executive stopping process over long term memory retrieval

Much research has investigated whether and how executive control can be deployed to prevent unwanted thoughts from being retrieved from long term memory (LTM). In the so-called Think/No Think (TNT) task subjects first learn multiple word pairs. In a later phase, subjects are presented with a cue word from the pair and asked to either think or not think of the learned associate. Several studies show that “no-think” trials recruit prefrontal regions, perhaps those overlapping with action-stopping, and that this might be key in preventing intrusions and inducing subsequent forgetting. Research in this area is somewhat hampered, however, by poor experimental control over what subjects do when instructed to “not think”. Here we designed a new task to more explicitly test whether a motor stop-like process does indeed disrupt LTM retrieval. In this task the TNT instruction was replaced with “Speak” or “No Speak” – on each trial they prepared to speak the associate, but on some trials a stop signal instructed them to withhold. After each trial participants responded to an “intrusion” question by reporting whether the associate came to mind. In a pilot study we found that “no speak” signals 150ms post cue word resulted in fewer intrusions ($p=.025$). Results will be presented from a fully powered sample. This research has the potential to clarify whether, how and when a prefrontal action-stopping like process disrupts LTM. In so doing, this may reveal new insights into the executive control processes for preventing unwanted memories from coming to mind.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F37 Exploring the association between the facets of NEO PI-3 and cognitive control functioning

Eva Langvik¹, Alexander Olsen^{1,2}, Simen Berg Saksvik^{1,2}, Håvard Karlsen¹, Torhild Anita Sørengaard¹, Ingvild Saksvik-Lehoullier¹; ¹1. Department of Psychology, Norwegian University of Science and Technology, ²2. Department of Physical Medicine and Rehabilitation, St. Olavs Hospital, Trondheim University Hospital

Substantial research exists on personality disorders and cognitive control impairment, while the literature on normal personality traits and cognitive control function is marginal. 59 healthy individuals between 18-35 years of age completed the Personality Inventory NEO PI-3 and performed a not-X continuous performance test. We explored the associations between the personality traits and reaction time and accuracy. Extraversion, the facets gregariousness, activity and positive emotions, as well as the trust (facet of agreeableness) were negatively correlated with reaction time. Self-consciousness (facet of neuroticism) was positively correlated with reaction time. Regarding number of commission errors, only the agreeableness facet compliance showed significant, and negative correlation. The openness to experience facet emotions was positively correlated with the number of omission errors. No other traits or facets had significant association with the number of omissions nor commissions. In conclusion, personality facets concerning sociability and emotions seem to show some relation to cognitive control function, especially reaction time. The study has limited statistical power and further studies using a larger sample is needed to determine the strength and causal mechanisms behind these preliminary findings. It seems especially important to investigate how personality and cognitive control influence responses to the test situation.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F38 Learning under uncertainty: Confidence affects feedback processing

Michael Ben Yehuda¹, Robin A. Murphy¹, Nick Yeung¹; ¹University of Oxford

Contingency learning in a noisy environment comes with an inherent degree of uncertainty. Here we report three experiments using a combination of behavioral and scalp electrophysiological measures investigating how people’s subjective sense of confidence about their knowledge affects feedback processing (Experiments 1-2) and decisions about further information seeking (Experiment 3). Participants learned associations between two stimuli and two responses through probabilistic feedback. After each trial participants rated their confidence in having responded correctly. While response accuracy followed a traditional learning curve that reached asymptote relatively quickly, explicitly reported confidence continued growing, reaching asymptote significantly later. Analysis of the period post-accuracy asymptote indicated that, though their behavioral policy remained stable, the extent to which surprising feedback impacted confidence decreased as subjects progressed through a learning block. This effect was mirrored in event-related potentials time-locked to feedback delivery on trials following the accuracy asymptote: confidence at trial $t-1$ negatively predicted the size of the P300 at trial t , indicating decreased feedback processing as confidence increased. Furthermore, when in Experiment 3 participants could choose whether to view feedback at a cost or to skip it for free, confidence also significantly predicted the trial in which people stopped paying for feedback, whereas accuracy did not. The results suggest that subjective confidence modulates the extent to which feedback is processed, regulating the weighting of the impact of reward prediction error (RPE): higher confidence leads to higher RPEs upon receiving surprising feedback, but decreased feedback processing.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F39 Learning with confidence: Uncertainty is used strategically for information sampling

Naomi Carlebach¹, Nick Yeung¹; ¹University of Oxford

Upon making a decision we typically have a sense of the likelihood that the decision we reached was a good one, i.e. a degree of confidence in our decision. Usually, people are highly accurate at evaluating their performance, with reported confidence ratings strongly reflecting objective performance. Despite the evident connection between confidence judgments and decision-making, the functional importance of confidence judgments and how they affect decisions remains largely unknown. Here, we study how people use confidence when choosing between different types of information before making a decision. We hypothesize that confidence guides information sampling dynamically, depending on people’s immediate goal. In a series of experiments, participants performed a perceptual decision making task, in which they reported which of two boxes presented briefly on the screen contained more dots, and how confident they are in their decision. After giving an initial response, participants chose between viewing the stimulus again for a longer period and receiving advice from a virtual adviser. Following reception of this additional information, they gave their final response and confidence on which box contained more dots. Adviser accuracy varied between blocks, and participant’s prior knowledge of adviser quality was manipulated (known/unknown). We find that, when adviser accuracy was unknown, participants chose advice more often when confidence was high, allowing them to learn about the adviser’s quality. When adviser quality was known participants showed a trend towards selecting advice more when confidence was low. We suggest this reflects the strategic use of confidence, depending on one’s immediate goal.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F40 Not So Automatic Imitation: Expectation of Incongruence Reduces Interference in both Autism Spectrum Disorder and Typical Development

Raphael Geddert¹, Andrew Gordon¹, Jeremy Hogeveen², Marie Krug¹, Marjorie Solomon¹; ¹University of California, Davis, ²University of New Mexico

Individuals with autism spectrum disorder (ASD) exhibit social functioning deficits. A prominent theory of ASD suggests that such impairments are the result of an aberrant mirror neuron system (MNS), which impairs affected individuals' ability to imitate the actions of others. Imitative response tendencies can be probed in the laboratory through automatic imitation (AI)—the degree to which observed actions modulate action execution. However, a recent study found evidence that AI is intact in ASD, challenging the broken MNS hypothesis (Sowden et al., 2016). An alternative explanation is that the ability to exert top-down control of imitation may be aberrant in ASD (cf., Hogeveen et al., 2015). Data collection is ongoing for the current study, and at present we examined the control of AI in ASD (N=27) and an FSIQ case-controlled TD sample (N=27), including a non-imitative control task (effector priming, EP). Our variable of interest was drift rate (v), a combination of reaction time and accuracy. In contrast to the theory of a broken MNS, the degree of AI was equivalent between groups [BF01 (v) = 81.68], consistent with the notion that the MNS is intact in ASD. Further, the top-down control of imitation was matched between ASD and TD [BF01 (v) = 70.41], however there was suggestive evidence that imitative responding may be uniquely related to higher social functioning in ASD. Lastly, both AI and EP interference effects decreased when the ratio of incongruent-to-congruent trials increased, suggesting that AI effects are not as 'automatic' as previously theorized.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F41 The Cost of a Cell Phone: An Investigation of the Neural Correlates Related to Cognitive Control and Cellular Phone Distraction

Joshua Upshaw¹, Carl Stevens¹, Georgio Ganis², Darya Zabelina¹; ¹University of Arkansas, ²University of Plymouth

Prior research has shown that cellular phone use, and even the mere presence of a phone can have detrimental effects on people's attention and cognitive control (Thornton et al., 2014). The present study examines the extent to which cellular phone notifications can impact cognitive control. College students completed a Local-Global Navon letter task (adapted from Zabelina & Ganis, 2017), where they indicated the presence of a frequent or a rare target letter. Concurrently, a randomly timed cellular phone vibration, lawnmower, or control sound occurred. We hypothesized that participants would display changes in levels of cognitive control, as indicated by slowed reaction times, and by larger N2 event-related potentials (ERPs), on rare compared to the frequent targets (Oddball effect). Moreover, we hypothesized that the size of the Oddball effect would differ on trials with (compared to without) cellular phone notifications. Overall, participants responded faster to frequent ($M = 821\text{ms}$, $SE = 337$) compared to rare targets ($M = 954\text{ms}$, $SE = 367$, $p = .004$). Critically, and as predicted, the size of the Oddball effect differed depending on the type of sound ($p = .004$), with larger Oddball effect on trials with the cellular phone vibration ($M = 164\text{ms}$, $SE = 182$) compared to the mower sound ($M = 108\text{ms}$, $SE = 242$, $p = .005$). Electroencephalography data are being processed to determine condition differences in N2 ERP. Future research will seek to determine the effectiveness of mindfulness interventions in reinforcing attentional capacities during a cognitively demanding task.

Topic Area: EXECUTIVE PROCESSES: Monitoring & inhibitory control

F42 Interpersonal neural synchronization tracks real-world dynamically competitive interaction

Nan Zhao¹, Yafeng Pan¹, Yi Hu¹; ¹East China Normal University

Competition is one of the footstones of social interaction, however the elucidation of neural substrate for this process has been constrained by the single brain research, rather than by the real-world interpersonal brain recording from a neurophysiological perspective. Here, given that Go game (a board game) provides a naturally competitive paradigm, we enrolled 9 groups of players (each contained four high-ranking amateur Go players), simultaneously recorded brain activity through functional near-infrared spectroscopy-based hyperscanning approach for each member during the real-time playing. Go players were randomly divided into two sides, in which subject A and subject C belonged to the white side, and subject B and subject D belonged to the black side. They played in order from A to D, and were naturally divided into face-to-face adjacent competitive dyad and face-to-face nonadjacent competitive dyad. We found increased interpersonal neural synchronization (INS) in all the competitive dyads at left Middle frontal gyrus during Go playing. Moreover, the results showed consistently enhanced interpersonal neural synchronization (INS) in face-to-face adjacent competitive dyads, compared with face-to-face nonadjacent competitive dyads. Also, a linear increase for INS across time was identified in the face-to-face adjacent competitive dyads, but not in the face-to-face nonadjacent competitive dyads. Taken together, our results implicate that the interpersonal neural synchronization which mainly driven by social dynamics factors can track real-time competitive interaction, and further uncover the development of this specific coherence between brain signals in competitive dyads is time-dependent.

Topic Area: THINKING: Other

F43 Aberrant processing of salience in first-episode psychosis patients during movie watching

Jussi Alho¹, Teemu Mäntylä², Tuula Kiesepää³, Eva Rikandi², Jaana Suvisaari², Tuukka Raji^{1,3}; ¹Aalto University School of Science, Espoo, Finland, ²National Institute for Health and Welfare, Helsinki, Finland, ³Helsinki University and Helsinki University Hospital, Helsinki, Finland

Psychotic symptoms are hypothesized to be due to aberrant assignment of salience to stimuli. To elucidate salience processing in psychotic disorders, we analyzed 3T-fMRI-BOLD brain data collected from 36 first-episode psychosis (FEP) patients (mean age \pm SD 24.9 \pm 4.8 years, 23 males) and 30 population controls (mean age \pm SD 26.9 \pm 5.9 years, 21 males) while they watched scenes from the movie Alice in Wonderland. Time-windowed intersubject correlation (ISC) was calculated between the voxel-wise BOLD time series for every within-group subject pair using a 1-TR (repetition time, 1.8 sec) step and 10-TR window. In each ISC window, a two-sample t-test between patients and controls was performed to obtain a t-statistic time series of group difference. Salience rating was obtained through an independent group of healthy subjects (N=17) continuously assessing how salient (i.e. noticeable or attention-capturing) the events in the movie are. To disambiguate the interpretation of results, the salience rating was divided into high and low salience regressor by z-scoring and taking the positive and negative values, respectively. Permutation-based GLM was used to identify brain regions where the t-statistic time series correlated with the salience regressor. Results show significantly weaker ISC within patients than within controls in areas associated with executive functions and cognitive control such as lateral prefrontal cortex during low salience, and areas of the default mode network such as medial prefrontal cortex during high salience. In conclusion, our results imply dysfunctional salience processing in FEP patients, manifested in aberrant recruitment of the central executive and default mode networks while following a movie narrative.

Topic Area: EXECUTIVE PROCESSES: Other

F44 Executive Dysfunction in Traumatic Brain Injury is Related to Chronic Symptom Status, Not Injury Severity

Keith Main^{1,2,3}, Anna-Clare Milazzo^{2,3}, Bernard Ng³, Salil Soman⁴, Jordan Nechvatal^{2,3}, Jennifer Kong², Stephanie Kolakowsky-Hayner⁵, Ansgar Furst^{2,3}, J. Wesson Ashford^{2,3}, Maheen Adamson^{1,3}; ¹Defense and Veterans Brain Injury Center, ²War Related Illness and Injury Study Center, ³Stanford University School of Medicine, ⁴Harvard University Medical School, ⁵Icahn School of Medicine at Mount Sinai

The chronic symptoms associated with traumatic brain injury (TBI) may be partly due to alterations in the connectivity of neural networks. Using resting-state fMRI and diffusion weighted imaging, we examined functional and structural connectivity in 57 participants: 23 with chronic TBI and 34 without. We hypothesized that chronic symptom status would correlate with altered functional connectivity in predefined regions of the dorsolateral prefrontal and lateral parietal cortices (executive control network). Regression analyses demonstrated that chronic symptoms significantly predicted decreased connectivity in the left executive control network. Additional between-group tests showed decreased connectivity for the left dorsolateral prefrontal cortex of the chronic symptom group. Further tests on 14 large-scale, resting-state networks revealed a decrease in chronic symptom connectivity between the following networks: left executive control, retrosplenial/medial temporal, and precuneus/posterior cingulate. Structural connectivity measured by fractional anisotropy correlated with initial injury severity but not chronic symptom status. Our results suggest that a decrease in functional connectivity in the left executive control network, particularly connections with the left dorsolateral prefrontal cortex, aligns more closely with chronic symptom status following TBI than injury severity.

Topic Area: EXECUTIVE PROCESSES: Other

F45 Monolingual and bilingual processing differences on a Color-Word Stroop Task: Examining the adaptive control hypothesis

Vanessa Rainey¹, Valerie Flores-Lamb², Laura Stockdale³, Eva Gjorgieva⁴, Delaney Diehl¹, Rebecca L. Siltan⁵, Robert G. Morrison⁵; ¹University of West Florida, ²Arizona State University, ³Brigham Young University, ⁴Duke University, ⁵Loyola University Chicago

According to the adaptive control hypothesis, bilinguals' cognitive control processes have adapted to their language demands. The effects of these demands have been documented through greater efficiency on inhibitory control tasks, such as the Color-Word Stroop Task. Although previous Color-Word Stroop task studies with bilingual speakers have shown neural and temporal differences in conflict detection/resolution processes for bilinguals compared to monolinguals, behavioral performance is often comparable across groups. This suggests that bilinguals may use compensatory strategies at early sensory phases when approaching conflicting linguistic stimuli. A Color-Word Stroop task was administered during scalp electroencephalography (EEG) to evaluate the temporal course of inhibitory control in bilinguals (n=19) and monolinguals (n=19). The Stroop effect was observed across the whole sample, however, there were no group differences in accuracy or reaction time. Event-related potentials (ERPs) were calculated for P150 and N450, which indicated differential processing of the congruent and incongruent trials between the language groups. For the bilingual group, a larger P150 amplitude was evoked by incongruent trials than congruent trials compared to the monolingual group ($p = .005$), suggesting recruitment of increased early visual attention to visual and linguistic information. Additionally, reduced N450 amplitude was evoked by incongruent trials compared to congruent trials for the bilingual group compared to the monolinguals ($p = .04$), suggesting less cognitive effort for the bilinguals at the conflict detection/resolution phase of processing. These results suggest that bilinguals utilize early visual attention to decrease subsequent conflict compared to monolinguals. Overall, these results provide support for the adaptive control hypothesis.

Topic Area: EXECUTIVE PROCESSES: Other

F46 White Matter Organization and Metacognitive Monitoring in Traumatic Brain Injury

Kathy S. Chiou¹, Jeremy A. Feiger¹, Mackenzie Cissne¹; ¹University of Nebraska-Lincoln

Disruptions to white matter (WM) organization are related to cognitive deficits observed following traumatic brain injury (TBI). To date, investigations of WM organization and cognition in TBI have focused on domains such as memory and executive functioning. However, less is known about the role of WM organization in supporting metacognitive processes after TBI. The purpose of this study is to determine the relationship between WM organization and metacognition after TBI. 15 adults with moderate/severe TBI and 9 healthy controls completed a working memory task, whereby a metacognitive confidence judgment was collected after each task item. Metacognitive performance was determined by area under the curve (AUC) analyses of task accuracy and confidence judgments. Participants also completed a 64-direction diffusion tensor imaging (DTI) scan. Metacognitive performance was included as a covariate in a mixed linear model to determine between-group differences. Family-wise error correction was applied at $p < 0.05$. In adults with TBI, metacognitive performance was found to be positively correlated with WM organization near the right supramarginal gyrus. Healthy controls showed additional relationships between metacognitive performance and WM organization in the corpus callosum bilaterally, the right superior corona radiata near the cingulate, left superior longitudinal fasciculus, left cingulum, and left posterior corona radiata near the cingulate. The findings indicate that WM organization associated with metacognitive performance differ between adults with TBI and healthy peers. Implications of the close proximity between regions of WM associated with metacognitive function found in this study and functional structures previously identified in the literature will be discussed.

Topic Area: EXECUTIVE PROCESSES: Other

F47 A Comparative Study of Event-related Potential Classification During Variations of N-back Task

Mahsa Alizadeh Shalchy¹, Valentina Pergher², Anja Pahor¹, Susanne Jaeggi³, Marc M. Van Hulle², Aaron Seitz¹; ¹University of California, Riverside, ²KU Leuven - University of Leuven, ³University of California, Irvine

A common problem in cognitive sciences is that a large variety of task variants are used when studying any given cognitive construct with the assumption that they are measuring the same construct. This is a particular issue with electroencephalogram (EEG) studies, where the factors such as stimulus type and task structure can potentially give rise to systematically different event-related potentials (ERPs), which may or may not be relevant to the construct of interest. Here we address these issues, conducted 9 different variations of a working memory (WM) task, called "N-Back". The task requires that subjects report whether the current stimulus matches the one N presentations before. Each variation of the N-back task in this study was generated by manipulating experimental features, such as stimulus duration, inter-stimulus interval (ISI) and stimulus type. We recruited 36 healthy young subjects who each performed 4 variants of the task during two consecutive days. Preliminary results suggest differential neural and behavioral signatures for our variations of the N-Back task, especially for early visual ERP components and accuracy. We also applied several classification algorithms to extract not only task differences, but also individual characteristics that might affect the performance. This study provides insight about neural correlates of WM as well as data of how stimulus type and task explain ERP data during variations of the N-Back performance and ERPs. Keyword: ERP classification

Topic Area: EXECUTIVE PROCESSES: Working memory

F48 Active vs. passive learning – effects of age, handedness, and sex

Sangeeta Nair¹, Rodolphe Nenert¹, Jane B. Allendorfer¹, Jennifer Vannest², Daniel Mirman¹, Jerzy P. Szaflarski¹; ¹University of Alabama at Birmingham, ²Cincinnati Children's Hospital Medical Center

Improved memory performance with self-generation compared to passive learning may be related to recruitment of a frontotemporal encoding network. Objective: To examine the effects of age, sex, and handedness on the neural correlates of self-generation and memory performance during verbal paired-associate learning fMRI task. Methods: Data from 174 healthy English-speaking participants (78M, 56 atypically-handed, ages 19-76) were processed with GIFT (Group ICA fMRI Toolbox). 41 independent components were temporally sorted by task time series. Retaining correlations >0.25 resulted in three task-positive (“generate”) and three task-negative (“read”) components. We evaluated effects of sex and handedness with two-sample t-tests, and of age using multiple regression; masks of each component were applied to subjects back-projected components and a mean value was extracted as a measure of subject component connectivity. Results/Discussion: For males compared to females, spatial extent for self-generation was larger in right postcentral gyrus and left insula, and for reading in right superior temporal gyrus (STG) and left supramarginal gyrus ($p < 0.02$). For right-handed compared to atypically-handed participants, extent was larger in left insula and angular gyrus during reading and self-generation respectively, and smaller in left cuneus and posterior cingulate cortex (PCC) during generation ($p < 0.02$). Self-generation areas showed decreasing component connectivity with increasing age across frontal and temporoparietal areas ($p < 0.001$). Passive encoding areas including STG, PCC, and inferior parietal lobule also showed decreasing connectivity as age increases ($p < 0.001$). Identified neuroimaging differences suggest that sex, handedness and age are factors in the differential recruitment of encoding network regions for both passive and active learning.

Topic Area: EXECUTIVE PROCESSES: Working memory

F49 Beyond g: Individual differences in visual and auditory working memory.

Ningcong Tong¹, Branton Shearer², David Somers¹, Abigail Noyce¹; ¹Boston University, ²Kent State University

Discrete sensory-specific cortical networks are recruited for visual and auditory working memory (WM), including six bilateral sensory-biased structures in human lateral frontal cortex (Noyce 2017). These networks are hypothesized to instantiate content-specific working memory stores. Such content-specific stores may account for individual variability in cognitive strengths and limitations, as assessed in multiple intelligences research (Shearer 2007). Here, we use a Sternberg-type WM paradigm in two studies probing relationships between visual and auditory WM. Visual stimuli were photographs of inanimate objects; auditory stimuli were recordings of animal noises. Each trial's memory set were items from one category, reducing reliance on verbal labeling strategies. WM performance was measured by estimating capacity (Cowan's k). In Experiment 1, subjects ($n = 68$) completed a pre-exposure task followed by 80 trials of both the visual and auditory WM tasks. While average performance on each task was good ($k_{vis} = 2.43$, $k_{aud} = 2.14$), correlation between visual and auditory capacity estimates was only moderate ($r = 0.52$). In Experiment 2, subjects ($n = 24$) completed 80 trials of both the visual and auditory task on each of two separate days. On day 2, subjects also completed self-report inventories of visual and auditory exposure and expertise, and an assessment of their multiple intelligences profile. Formal training in arts or music was the strongest predictor of modality-specific WM capacity. These individual differences in WM capacity support the content-specific account of WM organization.

Topic Area: EXECUTIVE PROCESSES: Working memory

F50 Quantifying the demands of value-based decision-making with short-term memory interference

Harrison Ritz¹, Carolyn Dean Wolf¹, Romy Frömer¹, Amitai Shenhav¹; ¹Brown University

People find decision-making to be cognitively demanding. However, quantifying these cognitive demands remains a challenge. To address this challenge, we developed a dual-task paradigm to examine the degree to which value-based decisions interfere with the maintenance of an item in short-term memory. Twenty-nine participants performed a modified delayed estimation task. On each trial, they viewed a Gabor patch at a particular orientation and then, following an 8 sec delay, they rotated a new Gabor to best approximate their recollection of the original orientation. During the fixed delay period, participants engaged in an unrelated value-based decision task, in which they selected their most preferred item out of a set of four consumer products. Choice sets varied in overall value and value similarity across trials and were tailored to each participant's own item preferences (indicated earlier in the session). Replicating previous findings, choice RTs were significantly slower when options were more similar in value. Critically, we found that slower choice RTs were also associated with poorer recollection for the memory item (greater misestimation of Gabor orientation). We fit these orientation estimates with a standard mixture model, finding that slower product choice RTs linearly predicted poorer memory precision, but did not predict bias or guess rate. Our findings suggest that decision-making demands can be quantified through estimates of short-term memory interference, providing a path toward addressing deeper questions regarding the nature and specificity of these demands and how they vary across individuals.

Topic Area: EXECUTIVE PROCESSES: Working memory

F51 The effects of cerebellar transcranial direct current stimulation on the cognitive stage of sequence learning

Hannah K. Ballard¹, James R.M. Goen², Ted Maldonado², Jessica A. Bernard^{1,2}; ¹Texas A&M Institute for Neuroscience, Texas A&M University, ²Psychological & Brain Sciences Department, Texas A&M University

Though the cerebellum has previously been implicated in explicit sequence learning, the exact role of this structure in the acquisition of motor skills is not completely clear. The cerebellum contributes to both motor and non-motor behavior. Thus, this structure may contribute not only to the motoric aspects of sequence learning, but may also play a role in the cognitive components of these learning paradigms. Therefore, we investigated the consequence of both disrupting and facilitating cerebellar function using high definition transcranial direct current stimulation (HD-tDCS) prior to the completion of a motor sequence learning paradigm. Using a mixed within- and between-subjects design, we employed cathodal ($n=21$) and anodal ($n=23$) tDCS (relative to sham), targeting the right posterior cerebellum, to temporarily modulate function and investigate the resulting effects on the acquisition of a sequential pattern of finger movements. Results indicate that cathodal stimulation has a positive influence on accuracy during learning while anodal stimulation has the opposite effect, relative to sham. Though the cerebellum is presumed to be primarily involved in procedural motor function and movement coordination, our results support a cognitive contribution that may come into play during the early stages of sequence learning. Through stimulation of the lateral posterior cerebellum, which communicates with the prefrontal cortex via closed-loop circuits, we enhanced motor sequence learning early on with the cathodal approach compared to anodal. Thus, our results provide important new insights into the cerebellar contributions to sequence learning and the ability to modulate skill acquisition, considering both motor and non-motor processes.

F52 The Neural Underpinnings of Mental Attention Capacity in Healthy Young Adults

Mylann Guevara¹, Marie Arsalidou², Juan Pascual-Leone¹, W. Dale Stevens¹; ¹York University, Toronto, ²National Research University Higher School of Economics, Moscow

Working memory enables the online maintenance and manipulation of information to solve problems, and is constrained by a limited mental attention capacity (M-capacity). The Theory of Constructive Operators (TCO) describes M-capacity as a domain-general operator that can boost task-relevant information in the brain, while task-irrelevant information is inhibited, to facilitate successful task performance. The activation and interactions of functional brain networks underlying M-capacity are not well known. Further, there is conflicting evidence regarding how neural activity is modulated as a function of cognitive load and the domain of information held in working memory. The current investigation used functional magnetic resonance imaging to quantify brain activation in healthy young adults (n=23) while they performed three different mental-attention tasks designed to test specific hypotheses based on the TCO. Brain activity was dynamically modulated by cognitive load, regardless of stimulus domain (colors vs. numbers), such that brain regions associated with cognitive control and attention networks showed monotonically increasing activation, while regions associated with the default network showed decreasing activation, as cognitive load increased, within the range of M-capacity. However, both sets of brain regions showed a complete reversal of this activation pattern when the theoretically estimated average M-capacity of the sample was exceeded. Moreover, this relation interacted with stimulus-domain (colors vs numbers) in the fusiform gyri and right middle occipital gyrus, and not in prefrontal cortices. These observations support the TCO and inform future investigations aiming to understand the neuroscience for well-established behavioral development of M-capacity in childhood/adolescence and across the adult lifespan.

Topic Area: EXECUTIVE PROCESSES: Working memory

F53 Working Memory Training with tDCS in Young Adults Induces Transfer at Follow Up

Jorja Shires¹, Carlos Carrasco^{1,2}, Marian Berryhill¹; ¹University of Nevada, Reno, ²University of California, Davis

Working memory (WM) is an essential executive function that allows us to maintain and manipulate information to accomplish a goal. A real WM limitation, however, is that it is limited in capacity. Efforts to expand WM capacity by training reveal mixed results. A number of studies do report improved performance on trained tasks. To augment WM training benefits a number of groups have included noninvasive brain stimulation approaches including transcranial direct current stimulation (tDCS). This tool modulates the underlying neural activity in a task-specific manner. In our previous work in young and older adults we found improved outcomes when WM training was paired with tDCS compared to WM training alone. In older adults, we identified significant effects that were evident one month after training across several stimulation montages. Here, we implemented an improved training protocol in young adults including follow-up testing session, pre-/post- HD-EEG, and an expanded set of WM and transfer tasks. We also manipulated the tDCS montage (anode: F4, P4, alternating F4/P4, cathode: contralateral cheek) to improve optimization. No group differences in WM performance were evident at the end of training. Follow-up testing, however, revealed a more complex pattern of results on transfer tasks indicating that changes in performance can emerge over time even in young adults. Pairing tDCS with WM training did not provide immediate benefits. The temporal dynamics of tDCS-linked cognitive performance changes is worth tracking to fully characterize training benefits.

F54 Are differences in year-to-year cerebellar white matter growth rates linked to growth in reading skills in K-3 children?

Trang Nguyen¹, Bruce McCandliss¹; ¹Stanford University, Graduate School of Education

The cerebellum has long been implicated in reading. Even late in reading development, white matter tracts connecting the cerebellum to left hemisphere language regions continue to grow. What are the dynamic relationships between growth in cerebellar pathways and growth in reading skill? We explored this question over an 18-months period of development in an accelerated longitudinal design in children ages 5-9 (n=27). A tract defined by the outflow of the right superior cerebellar peduncle (right SCP), connecting to left-language regions revealed that growth in mean-tract-fractional anisotropy (FA) correlated with growth in reading skill ($p < 0.05$). Multiple regression revealed a marginal growth relationship effect even after age and motion were accounted for ($p = 0.057$). Additionally, even though initial FA of the right SCP correlated with reading improvement ($p = 0.011$), adding initial FA to the above growth model failed to account for additional variance. Post-hoc explorations revealed that this brain-behavior-growth relationship was anatomically specific: no such findings were evident in any other cerebellar peduncle-defined tract. These findings support the notion that children may experience "growth spurts" that have both cognitive and anatomical dimensions, and opens up the possibilities that these two forms of development may be intrinsically related. This modest finding within a small longitudinal sample motivates our current efforts to examine this growth hypothesis within a larger longitudinal dataset. Such studies hold promise of providing insights into the role of the cerebellum in cognitive development and the design of effective neuroscience-based reading interventions that may benefit children with underdeveloped cerebellar pathways.

Topic Area: LANGUAGE: Development & aging

F55 Characterizing the Whole-Brain Functional Connectivity Signature of Bilingualism

Sara Sanchez-Alonso^{1,2}, Monica Rosenberg², Richard Aslin^{1,2}; ¹Haskins Laboratories, ²Yale University

Language is a core human capacity. It is acquired effortlessly after birth and is crucial for many human experiences. Despite its unique role, there is no definitive model of language that captures the mapping between language-relevant behavior and its whole-brain functional network organization. To address this knowledge gap, we capitalize on the unique features of the bilingual brain, which provides a window into how experience shapes language acquisition. We studied resting-state and movie-watching fMRI data from 70 Spanish-English bilinguals and English monolinguals derived from the Healthy Brain Network project, which we processed via Human Connectome Project (HCP) pipelines. We employed a whole-brain data-driven approach to map the distributed functional network organization that is associated with bilingualism. Specifically, we applied a recently developed method in functional brain imaging analysis - connectome-based predictive modeling (CPM) - to predict an individual's linguistic category (bilingual vs monolingual) from his or her functional connectivity patterns. We explicitly focused on the recently mapped 'language network' (LN) derived from the HCP parcellation. Critically, we examined behaviorally-relevant variation in the LN, which spanned both cortical and subcortical areas. In turn, we built a model based on this variation to predict the linguistic category of the left-out individual. Our findings support the hypothesis that bilingualism is associated with a distinct brain connectivity profile across the core LN relative to monolinguals. These results reveal the vital interplay between language-specific and general

cognitive neural substrates and provide evidence that language is supported by a distributed functional network organization.

Topic Area: LANGUAGE: Development & aging

F56 - WITHDRAWN

F57 Looking Ahead in Life and Language: An ERP study on prediction during sentence reading in older adults

Matthew Wood¹, Viridiana Estrada², Alondra Chaire³, Nicole Y.Y. Wicha^{1,4}; ¹The University of Texas at San Antonio, ²The University of Texas Medical Branch, ³Otto-von-Guericke-Universität Magdeburg, Germany, ⁴UTSA Neurosciences Institute

Several studies have shown that young adults anticipate upcoming words when reading a sentence. Yet older adult readers of English seem to favor integrating sentence information as it is encountered rather than predicting words in advance. Older adults may benefit from sentence context when it is sufficiently constraining or provides salient cues for assessing their predictions. We tested for evidence of prediction in older adult Spanish speakers using a similar design to Wicha et al. 2004. We measured event-related potentials (ERPs) while older adults (mean age 64 years) read moderate-to-strongly constraining sentences containing a target article-noun pair. Critically, the article preceding any noun in Spanish must agree with that noun in grammatical gender. We exploited this rule by manipulating the article to either agree or disagree in gender with the expected but yet unseen noun. Similar to young adults, older adult ERPs showed a positive-going deflection to gender-disagreeing compared to gender-agreeing articles. This effect appeared earlier in time (350 – 550 ms post-article onset) and was more focal in distribution (left-lateral) compared to young adults. However, this positivity likely still indexes the anticipated violation of grammatical gender with the predicted noun. In addition, gender-agreement violations on the subsequent noun modulated meaning-level processing, as indexed by the N400, confirming high sensitivity to gender-agreement. Thus, contrary to findings with older adult speakers of English, readers of Spanish appear to use the reliable cue provided by the gender of articles and nouns to assess their predictions based on the preceding sentence context.

Topic Area: LANGUAGE: Development & aging

F58 The effect of feedback validity on learning in children and adults: an electrophysiological study

Calais Larson¹, Isabelle Moore¹, Annie Fox¹, Yael Arbel¹; ¹Massachusetts General Hospital Institute of Health Professions

The present study evaluated at the behavioral and neurophysiological level the effect of feedback validity on learning in adults and children. Participants (82 children aged 7-11; 42 adults aged 18-25) completed a two-choice classification task, in which they sorted items from eight different categories into one of two bins, by pressing one of two buttons on a response box. Each response was followed by positive or negative feedback. Four of the eight categories were mapped consistently to a specific response, leading to consistent valid feedback. The other four were mapped to a specific response 80% of the time; in 20% of these trials, participants received invalid feedback. As participants performed the task, their EEG data were recorded. Behaviorally, accuracy was greater for the consistently valid condition than the inconsistently valid condition for both adults and children. There were no significant differences in accuracy between adults and children. Feedback-related event related potentials (ERPs) were evaluated and compared between the two groups. The amplitudes of the feedback related negativity (FRN) and fronto-central positivity (FCP) were sensitive to valence and age group, with FRN being larger in children, and FCP larger in adults. Interaction effects suggested that FRN response to positive feedback was sensitive to

feedback validity in both age groups. However, the FCP was sensitive to validity for only for positive feedback in children and only for negative feedback in adults. These results further evidence of differing neurophysiological reactions to feedback in learning between children and adults.

Topic Area: LANGUAGE: Development & aging

F59 What neural processes support word learning in school-aged children?

Alyson Abel¹; ¹San Diego State University

Starting in elementary school, children learn most of their new words by using the surrounding language to determine a word's meaning, or word learning from context (WLfC). WLfC happens incrementally, with increased lexicalization occurring with multiple exposures to the word. The goal of this research is to examine the neural processes underlying the process of WLfC. We collected electroencephalogram (EEG) data as seven 9-year old children completed a WLfC task where they heard a novel word in three sentences that either established meaning for the word (Meaning condition) or did not establish meaning (No Meaning condition). EEG measures included event-related potential (ERP) and event related spectral perturbations (ERSP). The ERP analysis focused on the N400, associated with semantic processing, and the ERSP analysis focused on the theta and alpha frequency bands, generally associated with semantic retrieval and attention/inhibition, respectively, in the language processing literature. Participants successfully identified meanings for the novel words in the Meaning context (M=73.4% correct), supporting the experimental design. The N400 amplitude to the novel word attenuated across exposures in the Meaning condition but not the No Meaning condition. The ERSP analysis indicated differences in oscillatory engagement across exposures to the novel word in the Meaning condition with theta synchrony followed by alpha synchrony then alpha desynchrony. This pattern suggests differential engagement of lexical retrieval, inhibition, and attention during the course of WLfC. Taken together, the EEG analyses show that school-aged children draw on multiple processes at different times during word learning.

Topic Area: LANGUAGE: Development & aging

F60 Auditory and visual speech perception is predicted by distinct cortical encoding networks

Anne Keitel¹, Joachim Gross², Christoph Kayser³; ¹University of Glasgow, ²University of Münster, ³Bielefeld University

Auditory and visual speech signals are an integral part of our everyday communication. How our brain represents these signals has therefore been a matter of intensive investigation. An interesting pattern has recently emerged, showing that large areas of the cortex encode auditory signals, but only smaller focal areas contribute significantly to our perception. Here, we investigate this discrepancy between overall encoding and perceptually relevant encoding in more detail, for auditory and visual speech. The MEG (magnetoencephalogram) was recorded while participants listened to spoken sentences in noise (auditory condition) or watched a talker speaking (visual condition, "lipreading"). After each sentence, participants indicated which target word they had perceived. Source-localised brain signals were used to study which cortical areas represented (i.e. encoded) the identity of the target words compared with different target words (decoding analysis). Above-chance overall decoding was widespread in the brain, peaking in early sensory areas, consistent with previous findings. However, considering only decoding that predicted whether participants perceived the correct target word (logistic regression analysis) revealed distinct networks for auditory and visual speech, which overlapped in left inferior frontal and temporal pole areas. Strikingly, the areas that predicted perception were typically not the ones that had a high overall decoding performance. Our results suggest that brain areas that consistently show good encoding do not necessarily influence our behaviour

in difficult perceptual situations. Instead, extended cortical networks contribute critically under these circumstances, a pattern that generalises to auditory and visual speech perception.

Topic Area: LANGUAGE: Other

F61 Behavioral and Neuroanatomical Characteristics of Stimulation-Induced Speech Arrest

Garret Kurteff^{1,2}, Neal Fox¹, Maansi Desai^{1,2}, Alia Shafi¹, Edward Chang¹; ¹University of California, San Francisco, ²University of Texas, Austin

For over a century, neurosurgeons performing awake cortical stimulation mapping have described the phenomenon of Speech Arrest, the temporary discontinuation of speech without simultaneous sensorimotor involvement. Despite its clinical and theoretical importance for the neuroanatomical localization of language function, Speech Arrest remains poorly characterized in the scientific literature. This study provides a comprehensive report of Speech Arrest in 34 patients who participated in clinical mapping tasks (e.g., counting to thirty) while undergoing awake language mapping during left hemisphere neurosurgery. We analyzed 291 speech disruptions using video and audio recordings acquired simultaneously with stimulation mapping, which were behaviorally classified as either instances of Speech Arrest or as Motor Errors. We found that Speech Arrest is characterized by a stimulation-induced delay in the onset of articulation until the termination of stimulation. Once initiated, the quality and duration of pronunciation is unaffected, and patients typically report subjectively feeling “unable to talk.” In contrast, stimulation-induced Motor Errors often begin while stimulation is still ongoing, and the resulting utterances are less intelligible and longer in duration than non-errors. A neuroanatomical dissociation between Speech Arrest and Motor Errors was also found. Most instances of Speech Arrest resulted from stimulation to pars opercularis and ventral/rostral precentral gyrus, while Motor Errors were the dominant error-type in dorsal/caudal quadrants of precentral gyrus. Interestingly, stimulation to pars triangularis (a region often considered part of anatomical Broca’s area) rarely elicited speech errors of either type. This study represents the first comprehensive quantitative characterization of Speech Arrest for neuroscientists and clinicians.

Topic Area: LANGUAGE: Other

F62 Measuring the N400 during scripted conversation: An ERP hyperscanning study

Caitriona Douglas^{1,2}, Antoine Tremblay¹, Aaron Newman¹; ¹Dalhousie University, ²University of Saskatchewan

Our goal was to determine the feasibility of using EEG hyperscanning techniques during face-to-face conversation, to detect ERPs time-locked to individual words. Specifically, we aimed to replicate the modulation of the N400 ERP component by lexical frequency as prior studies have consistently reported larger N400s in response to low than high frequency words. We recorded EEG simultaneously from pairs of native English speakers (29 EEG, 1 EOG, and 2 EMG channels/person) while they engaged in a ~20 min scripted conversation. EEG data were processed separately for each individual, including manual artifact removal and ICA artifact correction. ERPs were time-locked to the onset of target words that each individual heard (not words they produced themselves; 30 high and 30 low frequency words/person). A pattern consistent with the N400 ERP was obtained in both noun conditions, with a negativity from approximately 250–550 ms that was largest over midline central-parietal electrodes. However, there was no difference in N400 amplitude between the low and high frequency noun conditions. These results provide compelling initial evidence that it is possible to obtain ERPs to individual words in a conversational context using hyperscanning, opening the door to an exciting range of future possibilities for neurolinguistic research.

Topic Area: LANGUAGE: Other

F63 Neuropsychology In Temporal Lobe Epilepsy: A Machine Learning Approach

Elise Roger¹, Laurent Torlay¹, Jérémy Gardette¹, Chrystèle Mosca², Lorella Minotti², Philippe Kahane², Monica Baciú¹; ¹Univ. Grenoble Alpes, CNRS LPNC UMR 5105, F-38000 Grenoble, France, ²Univ. Grenoble Alpes, Grenoble Institute of Neuroscience & Neurology Department CHUGA, France

Drug-resistant temporal lobe epilepsy (TLE) is a severe neurological condition very often associated with brain injury and cognitive dysfunctions. Different clinical variables such as the hemispherical lateralization of the epileptogenic zone (EZ), or the presence of a lesion (e.g. hippocampal sclerosis), can modulate these cognitive deficits. We aim to identify neuropsychological profiles allowing a classification of TLE patients, through the use of a machine learning (ML) approach. We performed ML analyses in a dataset of 77 epileptic patients (57 TLE). The ML workflow includes feature selection and performance estimation on several subsets of patients according to different modulating factors. We have used as features for the ML, several standardized scores that evaluates general cognitive functioning (IQ), language, memory and executive functions. The most robust result in terms of TLE classification has been obtained according to the hemispheric lateralization of the epilepsy. Concretely, based on features such as auditory and visual memory indices (WMS-IV; Weschler, 2012) as well as phonological fluency scores, we obtained a classification performance of 85±3% (1000 times repeated AUC metric) to segregate the left-right TLE. Moreover, we obtained a classification performance of 89±3% between mesial left-mesial right TLE with the semantic fluency in addition to the same three features mentioned above. Interestingly, the main features separating TLE populations, were scores used to assess two main functions: language and memory. Overall our ML results reinforce the idea of interlinked and interactive language-and-memory functioning and highlight the useful role of neuropsychology to help with the location of epileptogenic networks.

Topic Area: LANGUAGE: Other

F64 Unravelling Neural Profiles Sustaining Reading in the First and Second Language: Evidence from Chinese-English Bilinguals

Jia Zhang¹, Hehui Li¹, Guosheng Ding¹; ¹Beijing Normal University

Previous studies have addressed neural topographic universality of reading in the first language (L1) and second language (L2) in bilinguals, but they obtained discrepancy results. Until now, we still have no conclusive idea as to how the two languages that highly-contrast with each other, e.g. Chinese and English, are organized in a bilingual’s brain. In the current study, we performed a meta-analysis and focused on literatures which recruited Chinese-English bilinguals to depict the cortical arrangement of reading system in L1 and L2. We firstly made meta-maps for L1 and L2 and then compared these two maps. The results demonstrated that the left superior/middle temporal gyrus showed a more consistent activation in L1 processing compared to L2 and the left inferior parietal lobule showed a more consistent activation in L2 processing in comparison to L1. To further explore whether the divergences in L1 compared to L2 were caused by the difference across writing systems or language acquisition orders, meta-map for native English speakers was also made. We found that the left superior temporal gyrus showed a consistent activation but not the left inferior parietal lobule. This result suggests that the specific relationship between the left superior temporal gyrus and L1 or between the left inferior parietal lobule and L2 could be accounted for by the language acquisition orders rather than the writing systems of two languages. Our study challenges the opinion that Chinese-English bilinguals apply L1’s reading network for L2’s processing.

Topic Area: LANGUAGE: Other

F65 Context-dependent Recruitment of the Angular Gyrus in Speech Comprehension under Challenging Listening Conditions

Anna Rysop¹, Lea Schmitt², Jonas Obleser², Gesa Hartwigsen¹; ¹Max Planck Institute for Human Cognitive and Brain Sciences, ²University of Lübeck

Speech comprehension is often challenged by acoustically adverse listening conditions but can be facilitated by semantic context. This contextual comprehension benefit is thought to be largest at intermediate levels of intelligibility and is accompanied by enhanced engagement of left angular gyrus (AG). Additionally, there is converging evidence for the recruitment of domain-general control networks when listening conditions become challenging. However, it remains unclear how domain-specific speech networks and domain-general control networks interact and influence each other during successful speech comprehension. To address this, we conducted a continuously-scanned, event-related auditory fMRI experiment while participants (n=23, age range 19-30 years) performed an overt sentence repetition task, overcoming many of the earlier studies' limitations (e.g., temporally sparse imaging; absent per-trial behavioural responses). Sentences varied in semantic predictability of the sentence-final word and were presented at six individually-titrated levels of intelligibility. At the behavioural level, we identified well-fitting psychometric speech-intelligibility curves, with steeper slopes for sentences with high opposed to low semantic predictability. Univariate fMRI group-analyses revealed that the intelligibility modulation drove broad bilateral activations in superior temporal, and pre- and postcentral regions, together with left inferior frontal gyrus. Supporting and extending previous research we found a significant context by intelligibility interaction with left AG, left supramarginal gyrus, and posterior portions of the middle and inferior temporal lobes showing increased activity for high predictable sentences under medium noise levels. These results provide novel evidence for a strong context-dependent recruitment of left AG in speech comprehension under challenging listening conditions.

Topic Area: LANGUAGE: Semantic

F66 Cultural background shapes mental associations and brain activity elicited during listening to a narrative

Iiro Jaaskelainen¹, Maria Hakonen¹, Annika Hulten¹, Arsi Ikäheimonen¹, Fa-Hsuan Lin², Anastasia Lowe¹, Mikko Sams¹, Miika Koskinen³; ¹Aalto University School of Science, Espoo, Finland, ²Taiwan National University, Taipei, Taiwan, ³University of Helsinki, Helsinki, Finland

We studied whether cultural differences in familial background shape how the brain processes a narrative, as well as how the narrative is interpreted. We recruited a total of 48 healthy volunteers who were all fluent in Finnish. Half of the subjects had both parents with Finnish cultural background. For the other half of the subjects, either one or both parents were with Russian cultural background. The subjects listened to a 71 min narrative depicting life of two protagonists, one with Finnish and the other with Russian cultural background, during ultra-fast fMRI combining dynamic inverse imaging and simultaneous multi-slice excitation to achieve 5x5x7-mm whole-brain acquisition with a TR of 0.1 sec. Afterwards, the narrative was replayed in 101 segments to the subjects, and they were asked to list words that best described what the narrative had brought to their minds at the end of each segment while they had been listening to the narrative during neuroimaging. The two subject groups produced qualitatively different word associations. Further, there were significant between-group differences in inter-subject correlation of brain hemodynamic activity in multiple brain regions, including lateral temporal, medial prefrontal, and medial parietal structures. Taken together, these results show that cultural differences in familial background shaped both how the subjects heard the narrative and how their brains processed it.

Topic Area: LANGUAGE: Semantic

F67 Discourse belief-updating in the right hemisphere

Maxime Tulling¹, Ailis Courneane¹, Liina Pyllkkänen¹; ¹New York University

The ability to communicate about things outside the here-and-now is a core trait of human language, yet its neural underpinnings are understudied. This study investigated the contribution of words that refer to possible states of affairs that are not actual or known: the modal verbs 'may' and 'must'. In a magnetoencephalography (MEG) study (N=25), we minimally contrasted visually presented sentences (word-by-word) containing the ambiguous modals 'may' and 'must' against sentences containing the non-modal verb 'do' (... and the squires do/may/must too). The interpretation of the ambiguous modals was dependent on prior (pre-normed) contexts that biased towards either an inferential or permission/obligation reading. We did not find any significant differences between the two types of modal verbs nor reliable activity increases for modal verbs in general. Instead, a full-brain analysis in the time window 100-900ms after target word onset did reveal a significant spatio-temporal cluster reflecting a substantial increase for the non-modal over modal conditions, at 210-350ms starting around the rTPJ and spreading up to the rIPS and right medial surfaces (cuneus-PCC). We hypothesize that this increased activation for the non-modal condition may reflect the effort it takes to evaluate and integrate claims made about the world of evaluation, a process absent from the modal condition as those sentences only assert possible compatibilities with the evaluated world. This belief-updating function is in line with suggestions that the rTPJ plays a role in theory revision and conceptual change, and supports that the right hemisphere is involved in pragmatic processing and contextual coherence.

Topic Area: LANGUAGE: Semantic

F68 Implicit versus Explicit Learning Assessment of Neuroscience Concepts in Undergraduates

Noah C. Yeagley¹, Sarah L. Wonsidler¹, Jennifer L. Stevenson¹; ¹Ursinus College

Implicit learning evaluations offer an alternative to traditional tests and quizzes; however, research is unclear about how implicit methods directly compare to explicit learning assessment methods for interdisciplinary fields like neuroscience. The current study investigates psychology and neuroscience undergraduate students' (n=56) implicit and explicit learning of structure-function relationships, neuroscience techniques, and statistics. To assess implicit learning, students made pairwise rankings of similarity for 15 terms for each of the three topics (e.g., correlation coefficient, independent variable, control group for statistics; Broca's area, language production for structure-function relationships; and MRI, DTI for neuroscience techniques). Using Pathfinder software, students' knowledge structures or networks were compared to a network created from five neuroscience experts (a subset of neuroscience professors at the institution). To assess explicit learning, students completed a 15 question multiple-choice quiz for each of the three topics. Students had equivalent links in common with the experts, the implicit measure of learning, for the three topics; however, student performance varied across the multiple choice tests or explicit measures of learning, $F(2, 52) = 95.68, p < .001$. More specifically, students were most accurate for statistics, and least accurate for neuroscience techniques. Furthermore, psychology and neuroscience majors performed equivalently on the implicit evaluation, but neuroscience majors outperformed psychology majors on the explicit evaluation, $F(1, 52) = 14.83, p < .001$. These results suggest explicit evaluations may better differentiate students' understanding of certain topics than implicit evaluations and add to the growing body of research on the use of implicit evaluations for neuroscience concepts.

Topic Area: LANGUAGE: Semantic

F69 Lexical Access in Comprehension vs. Production: Spatiotemporal localization of semantic facilitation and interference

Julien Dirani¹, Liina Pykkänen^{1,2}; ¹New York University Abu Dhabi, ²New York University

Humans understand words faster when they are preceded by semantically related words. This facilitation is thought to result from spreading activation between words with similar meanings. Interestingly, in language production, semantic relatedness often has the opposite effect: in object naming for example, a related prior word delays the naming time of the current object. This could be due to competition during conceptual search or later interference at the motor preparation stage. However, no study has systematically compared the facilitatory and inhibitory effects and thus their neurobiological relationship is unknown. We contrasted maximally parallel production and comprehension tasks during magnetoencephalography and found that in comprehension (specifically word reading), semantic relatedness modulated activity in the left middle superior temporal gyrus at 180-335ms, consistent with prior findings on the spatiotemporal localization of lexical access. In contrast, a semantic interference pattern for the production task (object naming) occurred in a post-lexical time-window at 395-485ms in left posterior insular cortex, consistent with post-lexical motor preparation. Thus, our data show that semantic priming during comprehension and interference during production are not two sides of the same coin but rather they clearly dissociate in space and time, consistent with a lexical account for comprehension and a post-lexical one for production.

Topic Area: LANGUAGE: Semantic

F70 Spoken language predicts print-speech spatial co-activation in 5-6 year old emerging readers

Rebecca Marks^{1,2}, Leo Zekelman^{2,3}, Ioulia Kovelman¹, Fumiko Hoefft^{2,4,5}; ¹University of Michigan, ²University of California, San Francisco, ³Harvard University, ⁴University of Connecticut, ⁵Haskins Laboratories

Learning to read transforms the brain, building on children's existing capacities for language and visuospatial processing. The integration of these processes results in a brain network of frontal, temporal, parietal and occipital regions that is activated for both auditory word (speech) and visual word (print) processing, across languages and orthographies (Rueckl et al., 2015). Though the development of a co-active print-speech network is critical for literacy acquisition, its antecedents remain unknown. In this study, we examine the relationship between spoken language proficiency and the emergence of the shared print-speech network in beginning readers (N = 68, mean age 5.7). Method: Using conjunction logic, we measured the number of voxels significantly activated by both print and speech processing in key cortical areas for reading, namely the left superior and middle temporal gyrus, and left fusiform gyrus. To investigate the mechanism driving this co-activation, we used structural equation modeling to examine how behavioral measures of children's language ability and early literacy skills predicted the extent of their co-activation for print and speech. Results: We find that early print-speech co-activation is preceded and predicted by spoken language proficiency, but not by literacy skill. Furthermore, print-speech activation in beginning kindergarten readers predicts children's reading abilities one year later. Our results suggest a developmental continuity from children's neural organization for spoken language processing to the gradual reorganization for reading, informing theoretical perspectives on language and literacy acquisition across the lifespan.

Topic Area: LANGUAGE: Development & aging

F71 A timescale-specific hierarchy for linguistic representations in cortical oscillations

Greta Kaufeld¹, Hans Rutger Bosker^{1,2}, Phillip M. Alday¹, Antje S. Meyer^{1,2}, Andrea E. Martin¹; ¹Max Planck Institute for Psycholinguistics, ²Donders Institute for Brain, Cognition and Behaviour

Recent accounts of language comprehension posit that cortical oscillations track acoustic and linguistic components (Ding et al., 2016; Keitel et al., 2018). While previous research has shown that oscillatory activity is modulated by acoustic landmarks and intelligibility (Doelling et al., 2014), it is unclear which information the brain utilizes to generate structure and meaning. We experimentally manipulated the amount of semantically- and syntactically-deployable information to investigate whether oscillations are modulated by the linguistic information conveyed at different timescales, asking how much information from distinct levels of linguistic representation we could detect in the brain response. EEG was recorded while 29 adult native speakers listened to naturally-spoken Dutch sentences, jaberwocky sentences with sentence-like prosody and morphology, and word lists (80 items/condition). Power analysis revealed a 'meaning-and-structure' hierarchy from jaberwocky (lowest) to grammatical (highest) in the delta-theta band. Mutual information (MI) analysis further revealed enhanced speech tracking at distinct timescales: MI was equally high at the phrasal timescale (0.6-1.5Hz) for grammatical and jaberwocky sentences, suggesting that delta-band tracking is largely driven by prosody, rather than lexically-driven syntactic processing (Glushko et al., 2018). At the word timescale (1.1-4.5Hz), MI was highest for word lists, and at the syllabic scale (1.7-26.1Hz) for sentences, indicating that linguistic information modulates the oscillatory response at distinct timescales. Taken together, our findings indicate that neural tracking is enhanced for linguistic structures at timescales specific to that structure's role in the unfolding meaning of the sentence, consistent with neurophysiologically-inspired models of language comprehension (Martin, 2016; Martin & Dumas, 2017).

Topic Area: LANGUAGE: Syntax

F72 Neural networks for sentence comprehension and production: an ALE-based meta-analysis of neuroimaging studies

Matthew Walenski¹, Eduardo Europa², David Caplan³, Cynthia K. Thompson¹; ¹Northwestern University, ²University of California San Francisco, ³Harvard Medical School

Comprehending and producing sentences is a complex endeavor requiring the coordinated activity of multiple brain regions. We examined three issues related to the brain networks underlying sentence comprehension and production in healthy individuals: First, which regions are recruited for sentence comprehension and sentence production? Second, are there differences for auditory sentence comprehension vs. visual sentence comprehension? Third, which regions are specifically recruited for the comprehension of syntactically complex sentences? Results from activation likelihood estimation (ALE) analyses (from 45 studies) implicated a sentence comprehension network occupying bilateral frontal and temporal lobe regions. Regions implicated in production (from 15 studies) overlapped with the set of regions associated with sentence comprehension in the left hemisphere, but did not include inferior frontal cortex, and did not extend to the right hemisphere. Modality differences between auditory and visual sentence comprehension were found principally in the temporal lobes. Results from the analysis of complex syntax (from 37 studies) showed engagement of left inferior frontal and posterior temporal regions, as well as the right insula. The involvement of the right hemisphere in the comprehension of these structures has potentially important implications for language treatment and recovery in individuals with agrammatic aphasia following left hemisphere brain damage.

Topic Area: LANGUAGE: Syntax

F73 Neural Representation of Pragmatic Knowledge: Focusing on Japanese Honorific Expressions

Pragmatic knowledge is determined socioculturally and associated with certain linguistic forms. From this perspective, investigating the neural representation of pragmatic knowledge can help us understand how the brain integrates sociocultural and linguistic information during communication. Thus, we examined the neural representation of pragmatic knowledge by focusing on Japanese honorific expressions. Japanese honorific expressions are known as grammaticalized honorifications that differentiate interlocutors' social positions by changing verb forms. They are commonly used when a speaker of lower social status (LS) verbally refers to a person of higher social status (HS). To this end, we recruited 29 native Japanese speakers to perform an honorification judgment task (information of interlocutors with auditory sentences) during fMRI scanning. The task consisted of 'congruent' (LS uses honorification, HS uses non-honorification) and 'incongruent' (LS and HS use unconventional honorification) conditions. Brain imaging data were analyzed by using SPM12. To examine how the brain integrates information related to social status while processing grammaticalized pragmatic knowledge, we analyzed the contrasts of [LS > HS] in the congruent and incongruent conditions. In the congruent conditions, LS induced greater activation in the left inferior frontal gyrus (LIFG) (BA44 and BA47) than HS (uncorrected $p < 0.001$). Consistent with this result, under the incongruent conditions, LS produced significantly greater activation in the LIFG (BA44) than incongruent HS (FWE $p < 0.05$ cluster level). These results suggest that LIFG plays an important role in processing grammaticalized pragmatic knowledge, which is constructed by integrating social and linguistic information.

Topic Area: LANGUAGE: Syntax

F74 Syntactic Processing in Bilinguals and Monolinguals: Evidence from Functional Near-infrared Spectroscopy (fNIRS)

Guoqin Ding¹, Kathleen A. J. Mohr¹, Ron Gillam¹, Boyu Zhang¹, Carla Orellana¹, Allison Hancock¹; ¹Utah State University

This study examined behavioral and neurophysiological data of monolingual and bilingual children to compare mechanisms underlying syntactic processing. Participants included ten English monolinguals (Female=5) and ten Chinese-English bilinguals (Female=5). They received a battery of English tests (including the Grammatical Judgment (GJ) subtest of the CASL-2) and completed a syntactic judgment task during fNIRS scans. Bilingual children received a similar task in Chinese. Auditory stimuli in both languages included two sentence types (Subject-Verb-Object and Passive). The semantic plausibility of the sentences was controlled, so that word order was the only relevant linguistic cue. Participants were asked to select the agent of each sentence. One-way and repeated-measure ANOVAs compared results, which showed that monolinguals performed significantly better than bilinguals on GJ. Both groups performed better on SVO than PAS in English and Chinese, and no significant differences were found between groups. Independent and paired-sampled t-tests of the fNIRS data were used to examine the activation in brain areas. No between-group difference was found for the English tasks. Monolingual children showed no difference between sentence types, but bilingual children showed greater activation in middle pre-frontal cortex (MPFC) for PAS sentences. No difference was found for Chinese tasks. Thus, although monolinguals outperformed bilinguals on an English GJ task, both groups showed very similar levels in accuracy and brain activation patterns on the syntactic judgment task, which may indicate both groups processed English in similar ways. More activation of MPFC for PAS constructions evidenced more cognitive control was required in processing this second language syntax.

Topic Area: LANGUAGE: Syntax

F75 Tracking brain prediction based on associative representations in subject-verb agreement

Jane Aristia¹, Angèle Brunellière¹, Alec Marantz^{2,3}; ¹Université de Lille, ²New York University, ³New York University Abu Dhabi

Previous electrophysiological studies in subject-verb agreement have usually shown that the grammatical features, such as number and person, are accessed during agreement processing. Moreover, there is experimental evidence for predictive mechanisms in language processing. In the present study, we probed cortical activation of associative representations between a pronominal subject and a verb inflection in subject-verb agreement, such that a neural prediction about an inflection can be made after hearing a pronoun. Here, we used magnetoencephalography (MEG) to study the dynamics of prediction within spoken pronominal subject-verb phrases in French. We manipulated (1) the associative frequency (low versus high) between the subject pronoun and specific inflections and (2) the grammatical features relevant to processing by creating agreement violation (person, number person, and number violation). During this study, French-speaking participants ($n=12$) listened to a pronominal prime followed by a target inflected verb and they were asked to indicate whether the target is a word or not. We found that while the associative frequency affected the processing of the verb around 100-270 ms after its onset with stronger activity for the high associative frequency, agreement violations influenced the processing of inflections around 315-430 ms after their onset in the right parietal lobe. These findings shed light on the predictive role of associative representations and the neurocognitive process involved in subject-verb agreement.

Topic Area: LANGUAGE: Syntax

F76 Amygdala and VTA differentially interact with hippocampus and cortical MTL during rest.

David F. Gregory¹, Maureen Ritchey², Vishnu P. Murty¹; ¹Temple University, ²Boston College

Neuromodulatory regions that detect salience have distinct effects on motivated behavior and memory. Yet, questions remain about how modulatory regions such as the amygdala and ventral tegmental area (VTA) target medial temporal lobe (MTL) subregions. The VTA and amygdala differentially engage the hippocampus versus cortical MTL during states of reward- versus threat-motivated encoding, respectively. Here, we sought to characterize how VTA and amygdala subregions (i.e., the basolateral (BLA) and central-medial (CeM) nuclei) interact with the anterior hippocampus (aHPC), posterior hippocampus (pHPC), perirhinal cortex (PRC) and parahippocampus (PHC) in a task-free state. We quantified interactions of the VTA, BLA and CeM with MTL subregions using high-resolution, resting state fMRI ($N=22$) and characterized pair-wise, partial correlations across regions-of-interest. We found that the BLA showed greater functional coupling with aHPC, pHPC and PRC when compared to either the VTA and CeM ($p < .001$). Further, the VTA showed greater functional coupling with the pHPC compared to the CeM ($p=0.01$). There were no significant differences in functional coupling with PHC. These results support a model by which neuromodulatory regions do not indiscriminately influence all MTL subregions equally, but rather bias information processing to discrete MTL targets. Further, our results show that these biases exist during resting state, when there are no explicit affective or mnemonic demands. These findings provide a more specified model of the intrinsic properties of systems underlying MTL neuromodulation, and highlights the need to consider heterogeneity both across and within neuromodulatory systems to better understand affective memory.

Topic Area: LONG-TERM MEMORY: Episodic

F77 Developmental changes and neural correlates of associative, spatial and temporal relational memory

Jaione Arnaez-Telleria¹, Pedro M. Paz-Alonso¹; ¹BCBL. Basque Center on Cognition, Brain and Language, Donostia-San Sebastián, Spain

Relational memory refers to the ability to store and retrieve elements of an episode in an associative way and constitutes a critical process in many of our daily cognitive operations. This form of memory is thought to be supported by at least three types of processes with specific neural substrates, including i) binding operations supported by the hippocampus, ii) semantic processing which typically engages lateral temporal cortex, and iii) mnemonic control operations recruiting lateral prefrontal cortex (IPFC). These three cognitive processes are subjected to substantial changes from middle-childhood to adulthood. However, it is still unclear their specific contributions to different forms of relational memory: associative, spatial, and temporal. We conducted behavioral and magnetic resonance imaging (MRI) experiments examining item and relational memory with 8-to-14-years-old children and young adults aimed at investigating: 1) the involvement of hippocampus in binding operations; 2) the impact of the semantic versus non-semantic nature of the stimuli and the contribution of lateral temporal cortex, and 3) the role of mnemonic control operations typically supported by IPFC. Behavioral data showed significant age-related changes in item versus relational memories. Neuroimaging results revealed stronger hippocampal engagement for associative memories as compared to item memories, as well as differences in the functional coupling between hippocampus and cortical areas as a function of relational memory type. These results constitute the strongest evidence so far of the interactions between binding, semantic and mnemonic control operation in relational memory.

Topic Area: LONG-TERM MEMORY: Episodic

F78 Functionally specific effects of targeted noninvasive stimulation on hippocampal-cortical network connectivity

Kristen Warren¹, Molly Hermiller¹, Steven VanHaerents¹, Joel Voss¹; ¹Northwestern University

Episodic memory is supported by the hippocampus and a distributed network of interacting cortical regions. We have shown that stimulation targeting this hippocampal-cortical network (HCN) increases resting-state fMRI correlations among network regions and influences episodic memory. However, connectivity of this network is also altered by memory retrieval. Here, we investigated the functional and regional specificity of stimulation effects on connectivity measured during a specific memory demand, autobiographical retrieval, relative to those observed via resting-state fMRI. Subjects (n=32) underwent resting-state and autobiographical retrieval-state fMRI scans following five days of high-frequency (20 Hz) transcranial magnetic stimulation to either a left lateral parietal cortex location of the HCN (n=16) or a left prefrontal cortex location that is not part of the HCN and not associated with autobiographical retrieval (n=16). We identified state-specific and network-specific effects of stimulation on connectivity. Parietal stimulation had a greater effect on retrieval-state relative to resting-state connectivity primarily in HCN regions, whereas prefrontal stimulation had a greater effect on resting-state relative to retrieval-state. fMRI connectivity changes in the medial temporal lobe due to stimulation predicted corresponding changes in episodic memory performance measured during a separate task, with greater modulation of retrieval-state connectivity relative to rest predicting greater context recollection improvement. These findings indicate that the expression of neuroplasticity generated by HCN-targeted stimulation is most robust when measured during memory processing. Additionally, recollection memory is causally related to memory-specific fMRI connectivity of the MTL. This result supports the utility of noninvasive stimulation for functionally selective modulation of brain networks.

Topic Area: LONG-TERM MEMORY: Episodic

F79 Integration of Event Order and Duration during Movie Watching

Saebyul Lee¹, Su Keun Jeong¹; ¹Korea Brain Research Institute

Knowing the order and duration of events is crucial for many aspects of everyday life. In the laboratory, however, researchers have investigated how humans process event order and duration information in isolation and limited approach has been made to integrate these two aspects of event processing. Here, we sought to examine the integration of temporal duration in event order memory by specifically asking whether duration information is reconstructed from event order at retrieval or whether it is already encoded in event representations. To this end, we asked participants to estimate temporal positions of experienced events (still images from a video-clip) on a bounded horizontal timeline. We found that the participants overestimated the duration between earlier events and underestimated the duration between later ones. This systematic distortion corresponds to previous duration perception literature showing logarithmic time perception, suggesting that the participants might have retrieved event duration and order directly from their event representations. To rule out the possibilities that this logarithmic pattern of duration judgments is due to a response bias or strategy use during reconstruction (e.g., serial dependency and proportion judgment), in the following experiment, we provided an unbounded timeline without an informative endpoint. Results showed that serial dependency of estimates disappeared when the participants could not use reference points and proportion judgment strategy. Nevertheless, the logarithmic pattern of estimation was still found. These results implicate that event duration and order are integrated in event representation and the post-hoc reconstructive process might not be necessary at duration retrieval.

Topic Area: LONG-TERM MEMORY: Episodic

F80 Investigating contributions of memory systems to concept generalization using individual differences in cognitive abilities

Takako Iwashita¹, Caitlin R. Bowman¹, Dagmar Zeithamova¹; ¹University of Oregon

Concept generalization involves regions implicated in both declarative memory (hippocampus, prefrontal cortex) and procedural learning (caudate, posterior visual cortex). Whether these systems compete or cooperate is a matter of debate. To elucidate the shared or dissociable roles of these brain systems in concept generalization, we tested the relationship between individual differences in several cognitive abilities and neural categorization effects in the hippocampus, ventromedial prefrontal cortex, caudate, and lateral occipital cortex. While undergoing fMRI, participants completed a visual category generalization task in which they learned category labels for a set of cartoon animals and then were tested on their ability to generalize category labels to new animals. A separate cognitive assessment included measures of working memory, processing speed, perceptual reasoning, and verbal comprehension. We found that verbal comprehension uniquely predicted concept generalization performance and correlated with neural categorization effects in all regions. These results suggest common rather than dissociable contributions of distinct memory systems to concept generalization and newly implicates verbal comprehension as a factor contributing to visual categorization.

Topic Area: LONG-TERM MEMORY: Episodic

F81 Memory for outdoor scenes after sleep: Procedures for separately measuring specific scene learning and category learning

Sarah J. Witkowski¹, Victoria Lee¹, Max K. Smith¹, Paul J. Reber¹, Ken A. Paller¹; ¹Northwestern University Psychology Department

Learning can provide both knowledge of specific details and extraction of general categories. Sleep may contribute to one or both. As a first step in a new line of research on this topic, we sought to measure the two types of memory following an interval that either did or didn't include nocturnal sleep. We asked whether there is a trade-off between these two memory-types or if they change in parallel. In the learning phase, participants viewed 4-second video clips of navigation through a virtual terrain that varied in parameters such as hilliness or weather, and that formed three distinct categories. After each of 30 unique clips (each shown 9 times), participants selected a category label (A/B/C) and received feedback (correct/incorrect). Memory was then tested before and after a 12-hour delay. In the memory-specificity test, participants viewed a sequence of clips (old and new intermixed) and registered old/new recognition judgments. In the category-knowledge test, participants attempted to categorize old and new clips. Both tests included confidence ratings. Sleep and wake groups performed equally well on the memory-specificity and category-knowledge pre-delay tests. We used post-delay minus pre-delay performance to calculate forgetting scores for each test. On both tests, the sleep group showed less forgetting than the wake group. These results suggest that sleep may facilitate both memory specificity and generalization learning, rather than producing a tradeoff between the two.

Topic Area: LONG-TERM MEMORY: Episodic

F82 Modulation of Posterior Parietal Subregions by Prior Knowledge during Multimodal Episodic Retrieval

Marty Fiati^{1,2}, Peter Bright², Shanti Shankar¹, Peter Hills¹; ¹Department of Psychology, Bournemouth University, UK, ²Department of Psychology, Anglia Ruskin University, UK

Increasingly findings within memory literature implicate the posterior parietal cortex (PPC) in the memory operations which occur at the time of episodic retrieval. Involvement of the PPC has been found to support fine multi-sensory recollection of features within episodic memories, and has also been suggested to reflect binding of such contextual information within an episode. Studies of semantic memory similarly implicate regions of the PPC in retrieval of semantic features, which are also often embedded in episodic frameworks. The current study examined PPC involvement in the integration of semantic and episodic details during retrieval. Participants performed a multisensory episodic task in which they first identified previously studied (Old) famous and nonfamous faces, and subsequently made context-based source judgements denoting the spatial location (left/right), voice (male/female), and study task (pleasantness rating/celebrity judgement) that they had associated with each face at study. Recorded ERPs from 17 participants associated accuracy of source recollection with a late positivity (450ms-800ms) maximal over centro-parietal sites. The magnitude of the parietal positivity increased with the number of accurate source memory judgements for each face. These effects were localised with fMRI recordings from 22 participants. The activity from histological PPC subregions was analyzed for their differential sensitivity to prior knowledge and episodic detail. The left PGp and PFcm subregions displayed linear effects of increased source accuracy, and a linear effect of prior knowledge was additionally present for the PGp. The findings indicate a dissociation between PPC subregions in the integration of different types of features during episodic retrieval.

Topic Area: LONG-TERM MEMORY: Episodic

F83 Neural Correlates of Emotional Episodic Memory Encoding and Retrieval: Activation Likelihood Estimation Meta-Analyses

Kristina Dahlgren¹, Charles Ferris¹, Stephan Hamann¹; ¹Emory University

Neuroimaging meta-analysis methods such as Activation Likelihood Estimation (ALE) can summarize the brain regions associated with a cognitive function that are consistently activated across multiple studies, elucidating findings that may be obscured in individual studies with limited statistical power. A previous ALE meta-analysis of successful encoding of episodic emotional memory (Murty et al., 2010) identified the amygdala, hippocampus, and multiple neocortical regions. However, since that initial study, the ALE method has been substantially improved and nearly a decade of new neuroimaging studies have been published. Moreover, although qualitative reviews exist, no quantitative meta-analysis has yet been conducted to characterize activations during the successful retrieval of emotional memory. To address these gaps, we conducted separate ALE meta-analyses of emotional memory encoding and retrieval, respectively. All relevant neuroimaging studies of successful (vs. unsuccessful) encoding and retrieval of emotional (vs. neutral) episodic memory were selected, following methods adapted from Murty et al. (2010). For emotional memory encoding, ALE activations overlapped substantially with those of the prior meta-analysis (e.g., amygdala, hippocampus, prefrontal regions) but also showed significant differences, likely reflecting the larger new data set and new ALE method. For emotional memory retrieval, the primary ALE activation encompassed the left amygdala and hippocampus. The current findings further clarify the role of the amygdala, hippocampus, and neocortical regions in successful encoding and retrieval of emotional episodic memory and provide an important summary of the current literature in this area.

Topic Area: LONG-TERM MEMORY: Episodic

F84 Neural differentiation at encoding predicts subsequent source memory performance in young and older adults.

Sabina Srokova¹, Paul F. Hill¹, Joshua D. Koenig², Danielle R. King¹, Michael D. Rugg¹; ¹Center for Vital Longevity and School of Behavioral and Brain Sciences, University of Texas at Dallas, ²Department of Psychology, University of Notre Dame

The aging brain is characterized by neural dedifferentiation, which has been characterized as reduced selectivity in category-selective cortical regions. These age differences in functional specialization have been argued to play a crucial role in cognitive aging. Here, young (N=24, mean age 22 years) and older (N=24, mean age 70 years) adults underwent fMRI as they studied words paired with images of faces or scenes prior to a subsequent source memory test. We computed a neural differentiation index as an index of category selectivity in two bilateral regions-of-interest (ROIs) identified using an independent dataset from our laboratory: fusiform face area (FFA) and parahippocampal place area (PPA). The index was operationalized as the difference between the mean BOLD response of a given ROI's preferred and non-preferred image class, scaled by the pooled standard deviation. Differentiation indices were submitted to a 2 (age group) x 2 (ROI) mixed factorial ANOVA. This analysis identified a significant interaction driven by lower differentiation indices from the PPA in older compared to younger adults. We did not observe any age differences among FFA differentiation indices. Additionally, the PPA, but not the FFA, differentiation index predicted subsequent source, but not item, memory performance. Critically, this relationship was age invariant. These results support prior findings in suggesting that age-related neural dedifferentiation can be category- and regionally specific and, more generally, that neural dedifferentiation is independently associated with age and cognitive performance.

Topic Area: LONG-TERM MEMORY: Episodic

F85 Neural mechanisms of episodic memory reconsolidation: A critical role for prediction error

Alyssa Sinclair^{1,2}, Grace Manalili¹, Morgan Barense¹; ¹University of Toronto, ²Duke University

Through the process of reconsolidation, memories can be reactivated, destabilized, and updated with new information. Recent research has proposed that prediction error, or surprise, is a critical prerequisite for reconsolidation. Yet, the neural mechanisms of this process remain elusive, particularly with regards to naturalistic episodic memories. In our novel fMRI paradigm, we demonstrated that prediction error drives episodic memory reconsolidation. On Day 1, Experimental group participants (N=24) viewed 70 multi-modal videos, each depicting a narrative action-outcome event. During the Day 2 fMRI session, we reactivated these memories by presenting the videos again. Critically, we interrupted half of the videos to violate the action-outcome contingency, thus eliciting a prediction error. On Day 3, we assessed memory for the videos with a structured interview. Control group participants (N=24) completed the memory test on Day 2, preventing the hours-long reconsolidation process. Behaviorally, we found that interrupting videos during reactivation significantly increased subsequent false memories in the Experimental group. In accordance with reconsolidation theory, Control participants exhibited significantly fewer false memories. In an event-related design, we examined neural activity following the offset of each video, including subsequent false memories as a parametric modulator. We found distributed post-video processing in regions including the bilateral hippocampus, dorsal and ventral striatum, and cingulate cortex. Moreover, relative to intact videos, interrupted videos elicited greater activation in the temporoparietal junction, precuneus, and inferior frontal gyrus. For the first time, we demonstrate that prediction error allows naturalistic episodic memories to be altered, and implicate the neural correlates of memory destabilization.

Topic Area: LONG-TERM MEMORY: Episodic

F86 Neural pattern classification reveals the temporal dynamics of competitive memory retrieval

Inês Bramão¹, Jiefeng Jiang², Anthony D. Wagner^{2,3}, Mikael Johansson¹; ¹Department of Psychology, Lund University, Sweden, ²Department of Psychology, Stanford University, Stanford, ³Wu Tsai Neurosciences Institute, Stanford University, Stanford

Resolution of interference between competing memories is often critical for remembering. This study employed multivariate pattern analysis of electroencephalographic data to investigate the temporal dynamics of retrieval competition and competition resolution. Competition between memories was created through the AB/AC interference paradigm. Memory retrieval of competitive AB and AC cue-associate was compared with non-competitive DE pairs. Behavioural results showed worse memory performance for AC compared with DE word pairs, but comparable performance for AB and DE word pairs, revealing proactive without retroactive interference. Critically, the AB, AC and DE word pairs were encoded embedded in a movie with a distinct theme (first-person perspective of underwater, forest, and city environments). We trained classifiers to discriminate patterns of brain activity associated with the movies at encoding. The classifiers were applied at retrieval to track memory reactivation. In the cue time window, where only the word cue was presented (i.e. A or D), we observed classification performance for non-competitive retrieval, revealing target reactivation, but no classification for competitive retrieval, presumably due to the simultaneous reactivation of target and competitor memories. In a following time window, when participants were given a first-letter probe to retrieve the target word (i.e. B/C/E), we observed classification performance ~700 ms after probe onset for the competitive retrieval, revealing the time course of competition resolution. Importantly, classification accuracy in this late time window co-varied with memory performance, that is, with the resolution of proactive interference. This study offers novel insights into the time course of memory competition and competition resolution.

Topic Area: LONG-TERM MEMORY: Episodic

F87 Oscillatory Mechanisms for Hippocampal Memory Encoding Tested in Humans

Sarah Lurie¹, Joel Voss¹; ¹Northwestern University

Hippocampus and functionally connected structures are known to mediate declarative memory, although mechanisms for memory encoding by this network are not fully understood. Hippocampal ensemble activity shows prominent coherence in the theta range, which could serve as a rhythm to orchestrate binding of various sensory inputs into coherent memory traces (Buzsáki, 2002). Activity carrying information about memoranda might be optimally bound into memory traces when arriving at the hippocampus during theta peaks (Siegle & Wilson 2014 eLife). Although theta power during and before episodic memory encoding benefits memory formation (Addante et al. 2011; Fell et al. 2011), no studies assessed whether the phase of hippocampal theta relative to memoranda is relevant to memory formation in humans. Our study addresses this question using several innovative methods. We entrain the hippocampal theta rhythm using periodic repetitive transcranial magnetic stimulation (rTMS) delivered to the hippocampal network at a theta frequency. As hippocampus cannot be stimulated directly in humans using noninvasive measures, we stimulate cortical network locations to indirectly influence hippocampal activity, as in other recent work from our laboratory (Nilakantan et al., 2017, Wang et al., 2015). We then present brief visual memoranda synchronized to the entrained hippocampal oscillation. Preliminary findings suggest that our iTBS protocol results in oscillatory entrainment of hippocampal or other memory mediating structures. Recall accuracy trends highest for items encoded during extrapolated 'peak' theta phase positions and lowest for items encoded during extrapolated 'trough' positions, with intermediate phase positions yielding intermediate recall accuracies.

Topic Area: LONG-TERM MEMORY: Episodic

F88 Rhythmic encoding improves recognition memory

Alexander Jones¹, Emma Ward¹; ¹Middlesex University London

There has recently been an increased interest in the way temporal expectancies shape perception and drive behaviour. Research has observed that intrinsic neural oscillations can entrain to external rhythms by aligning the firing pattern of neurons. This entrainment has shown to enhance perception and facilitate behaviour for stimuli that appear in phase with the rhythm, yet little is known about how temporal expectation during encoding influences subsequent memory. Participants in the present study were presented with a rapid succession of everyday objects in an encoding phase and asked in a subsequent recognition test phase to judge whether individually presented objects were presented before (old) or not (new). Importantly, the presentation of objects in the encoding phase followed a either rhythmic or arrhythmic temporal pattern, of which participants were not made aware. Recognition was significantly greater for items that were presented rhythmically compared to those presented arrhythmically. There was evidence entrainment with increased phase locking for rhythmic over arrhythmic stimuli during encoding. Moreover, memory specific ERP components at test phase were influenced by rhythmic encoding. Specifically, the FN400 old/new effect was present in both conditions, but a late positive component (LPC) old/new effect was only observed for rhythmically encoded items. This parietal old/new effect (LPC) has been proposed as an index of recollection, specifically linked to memory for the contextual details associated with the encounter with the item. The study provides new evidence through EEG and behavioural measures that presenting stimuli in a rhythmic manner provides a benefit to recognition memory.

Topic Area: LONG-TERM MEMORY: Episodic

F89 Scanpath components reveal how eye movement reinstatements differentially contribute to episodic remembering

Roger Johansson¹, Marcus Nyström², Richard Dewhurst³, Mikael Johansson¹; ¹Department of Psychology, Lund University, ²Humanities Laboratory, Lund University, ³Interacting Minds Centre, Aarhus University

An extensive body of research has shown that episodic remembering involves spontaneous eye movements that largely reproduce the gaze patterns that were present during encoding (e.g., Brandt & Stark, 1997; Johansson et al., 2012). Recent work has further shown that fixation locations that overlap between encoding and recall promote cortical episodic reconstruction (Bone et al., 2018; Johansson et al., 2018) and successful remembering (Johansson & Johansson, 2014). While such findings indicate that gaze location plays an active role during episodic reconstruction, the unfolding scanpaths also encompass more complex information over and above simple gaze locations, such as order, direction, shape, length and duration. Virtually nothing is known about how such spatio-temporal components contribute to episodic reconstruction. The present study investigated the encoding-retrieval overlap in scanpaths for 60 participants who encoded and recalled 36 visuospatial stimuli of two types: scenes and object arrangements. Results replicate and extend previous findings, by analyzing scanpath reinstatement over a multitude of spatio-temporal components. Critically, by combining subjective ratings of memory quality with a surprise test of forced-choice recognition, we demonstrate how such components contribute to successful remembering to different extents, and in different ways depending on the stimulus type. Results indicate that scanpath shape contributes to reconstructing the global scene structure whereas scanpath position, order and direction contribute to reconstructing the arrangement of individual objects in a spatial context. To our knowledge, this is the first systematic demonstration of how eye movement reinstatements contribute to episodic remembering in a multifaceted way.

Topic Area: LONG-TERM MEMORY: Episodic

F90 Sex differences rather than individual differences account for differential brain activity between females and males during visual long-term memory

Dylan Spets¹, Scott Slotnick¹; ¹Boston College

In a previous fMRI investigation, we identified sex differences in the human brain during visual long-term memory. During study, abstract shapes were presented to the left or right of fixation. During test, old shapes were presented at fixation and participants classified each shape as previously in the "left" or "right" visual field. We selected eighteen female participants (from forty) to match the behavioral accuracy and standard error of the eighteen male participants. Despite equivalent behavioral performance, females and males activated different brain regions. Females produced greater activity in language processing and visual processing regions, whereas males produced greater activity in prefrontal cortex. It is possible that such differential brain activity may have reflected individual-participant differences between the two groups rather than sex differences. To determine if this was the case, we ran 10,000 Monte Carlo simulations by parametrically varying the number of females and males in each group (from an approximately equal number in each group to all females in group 1 and all males in group 2). If the female versus male activation differences were due to individual differences rather than sex differences, the number of significant thresholded clusters of activity would not vary as a function of the number of females/males per group. Critically, we found a significant correlation between the number of females/males in each group and the number of significant activations. These results suggest that differential activity between females and males during visual long-term memory can be attributed to sex differences rather than individual participant differences.

Topic Area: LONG-TERM MEMORY: Episodic

F91 The impact of emphasizing contextual and conceptual details on neural activity during discrete phases of autobiographical memory retrieval

Lauri Gurguryan¹, Signy Sheldon¹; ¹McGill University

Retrieving autobiographical memories is a multi-phasic process that involves constructing detailed representations of past personal experiences. There are questions concerning how different details guide remembering during the multiple phases of retrieval and whether this alters neural activity. Based on theories of autobiographical memory organization, we tested for common and distinct neural activity that support remembering when conceptual and contextual details are used to reorient a memory versus when they are used to access a new memory. In an fMRI study, 24 participants retrieved autobiographical memories during three phases of remembering, under two experimental conditions. First, participants recalled pre-selected autobiographical memories (initial retrieval), then they reoriented their retrieval of these memories either towards the memory's thematic elements (conceptual condition) or spatial location (contextual condition). Finally, they used this oriented content (conceptual versus contextual) to access a new and related autobiographical memory. Using a multivariate analytic approach (Partial Least Squares), we found separate neural patterns associated with these different phases of remembering as a function of the contextual and conceptual conditions. Notably, condition effects were present only when participants were reorienting to the details of a memory rather than accessing a new memory. We also found that the neural pattern associated with the contextual condition when reorienting a memory overlapped with the pattern recruited during initial retrieval. These data provide insight into the phase of the retrieval process that is most sensitive to changes in details used to guide remembering and highlight the importance of spatial information in framing remembering.

Topic Area: LONG-TERM MEMORY: Episodic

F92 Threat impairs flexible use of a cognitive map

Brian Silston¹, Kevin Ochsner¹, Mariam Aly¹; ¹Columbia University

Goal-directed behavior requires adaptive systems that respond to environmental demands. In the absence of threat (or presence of reward), individuals are free to explore a large state space of trajectories, effectively interrogating the environment across a large number of dimensions. This leads to flexible, relational memory encoding and retrieval, governed by the hippocampus. In the presence of imminent danger, motivation shifts to an imperative state characterized by attention that is narrowly focused at threatening items. This impairs flexible, relational memory, instead prioritizing encoding of salient items by the amygdala and perirhinal cortex. We test how these proposed motivational shifts (Murty & Adcock, 2017) affect behavioral flexibility and memory. We designed a 3D navigation platform in which participants learned the structure of a maze-like environment and navigated to the location of everyday objects, in safe and threatening contexts; the latter contained a predator that could 'capture' participants (leading to electric shock). After learning, the path to some objects was blocked, forcing a detour for which one route was significantly shorter. We predicted that the threatening environment would push participants toward an imperative state, leading to less efficient and less flexible navigation. Under threat, individuals took longer paths to goal objects and less efficient detours when obstacles were encountered. Less efficient navigation was present despite no difference in recognition memory for the maps learned in safe vs threatening contexts. These results provide ecologically valid evidence that imperative states, triggered by threat, reduce the ability to flexibly use cognitive maps to guide behavior.

Topic Area: LONG-TERM MEMORY: Episodic

F93 Tracking the neural signature of incidental and intentional memory retrieval

Gerd T. Waldhauser¹, Malte Kobelt¹, Marie-Christin Fellner¹, Nikolai Axmacher¹; ¹Institute of Cognitive Neuroscience, Ruhr University Bochum

The incidental retrieval of involuntary memories is a frequent but poorly understood phenomenon in autobiographical memory and a hallmark symptom of posttraumatic stress disorder. In order to shed light on the particular processes underlying this type of memory retrieval, we contrasted neural activity between incidental and intentional retrieval, employing electroencephalography. Participants first encoded associations between abstract cues and everyday objects presented in the left or right visual hemifield. During intentional retrieval, participants engaged in recognition of the cues and retrieved the hemifield and identity of the associated object. During the subsequent incidental retrieval phase, the abstract cues were presented again in an identical manner, but now participants conducted a speeded visual discrimination task without any explicit instruction to recognize the cue or retrieve the associated object. Instead, participants were asked to indicate any incidentally occurring memories. Incidental retrieval led to longer reaction times in visual discrimination, indicating interference of involuntary memories. This was accompanied by increased left/mid-frontal theta (2-8Hz) oscillatory power, starting with stimulus onset. Representational similarity analysis revealed that incidental retrieval relied on rapid (~150 ms) reinstatement of sensory information about object lateralization at occipital electrodes. By contrast, intentional retrieval was accompanied by a late (>450 ms) theta power increase generated in the left medial temporal lobe and the right dorsolateral prefrontal cortex and involved the reactivation of information that is specific to stimulus identity but not to object lateralization. These results indicate that incidental and intentional memory retrieval involve qualitatively different types of memory representations and processes.

Topic Area: LONG-TERM MEMORY: Episodic

F94 Variability in episodic encoding: interactions between memory, attention, and media multitasking

Anna Khazenzon¹, Kevin Madore¹, Monica Thieu², Melina Uncapher³, Anthony Wagner¹; ¹Stanford University, ²Columbia University, ³University of California, San Francisco

An emergent literature points to chronic media multitasking – juggling more than one stream of media at a time – as a correlate of individual differences in cognition, including lower working memory and long-term memory performance in heavier vs. lighter media multitaskers (HMMs vs. LMMs). We predicted that HMMs would demonstrate greater bottom-up attentional capture by task-irrelevant information, reflected in greater distractor-related neural activity and impaired mnemonic encoding of target stimuli. In an fMRI-scanned incidental encoding task, participants made semantic judgments about words while attempting to ignore infrequent peripheral distractor images. We observed a main effect of distractor on memory performance (d') — both groups were worse at encoding words in the presence of distraction. While there was no effect of media multitasking on hit rate, HMMs showed a greater propensity to false alarm to new words at retrieval. Neurally, left inferior frontal gyrus showed greater activity during subsequent hit vs. miss trials without external distraction; the strength of this within-subject subsequent memory effect positively correlated with individual differences in memory performance. Relative to LMMs, HMMs showed widespread reductions in subsequent memory effects in the presence of external distraction, accompanied by increases in lateral occipital and supplementary motor activity on subsequently forgotten distractor vs. no distractor trials. These results suggest media multitasking-related differences in encoding processes, and suggest that effective resistance to distraction protects mnemonic encoding.

Topic Area: LONG-TERM MEMORY: Episodic

F95 “Blurred lines” – ‘Non-episodic’ content of future thinking narratives challenges a strict episodic-semantic distinction

Cherie Strikwerda-Brown^{1,2,3}, John R. Hodges^{1,2,4}, Olivier Piguet^{1,2,3}, Muireann Irish^{1,2,3}; ¹Brain and Mind Centre, the University of Sydney, Australia, ²School of Psychology, the University of Sydney, Australia, ³Australian Research Council Centre of Excellence in Cognition and its Disorders, Sydney, Australia, ⁴Sydney Medical School, the University of Sydney, Australia

Contemporary theoretical frameworks propose that episodic and semantic memory lie at opposite ends of a continuum. Informed by this view, we recently developed a new taxonomy (‘NExt’) for coding ‘non-episodic’ (external) content of autobiographical narratives, which revealed a spectrum of episodic and semantic elements within the external details category. The composition of these elements within other forms of episodic construction, however, has not yet been explored. Here, we employed the NExt taxonomy to examine external detail profiles in episodic future thinking narratives. Profiles in Alzheimer’s disease (AD) and semantic dementia (SD), neurodegenerative disorders with respective impairments in episodic and semantic memory, were compared with those of Controls. Within future narratives, somewhat counterintuitive profiles of external details emerged. Relative to Controls, AD patients produced increased ‘episodic’ external details, whereas elevations in ‘episodic’, ‘semantic’, and ‘general event’ (at the intersection of episodic and semantic) details were observed in SD. Voxel-based morphometry analyses of structural MRI, however, revealed an association between increased future ‘episodic’ external details in AD and the integrity of bilateral frontal regions typically associated with semantic memory. By contrast, elevated future ‘general event’ and ‘semantic’ details in SD related to preservation of right precuneus and other bilateral posterior temporoparietal regions implicated in vivid episodic retrieval. These findings reinforce the blurring of the episodic-semantic distinction, suggesting the external details category cannot be conceptualised merely in terms of ‘non-episodic’ content. Moreover, neurodegenerative populations offer unique insights into the episodic-semantic continuum, displaying compensatory reliance upon the most preserved memory system during future simulation.

Topic Area: LONG-TERM MEMORY: Semantic

F96 Is arbitrary episodic context suppressed when processing abstract concepts?

Charles P. Davis^{1,2}, Pedro M. Paz-Alonso³, Gerry T.M. Altmann^{1,2}, Eiling Yee^{1,2}; ¹University of Connecticut, ²Connecticut Institute for the Brain and Cognitive Sciences, ³BCBL. Basque Center on Cognition, Brain and Language

Abstract concepts like “idea” are central to the human experience, yet relatively little is understood about how they are processed. One recent hypothesis suggests that because abstract concepts can occur in many semantically distinct contexts, it is especially critical to suppress irrelevant information and actively select context-relevant information during their comprehension (e.g., Hoffman et al., 2015). Recent work in our lab suggests that arbitrary episodic context (e.g., frame color, voice source) may indeed be suppressed when processing abstract concepts (Davis et al., 2018). Here, we investigated the neural mechanisms underpinning this effect using fMRI. Participants were exposed to words referring to abstract and concrete concepts that were surrounded by arbitrarily colored box frames. They performed a synonym-judgment 1-back task on the words while undergoing fMRI scanning. Thereafter, participants were asked to recall the words and the contexts (i.e., box frames) in which they occurred. We hypothesized that abstract concepts would show greater activation than concrete concepts in frontal regions supporting cognitive control, reflecting suppression of arbitrary episodic context. As predicted, abstract concepts produced greater activation compared to concrete concepts in inferior and medial frontal cortex (in addition to language processing regions such as superior temporal gyrus). The results suggest that when processing abstract concepts, we inhibit arbitrary episodic

detail, perhaps to up-regulate more systematic relationships critical to abstract concept comprehension.

Topic Area: LONG-TERM MEMORY: Semantic

F97 The relationships between age, fMRI correlates of familiarity and recognition memory performance: Effects of a dual task manipulation

Marianne de Chastelaine¹, Erin D Horne¹, Michael D Rugg¹; ¹Center for Vital Longevity and the School of Behavioral and Brain Sciences, The University of Texas at Dallas, USA

We previously described age-invariant relationships between the neural correlates of familiarity and familiarity-driven recognition memory in an associative recognition procedure. Here, young and older participants were scanned while completing an associative recognition test during single and dual task conditions. The test followed a study phase in which word pairs were visually presented in a relational encoding task. Test items comprised studied, rearranged (items studied on different trials) and new pairs. fMRI familiarity effects were operationalized as greater activity for both studied and rearranged pairs identified as 'rearranged' than for correctly rejected new pairs. The reverse contrast was employed to identify 'novelty' effects. Item memory was lower for the older relative to the younger group. Age-invariant familiarity effects were identified in regions that are often reported as being sensitive to familiarity: medial and lateral parietal cortex, dorsal medial and left lateral prefrontal cortex, and bilateral caudate. These effects positively correlated with estimates of familiarity across participants. Novelty effects were also age-invariant but relatively weak – these effects were identified in ventral mPFC and right TPJ, but not in the MTL as we reported previously. Nevertheless, MTL novelty effects demonstrated an age-invariant relationship with item memory. When entered into the same regression model, familiarity and novelty contrasts independently predicted familiarity strength across participants. Together, these findings largely replicated our previous report. Extending our prior findings, and as expected, the dual task manipulation had a negligible effect on behavioral and neural estimates of familiarity in either age group.

Topic Area: LONG-TERM MEMORY: Development & aging

F98 Memory Reactivation During Rapid Eye Movement Sleep Facilitates Remote Associations

Anne C M Koopman¹, Nora Hennes², Karen Konkoly¹, Marleen Kempkes², Penny Lewis¹; ¹Cardiff University, ²The University of Manchester

Sleep can be broadly divided into rapid eye movement sleep (REM) and non-REM sleep, of which the deepest stage is slow wave sleep (SWS). The role of SWS in memory is well-established, whereas the role of REM is less clear. This study uses a between-participant design to examine the differential impact of targeted memory reactivation of an associative memory task during REM or SWS. Thirty-two participants (16 in the REM reactivation group and 16 in the SWS reactivation group), learned to match sounds to 40 semantically related scenes. Participants then learned to independently associate two faces with each scene-sound pair. Following learning, participants' sleep was monitored and half of the sounds were replayed to them either in REM or in SWS. In the morning and in a two-week follow-up, both learned face-scene associations and remote face-face associations were tested. A time x group x replay ANOVA on remote associations showed a main effect of replay ($F(1, 30) = 5.54$; $p = 0.025$; partial $\eta^2 = 0.156$). Further analyses revealed that this was due to better performance (% correct) of the REM group on the replayed compared to the non-replayed items in the remote associations test. At the two-week follow-up, this replayed/non-replayed difference was significant ($t(15) = 2.76$; $p = 0.014$; Cohen's $d = 0.691$). These results suggest that memory processing occurs during REM sleep, and we can trigger it using

learned sounds. They further suggest that REM sleep replay may strengthen indirect associations.

Topic Area: LONG-TERM MEMORY: Semantic

F99 Neural pattern change during repeated memory encoding.

Minjae Kwon¹, Sue-Hyun Lee^{1,2}; ¹Department of Bio and Brain Engineering, College of Engineering, Korea Advanced Institute of Science and Technology, ²Program of Brain and Cognitive Engineering, College of Engineering, Korea Advanced Institute of Science and Technology

Learning by repetition is a useful strategy for semantic memory acquisition. Association areas including the angular gyrus have been thought to be critical for the information integration process during memory encoding, but it remains elusive whether the moment-to-moment changes of the responses in the association areas reflect associative learning. Here, we used functional magnetic resonance imaging (fMRI) and multi-voxel pattern analysis to investigate the representation of integrative information during associative learning task. In the task, during the scan, participants learned pairs of images (object or building images) and person's names. While each image-name association was learned individually, an object image and a building image were associated with a common name. The participants showed progressive improvement in recall performance over the repeated trials. Using trial-by-trial similarity analysis, we found that between-stimulus pattern similarity for the associated object-building pairs was significantly higher than that for non-associated pairs at the 4th trial in the left angular gyrus. Moreover, this similarity was significantly greater than that of the earlier trials. The between-stimulus pattern similarity for the non-associated pairs was comparable across the trials. These results suggest that repeated associative learning elicit changes of the neural similarity patterns in the angular gyrus and that the increase of the pattern similarity underlies the storage of the associative information.

Topic Area: LONG-TERM MEMORY: Semantic

F100 The effect of sex hormones on sleep spindles and cognitive performance

Kerstin Hoedlmoser¹, Stefan Herzog¹, Hubert Kerschbaum²; ¹Laboratory for Sleep, Cognition and Consciousness Research, Centre for Cognitive Neuroscience, University of Salzburg, Salzburg, Austria, ²Department of Cell Biology, Centre of Cognitive Neuroscience, University of Salzburg, Austria

Sex hormones fluctuate across a monthly cycle. Whereas estrogen shows dominance and a peak during the follicular phase, progesterone is more pronounced in the luteal phase. There is growing evidence that these fluctuations in sex hormones influence sleep and cognition. 58 healthy women (age: 22.31 ± 3.19 yrs) spent two nights (baseline, experimental) in the sleep laboratory. Polysomnography was recorded during the nights. Before and after sleep saliva samples were collected. Preceding the experimental night subjects encoded 160 word-pairs. Retrieval of these word-pairs was assessed before (RET1) and after sleep (RET2). Subjects performed the Ravens Advanced Matrices test to examine intelligence. Memory performance was significantly improved after sleep ($t = -4.874$, $p < 0.001$). However, we did not find any relation between memory consolidation and brain oscillations during sleep. Women generally (baseline and experimental night) showing stronger fast (13-15Hz) sleep spindles performed better in the intelligence task ($r = 0.376$, $p = 0.012$). The higher the progesterone level, the higher the fast sleep spindle density ($r = 0.384$; $p = 0.017$). Our dataset replicates earlier findings that sleep spindles serve as a biological marker for intelligence. While we did not find any changes in sleep spindles after declarative learning, our data revealed that women with elevated progesterone levels show increased fast sleep spindle activity. This supports prior findings suggesting a role of progesterone in the production of sleep spindles. The menstrual cycle seems

to moderate thalamocortical communication, which has to be considered when exploring the role of sleep features in sleep-related memory consolidation.

Topic Area: LONG-TERM MEMORY: Semantic

F101 Implicit Associative Learning: Hippocampus and Striatal Involvement Over Time

Madeleine Mendoza¹, Jenna Klippenstein¹, Jessica Petok², Ilana Bennett¹; ¹University of California, Riverside, ²St. Olaf College

Implicit associative learning (IAL) refers to learning associations between events without conscious awareness. Previous functional magnetic resonance imaging (fMRI) studies of young adults found that hippocampus and striatum are active during the early and late stages of IAL, respectively. The current study aimed to replicate and extend this work by examining hippocampal and striatal activity over the course of learning. Young adults (21.10 +/- 1.64 years) completed eight runs of the Triplets Learning Task (TLT) during fMRI acquisition. Each trial ("triplet") consisted of two cues (one of four circles filling in red) followed by a target (one circle filling in green). Participants responded to the location of the target, which was predicted by the cue locations on 75% of trials (high frequency) but not the remaining 25% of trials (low frequency). Results revealed IAL as faster and more accurate responses to high versus low frequency triplets. Replicating previous fMRI work, significantly greater activity to high versus low frequency triplets was seen in left hippocampus during the early phase (runs 1-3) and in bilateral striatum during the late phase (runs 6-8) of learning. When examined as a linear function of the amount of learning, activity for high versus low frequency triplets decreased in left hippocampus and increased in bilateral striatum over fMRI runs. These novel results support the notion that hippocampus may facilitate the rapid formation of associations (between cues and target), even in the absence of explicit awareness, while striatum is slower to form or maintain these associations throughout learning.

Topic Area: LONG-TERM MEMORY: Skill learning

F102 Relationships Between Striatal Gray Matter Integrity and Implicit Associative Learning

Corinna Franco¹, Jessica Petok², Ilana Bennett¹; ¹University of California, Riverside, ²St. Olaf College

Previous studies have implicated striatal structures (i.e., caudate, putamen) in implicit associative learning (IAL), or the learning associations between events without conscious awareness that subserves language and habit learning. While previous neuroimaging studies have examined IAL in relation to striatal function and the integrity of white matter tracts emanating from the striatum, none have examined the relationship between striatal gray matter integrity and IAL. Gray matter integrity can provide valuable information about microstructural properties of caudate and putamen (e.g., degree of neuronal density) that may complement previous examinations of the neural substrates of implicit learning. In this study, young adults (20.82 ± 1.55 years old) underwent diffusion tensor imaging and completed the Triplets Learning Task, which requires the acquisition of associations between two cues (location of red circles) with a target (location of green circle). Task performance (IAL scores and mean reaction times) correlated with measures of bilateral caudate and putamen gray matter integrity (e.g., fractional anisotropy [FA], mean diffusivity [MD]). That is, faster overall reaction time was significantly correlated with lower right caudate MD. Additionally, better IAL scores were significantly negatively correlated with lower FA and higher MD in left caudate. These results for caudate gray matter integrity are consistent with previous neuroimaging studies demonstrating involvement of striatum in IAL. Moreover, it supports the notion that gray matter integrity is sensitive to individual differences in cognition, even among healthy younger adults.

Topic Area: LONG-TERM MEMORY: Skill learning

F103 The Power Curve of the Brain: Reward Prediction Errors Follow Learning Curves

Chad Williams¹, Olave Krigolson¹; ¹University of Victoria

Learning curves have long been used to explain changes in performance. Despite the depth of research investigating neural learning signals, whether changes in these signals follow learning curves is still untested. In the current research, we sought to determine the pattern of change that EEG-derived neural signals elicit across learning. In a reinforcement learning paradigm, participants learned sixty words of a novel language by developing symbol-word associations. Additionally, a reinforcement learning model completed the same task. Trial-by-trial analyses for both empirical and simulated data were completed for accuracy rates, reaction times, and neural signals reflecting reward prediction errors (i.e., the reward positivity). We hypothesized that accuracy rates would increase and reaction times would decrease analogous to power-law learning curves. Further, we predicted that the reward positivity would too diminish in this fashion. Indeed, we found behavioural and neural measures of learning alike adhered to power law functions for both empirical and simulated data. Thus, for the first time we demonstrated that learning networks of the brain obey principles of well-known behavioural phenomena.

Topic Area: LONG-TERM MEMORY: Skill learning

F104 Association between change in microscopic white matter pathways and cardiorespiratory fitness in response to a behavioral weight loss intervention

AG. Porter¹, C. Bañuelos¹, RL. Leckie², KI. Erickson^{3,4}, RJ. Rogers^{3,5}, JM. Jakicic^{3,5}, TD. Verstynen^{1,4}; ¹Carnegie Mellon University, ²University of Pittsburgh School of Medicine, ³University of Pittsburgh, ⁴Center for the Neural Basis of Cognition, Carnegie Mellon University and University of Pittsburgh, ⁵Healthy Lifestyle Institute, University of Pittsburgh

Lower cardiorespiratory fitness and higher adiposity are associated with poorer integrity of white matter pathways (Porter et al. 2018). Here we evaluated whether change in a measurement of cardiorespiratory fitness is associated with change in integrity of white matter pathways. To assess this, we evaluated data from a sub-sample of healthy community dwelling adults ranging from overweight to obese (N=91) who participated in a 12-month behavioral weight loss intervention involving an energy-restricted diet alone or in combination with physical activity that progressed to 150-250 minutes/week. Cardiorespiratory fitness was measured as a submaximal VO₂ defined as the volume of oxygen consumption attained at 85% of age-predicted maximal heart rate (VO_{2submax}) before and after the 12-month intervention. Longitudinal increases in VO_{2submax}, expressed as ml/kg/min, was associated with increased white matter integrity using a connectometry analysis (Yeh et al., 2016) on diffusion MRI (dMRI) data, controlling for framewise displacement, age, and sex. These associations were found in portions of the corticostriatal, corticothalamic, parietopontine, and central corpus callosum pathways. There was one negative association in the genu of the corpus callosum (FDR<0.05). These results show that, in the context of a behavioral weight loss program changes in cardiorespiratory fitness track with the integrity of large-scale association pathways in the human brain. Future research will need to determine the contribution of changes in cardiorespiratory fitness effects versus that of body composition and weight to these associations.

Topic Area: METHODS: Neuroimaging

F105 Decreases in Hemispheric Symmetry Levels of White Matter Tracts Following Mild Traumatic Brain Injury

Andrei Vakhtin^{1,2}, Yu Zhang¹, Wesson Ashford^{1,2}, Miguel Robinson¹, Dana Waltzman³, Max Wintermark², Ansgar Furst^{1,2}; ¹VA Palo Alto, ²Stanford University, ³Centers for Disease Control

Comparisons of white matter (WM) fractional anisotropy (FA) values between mild traumatic brain injury (mTBI) patients and controls have yielded mixed findings, particularly regarding the directions of FA changes following trauma. To address this we examined FA symmetry levels across WM tracts in 150 mTBI patients relative to 90 military controls. Automated fiber quantification was used to extract 18 WM tracts and 100 FA values along each one. To assess hemispheric symmetry levels, these FA values were used to compute correlation strengths between the 9 homologous tract pairs. The resulting Pearson's *r* values were Fisher z-transformed and entered into an ANCOVA examining the effects of group (mTBI and controls) and age on symmetry levels within each tract pair. The mTBI group displayed significant decreases in symmetry levels in the cortico-spinal tract and the inferior longitudinal fasciculus. Interactions between age and group were detected in the inferior fronto-occipital (IFOF), uncinate, and superior longitudinal fasciculi (SLF). Despite no significant relationship between the two variables in the IFOF within the control group, symmetry levels dropped with increasing age across the mTBI group. Analogously, the uncinate fasciculus displayed no changes in symmetry across age in controls, but revealed aging-related symmetry decreases in the mTBI group. In contrast, the control group's symmetry levels increased with age in the SLF, but no age-related symmetry changes were detected across the mTBI participants. We demonstrated the utility of symmetry levels for circumventing directional inconsistencies of trauma-related FA abnormalities, as well as their interactions with age following mTBI.

Topic Area: METHODS: Neuroimaging

F106 Estimating latent brain connectivity underlying multiple brain states

Katelyn L. Arnemann¹, Takuya Ito¹, Stephen J. Hanson¹, Michael W. Cole¹; ¹Rutgers University - Newark

Interpreting resting-state functional connectivity (FC) as intrinsic brain network properties implicitly assumes that a common "latent" connectivity architecture sculpts brain activity across states. While recent studies support the possibility of latent connectivity, it remains unclear whether the resting state provides privileged insight into the brain's state-independent network architecture. We estimated latent connectivity and assessed resting state in relation to 7 task states for 352 participants in the Human Connectome Project. In addition to standard preprocessing, we applied finite impulse response-based regression to the fMRI times-series to remediate inflation of FC estimates induced by task activations. For each subject and state, we defined functional brain networks using Pearson's correlation for 360 regions from the Glasser parcellation. Latent connectivity was estimated independently for each connection by applying leave-one-state-out factor analysis (LOSO-FA) on state FC estimates. LOSO-FA extracted latent connectivity that correlated with the left-out states (range: $R = 0.61$ to 0.71 , respectively for the reasoning task and resting state). The FC estimated during task states correlated to a lesser extent with resting-state FC (range: $R = 0.46$ to 0.57 , respectively for the relational and language tasks). While resting-state FC provided insight into underlying latent connectivity, estimating latent connectivity using factor analysis on multiple brain states better explained general, state-independent FC. More accurate estimates of latent connectivity may improve characterization of the brain's fundamental functional organization with likely implications for understanding changes associated with a wide variety of cognitive states and diseases.

Topic Area: METHODS: Neuroimaging

F107 Identification of first-episode psychosis from the brain activity of subjects viewing a naturalistic stimulus: Time-window-based neural network analysis

Vesa Vahermaa¹, Athanasios Gotsopoulos¹, Jussi Alho¹, Mikko Sams¹, Tuukka Raji¹; ¹Aalto University, School of Science

The neuronal basis of psychosis is not fully understood and diagnosis primarily entails non-objective methods such as interviews and questionnaires. Modern machine learning methods are able to identify patterns from large amounts of data, including functional magnetic resonance imaging (fMRI) data. Here, we presented a shortened movie (Alice in Wonderland, by Tim Burton, 2010) to our subjects with diagnosed first-episode psychosis ($N=51$) and controls ($N=33$) during whole-brain fMRI (voxel size 2mm, TR 1.8s). (54 male, average age of 25.14 years ($SD=5.46$)) We applied a neural network classifier to predict whether a subject belonged to the patient vs. control group. We applied this analysis to nine-second sliding windows. The classification accuracy throughout the movie was close to chance level (from 42.31% to 62.56%, mean 52.10%, $SD=5.73\%$), with certain time points exhibiting significantly above chance level accuracy. While our results do not convey the statistical power to be used for clinical purposes, they serve as a starting point for future research on diagnostic tools based on naturalistic stimuli.

Topic Area: METHODS: Neuroimaging

F108 The Neuroscience of Driving: An ecologically-relevant paradigm for MEG neuroimaging during simulated driving.

Elizabeth A. Walshe^{1,2}, William Gaetz², Chelsea Ward-McIntosh², Daniel Romer¹, Timothy Roberts², Flora K. Winston^{1,2}; ¹University of Pennsylvania, ²Children's Hospital of Philadelphia

Driving is a uniquely complex everyday behavior requiring integrated brain function across multiple systems. Driver errors are largely attributed to limited neurocognitive capacities, yet we know very little of the underlying substrates of driving. A paradigm was tested for whole cortex magnetoencephalographic (MEG) recording during an ecologically-valid simulated driving task. The goal was to demonstrate the feasibility and validity of this paradigm to reliably characterize motor and cognitive neural responses to driving in a preliminary sample. We recruited and scanned 6 healthy right-handed male adults (median age: 22 years). Components of driving performance (accelerating/braking and steering) were strategically isolated, while manipulating the scene to increase task demands. A MEG-compatible steering wheel and gas/brake pedals were used to record behavioral responses. Neuromagnetic data was recorded with a 275-channel MEG system (CTF International), and a volumetric MRI scan was used for MEG source localization. Differential beamformer methods were used to localize visual alpha-band, motor beta-band, and frontal gamma- and theta-band responses (Gaetz et al., 2010). Reliable MEG data was recorded, without significant artifact. The findings reveal localized beta-band (1-30Hz) activity for expected brain regions of the motor cortex activity in response to hand (steering) and foot (pedal) behavior, as well as additional grand average theta-band (4-7Hz) power increases in midline frontal areas when task demands were higher, likely reflecting an increased need for cognitive control. This paradigm can be utilized to not only understand the neural correlates of driving, but to also examine integrated brain function during more ecologically-relevant behaviors.

Topic Area: METHODS: Neuroimaging

F109 Dimensions of Psychopathology are Dissociably Linked to Brain Structure in Youth

Antonia Kaczurkin¹, Sophia Seonyeong Park², Aristeidis Sotiras¹, Tyler M. Moore¹, Matthew Cieslak¹, Zaiyu Cui¹, Daniel H. Wolf¹, Daniel S. Pine³, Ruben

C. Gur^{1,4}, Christos Davatzikos¹, Raquel E. Gur¹, Theodore D. Satterthwaite¹; ¹University of Pennsylvania, ²Temple University, ³National Institute of Mental Health, ⁴Philadelphia Veterans Administration Medical Center

High comorbidity among psychiatric disorders suggests that they may share underlying neurobiological deficits. Abnormalities in cortical thickness and volume have been demonstrated in clinical samples of adults, but less is known about when these structural differences emerge in youth. The purpose of this study was to examine the association between dimensions of psychopathology and brain structure. We studied 1,394 youth imaged as part of the Philadelphia Neurodevelopmental Cohort. Dimensions of psychopathology were constructed using a bifactor model of symptoms. Cortical thickness and volume were quantified using high-resolution MRI at 3T. Structural covariance networks were derived using non-negative matrix factorization and analyzed using generalized additive models with penalized splines to capture both linear and nonlinear developmental effects. Fear symptoms were associated with reduced cortical thickness in the anterior and posterior cingulate cortex, temporal-parietal junction, anterior insula, as well as orbitofrontal and temporal cortex. Overall psychopathology was associated with globally reduced gray matter volume across all networks. Lastly, structural covariance networks predicted psychopathology symptoms above and beyond demographic characteristics and cognitive performance. Our results suggest a dissociable relationship whereby fear is most strongly linked to reduced cortical thickness and overall psychopathology is most strongly linked to global reductions in gray matter volume. Such results have implications for understanding how abnormalities of brain development may be associated with divergent dimensions of psychopathology, and suggest potential biomarkers that could be used to enhance personalized interventions for psychiatric disorders in youth.

Topic Area: NEUROANATOMY

F110 Insular Functionally Connected Sub-regions of Healthy Developing Youth

Aliyah Jones¹, Biao Cai², Yu-Ping Wang², Jeremy D. Cohen¹; ¹Xavier University of Louisiana, ²Tulane University

Insular Cortex is a multimodal region with connectivity throughout the brain and involved in a wide range of cognitive functions. Typical analysis of fMRI data creates activation maps by testing each voxel separately for correlation with an experimental paradigm or performing a statistical analysis on a specific region of interest (ROI). A cluster-based analysis creates activation maps, which gives each voxel in the acquisition volume a priori chance of being discovered. Previous studies identified three clusters as insular sub regions of shared functional connectivity with other brain regions. This study implements a similar clustering procedure to measure connectivity differences across age and cognitive ability. Subjects (N=864) collected from the Philadelphia Neurodevelopmental Cohort (PNC) consisting of youths aged 8-21 years were used to compute insular clusters and to measure connectivity correlations. Results showed that there were three clusters within the left hemisphere of the insula and three clusters within the right hemisphere. A linear regression showed that the strength of connectivity of the insular cortex clusters, in both left and right hemispheres decreased with age to most brain regions, except posterior cingulate, insular cortex, precentral gyrus, and parahippo-campal gyrus. This data suggests that insular clusters in developing youth are similar to adult insular organization, but that perhaps learning and cognitive development diminish the influence of salience network. Insular connectivity with default mode network regions are maintained potentially aiding stable self-reference. This is the first step towards increased understanding of how insular cortex organizes with other brain regions during early life.

Topic Area: NEUROANATOMY

F111 The fruit below the rind: the importance of subcortical structures in cognition

Michael Ullman¹, Tanya M. Evans², Mariann Kiss³, Leela Shah², Hal Blumenfeld⁴, Karolina Janacsek^{5,6}; ¹Georgetown University, ²Curry School of Education and Human Development, and Brain Institute, University of Virginia, ³Doctoral School of Psychology, Budapest Institute of Technology and Economics, Budapest, Hungary, ⁴Yale School of Medicine, ⁵Institute of Psychology, Eotvos Lorand University, Budapest, Hungary, ⁶Institute of Cognitive Neuroscience and Psychology, Research Centre for Natural Sciences, Hungarian Academy of Sciences, Budapest, Hungary

Till now, the cognitive neurosciences have focused largely on cerebral cortex, the gray matter 'rind' enveloping the cerebrum. This emphasis on cortex is found in both theoretical and empirical research in many areas of cognition, including attention, executive function, memory, language, reading, music, and math. But there is much more to the brain than cortex: cortex is but part of the telencephalon, which is part of the forebrain, which is part of the entire brain. So do subcortical structures also support cognition? This might be expected, given that subcortical regions underlie cognition in non-human animals, and the evolutionary principle of cooptation might extend their cognitive roles even further. Indeed, increasing evidence suggests that subcortical gray matter subserves aspects of human cognition. However, the potential importance of subcortical regions in typical and atypical cognition has not yet been widely accepted. Here we aim to help rectify this situation. We highlight the problem, and comprehensively summarize evidence regarding both known and potential cognitive roles for subcortical structures throughout the brain. The evidence suggests that numerous brainstem, diencephalic, and telencephalic subcortical regions support cognition, from the pons and red nucleus to the hypothalamus, epithalamus, septal nuclei, claustrum, and basal ganglia. These and other structures underlie cognitive functions ranging from attention and memory to language and math, in typical functioning as well as dysfunction. The findings suggest that brain networks for cognition critically encompass subcortical as well as cortical structures. The fruit beneath the rind might indeed be juicier than the rind itself.

Topic Area: NEUROANATOMY

F112 Volumetric Differences of the Thalamus in Developmental Dyslexia

Mykayla Jeter¹, C. Nikki Arrington¹, Robin Morris¹; ¹Georgia State University

Learning and attention disorders are the most common issues impacting learning in school-aged children. Research indicates that developmental dyslexia (DD) and Attention Deficit Hyperactivity Disorder (ADHD) are associated with structural brain differences such as decreased volume in thalamic nuclei compared to typically developing readers (TDR). The aim of the current study was to further evaluate volumetric differences of the thalamus in children with DD only, and DD+ADHD. It was hypothesized that children meeting study criteria for co-morbid DD+ADHD would have reduced thalamic volume compared to children with DD only, and TDR. As part of a larger study, we assessed volumetric differences in the thalamus of 127 elementary-school aged children (male=72, mean age=9.13) obtained from structural brain images processed through Freesurfer software. Participants were classified into one of three groups (TDR, DD, and DD+ADHD) based on study diagnostic criteria using reading tests and ADHD behavioral ratings. A one-way ANOVA was conducted to compare the volumetric differences in the left and right thalamus between groups. A significant difference in left thalamus volume was found, $F(2,124)=4.54, p<.05, \eta^2=.068, HSD=401.32$. Post hoc comparisons indicated a significant difference between DD and TDR groups only. No other significant differences were found. Results indicate thalamic volume in co-morbid DD+ADHD was not different from the volume in DD only, while DD volume decreased compared to TDR children. Previous research indicates the left hemisphere of the brain as the primary center for reading and language

networks supported by left hemisphere thalamic nuclei. Decreased volume in this brain structure may contribute to reading impairments in DD.

Topic Area: NEUROANATOMY

F113 REM sleep respiratory behaviours match mental content in narcoleptic lucid dreamers

Delphine Oudiette^{1,2,3}, Pauline Dodet², Thomas Similowski^{2,3}, Isabelle Arnulf^{1,2,3}; ¹Brain and Spine Institute, ²Sorbonne Universités, ³Pitié-Salpêtrière Hospital

Breathing is irregular during rapid eye-movement (REM) sleep, whereas it is stable during non-REM sleep. Why this is so remains a mystery. We propose that irregular breathing has a cortical origin and reflects the mental content of dreams, which often accompany REM sleep. We tested 21 patients with narcolepsy who had the exceptional ability to lucid dream in REM sleep, a condition in which one is conscious of dreaming during the dream and can signal lucidity with an ocular code. Sleep and respiration were monitored during multiple naps. Participants were instructed to modify their dream scenario so that it involved vocalizations or an apnoea, -two behaviours that require a cortical control of ventilation when executed during wakefulness. Most participants (86%) were able to signal lucidity in at least one nap. In 50% of the lucid naps, we found a clear congruence between the dream report (e.g., diving under water) and the observed respiratory behaviour (e.g., central apnoea) and, in several cases, a preparatory breath before the respiratory behaviour. This suggests that the cortico-subcortical networks involved in voluntary respiratory movements are preserved during REM sleep and that breathing irregularities during this stage have a cortical/subcortical origin that reflects dream content.

Topic Area: OTHER

F114 Awake reactivation in the primary sensorimotor cortex after visuomotor learning in humans

Kenji Ogawa¹, Huixiang Yang¹, Fumihito Imai¹, Hiroshi Imamizu²; ¹Hokkaido University, ²The University of Tokyo

Recent human fMRI studies revealed reemergence of task-related activation patterns during a post-learning awake period, which have roles in picture-memory consolidation (e.g., Tambini & Davachi, 2013) or perceptual learning (e.g., Guidotti et al., 2015). This study aimed to reveal whether such replay-like activation occurs after procedural (visuomotor) learning in the primary sensorimotor cortex. During fMRI scanning, 42 normal participants (all right-handed) performed continuous visuomotor tracking movement (Ogawa & Imamizu, 2013), while a rotational perturbation of 30° was introduced between a cursor position and a joystick angle. This visuomotor learning block (12 sec) was interleaved with the control block (12 sec), during which the participants passively viewed a replay of previously performed cursor movements of their own. Half of the participants (n = 21) used their right hand, and the other half (n = 21) used their left hand to control the joystick. The 6-min resting-state scans were measured before and after the visuomotor learning sessions. Multivariate pattern classifier was trained to classify task volumes (visuomotor learning) versus control volumes (passive viewing), and then tested with the pre- and post-learning resting scans. Results showed a significant increase in the number of volumes classified as the task in post-learning rest-period compared with the pre-learning period. This effect is specific to the primary sensorimotor cortex contralateral to the hand used. Our finding revealed the reactivation of task-related patterns in the primary sensorimotor cortex for visuomotor learning.

Topic Area: PERCEPTION & ACTION: Motor control

F115 Coordinating immediate and final action goals in grasping preparation: Evidence from ERP and EEG time-frequency analysis

Lin Yu¹, Thomas Schack¹, Dirk Koester¹; ¹University of Bielefeld, Germany

Action goals are often confused with the result of a single movement. The coordination of different parts of the action goal is still unclear. In this study, the coordination of immediate and final goals in planning grasp movement was investigated with the help of electroencephalogram (EEG). 28 participants were asked to perform either free-choice or specified grips on a handle and rotate it to the given target positions based on the cues. The two cues were shown in different sequences. The sequences were consisted by the separately presented cues "how to grip" (immediate goal) and "where to rotate" (final goal) in the gradation of immediate-final or final-immediate. We found reach and rotation times were shorter for the free-choice compared to the specified grips. No difference was found on timing between different sequences. Larger frontal P2s were found time-locked to the final goals. A larger frontal P3 was found only in final-immediate condition time-locked to the first cue (final goal). We found a larger frontal N1 in the immediate-final condition time-locked to the second cue (final goal), while in the final-immediate condition we found no difference. We also observed an increase in theta power after the final goal onset. The results suggest that neural activity differed between final action goal and immediate action goal and the final goal gets more cognitive resources during motor planning. Final action goal seems more important than immediate grip demand during the planning of the grasping movement.

Topic Area: PERCEPTION & ACTION: Motor control

F116 Cortical processing of prediction error and self-agency in patients with schizophrenia.

Koichi Abe¹, Motoaki Sugiura¹, Tatsuo Kikuchi¹, Atsushi Sakuma¹, Hiroo Matsuoka¹, Ryuta Kawashima¹, Kazunori Matsumoto¹; ¹Tohoku University, Sendai, Japan

Self-disturbance in schizophrenia has been studied as an abnormality of self-agency. Dysfunction of prediction and inference may be involved in misattribution of agency, for which several models have been proposed, with different assumed functional abnormalities. Some models assume functional abnormality in the detection of prediction error dependent on action (i.e., forward model) or independent of an action (i.e., sensory gating); other models assume functional abnormality in the inference of attribution of detected prediction error. However, these models have never been verified systematically. Eighteen schizophrenia patients (9 males) and nineteen matched healthy controls (7 males) participated in the study. Patient's positive symptoms were well controlled. Using functional magnetic resonance imaging (fMRI), we examined brain responses to both action-dependent and independent prediction errors in brain regions implicated in action-dependent prediction error (temporoparietal junction, TPJ) and action-independent prediction error (superior temporal gyrus, STG). The brain responses in TPJ to action-dependent error and those in STG to action dependent / independent error were normal in patients. Unlike healthy controls, brain responses to the action-independent error were also observed in TPJ in patients and the group difference was significant. We observed that patients did not have deficits in error detection, but action-independent error was misattributed as action-dependent-error (i.e., inference process), an observation well explained by the abnormal attribution inference model. Given that patient's positive symptoms were well controlled, the abnormalities we identified may persist even if positive symptoms are controlled. This latent pathological factor may be a key target for diagnosis and early intervention.

F117 WITHDRAWN**F118 Effect of aging on covert intentions and change of intentions**

Ariel Furstenberg¹, Callum Dewar², Robert T. Knight², Haim Sompolinsky¹, Leon Y. Deouell¹; ¹The Hebrew University of Jerusalem, ²University of California, Berkeley

Decision making often requires making arbitrary choices ('picking') between alternatives that make no difference to the agent, that are equally desirable, or when the potential rewards are unknown. To investigate this common type of decision making, we compared two age groups: 18-25, and 41-67, on a masked-priming paradigm while recording EEG and EMG. Participants pressed a right or left button following either an instructive arrow cue or a neutral free-choice picking cue, both preceded by a masked arrow or a masked neutral prime. The prime affected the behavior on the Instructed and the Free-choice picking conditions both in the younger and older groups. Moreover, electrophysiological 'change of intention' and conflict signatures were observed via Lateralized Readiness Potential (LRP) and N2 component, respectively, in both age groups. 'Change of intention' was observed even in trials with a neutral prime, as a result of an endogenous early intention to respond in a direction opposite the eventual instructing arrow cue. Overall, older participants were more conservative in responding to the instructive cue, exhibiting a speed-accuracy trade-off. In a subset of trials, EMG measurements revealed covert activity in the non-responding hand, preceding the EMG activity in the responding hand. This manifestation of 'change of intention' at the muscle level was more common in younger subjects, and was associated with the Error Related Negativity in both the Instructed and the Free-choice conditions. This suggests that the overruled acts are considered as 'near misses', even when the choice is arbitrary and has no consequence.

Topic Area: PERCEPTION & ACTION: Motor control

F119 Neural correlates of auditory re-aferences

Nina Heins¹, Jennifer Pomp¹, Daniel S. Kluger¹, Karen Zentgraf², Markus Raab^{3,4}, Ricarda I. Schubotz¹; ¹University of Muenster, ²Goethe University Frankfurt, ³German Sport University Cologne, ⁴London South Bank University

Human actions produce sounds (i.e. auditory re-aferences, AR) that are either the by-product of the action (ARB) or part of the action goal (ARG). It is currently unclear whether these two types of action differ in their psychophysiological representation and whether the impact of AR on motor control diverges between the two. We examined if during the observation of tap dancing (ARG) compared to hurdling (ARB), auditory information is a stronger estimator of movement quality rating, and accordingly, if auditory brain areas play a bigger role in ARG vs ARB. Participants were filmed during tap dancing and hurdling practice, over the course of nine weeks. In the subsequent functional magnetic resonance imaging (fMRI) study, they were presented with point light videos that displayed their own movements and corresponding sounds and were asked to rate the quality of their movements. Videos were either in their original form or scrambled in one or both of the modalities (auditory or visual). While behavioral results showed no overall difference in rating scores between the two types of AR, an interaction effect revealed lower scores in the ARG condition compared to the ARB condition when the auditory modality was scrambled. Functional MRI revealed different active brain regions for the two action types, with increased activation of visual areas in the ARB condition and activation in the supplementary motor and auditory areas in the ARG condition. Results indicate diverging behavioral and neuronal mapping of actions depending on the role of AR for one's own actions.

F120 Neurophysiological insights into the development of complex movement processing in children and adolescents

Elizabeth Heinrichs-Graham¹, Michaela R. Frenzel¹, Jacob A. Eastman¹, Alex I. Wiesman¹, Yu-Ping Wang², Vince D. Calhoun^{3,4}, Julia M. Stephen^{3,4}, Tony W. Wilson¹; ¹University of Nebraska Medical Center, Omaha, NE USA, ²Tulane University, New Orleans, LA USA, ³University of New Mexico, Albuquerque, NM USA, ⁴Mind Research Network, Albuquerque, NM USA

Complex motor skill dramatically improves throughout development. While there is a wealth of peripheral muscle development during this time, it is unclear how the neurophysiological correlates develop in concert. In particular, there is a well-known beta (14-30 Hz) oscillatory response, termed the peri-movement beta event-related desynchronization (ERD), which begins approximately 1 s prior to movement onset and persists throughout movement. This response has been reliably associated with motor planning and/or execution operations in both children and adults in past studies, but how the response changes during the transition from childhood to adolescence has not been examined. In this study, we utilized magnetoencephalography (MEG) and a complex motor sequencing task to determine the oscillatory correlates of motor development in a sample of 105 children aged 9-15 years old. Accuracy, reaction time and movement duration each significantly improved with increasing age. All MEG data was transformed into the time-frequency domain and examined statistically using a nonparametric permutation approach. Significant peri-movement ERD responses were then imaged during motor planning and execution individually, and the impact of age was examined using mixed-model ANOVAs. We found a significant time (i.e., planning vs. execution) by age interaction in the left parietal cortex, such that the youngest participants had a greater difference in beta ERD power between planning and execution than did older participants. These results suggest that motor execution dynamics develop later than motor planning operations, and that these changes are primarily found in secondary motor regions.

Topic Area: PERCEPTION & ACTION: Motor control

F121 Observations of Physiological Responses to Perceived Fatigability during an Isometric Exhausting Task in Lower Extremity

Liyang Zheng¹, Xueyan Xu¹, Robert Carey¹, Erik Sinsel¹, Daniel Welcome¹, John Wu¹; ¹Physical Effects Research Branch, National Institute for Occupational Safety and Health (NIOSH), Centers for Disease Control and Prevention (CDC)

Understanding, assessing and reducing fatigue during physically and/or mentally demanding jobs have long been interests in occupational research. Due to the complex causes and mechanisms of fatigue, researchers face challenges in attaining consistent physiological and psychological measures of fatigue, which are key to evaluating the efficacy of ergonomic interventions (e.g., exoskeletons). The purpose of this study is to examine the associations between the physiological responses and perceived fatigability during a single-leg exertion task. Five healthy male subjects were directed to maintain the exertion level at 30% and 60% of their maximal voluntary capacity until exhaustion. Three major types of physiological responses were recorded—muscle activity by electromyography (EMG), cerebral and regional oxygenation by near-infrared spectroscopy, and cardiac activity by electrocardiography (ECG). Perceived fatigability was assessed by Borg's ratings of perceived exertion (RPE). The physiological measures (two-minute window; both in time and frequency domains if applicable) at the beginning of the task were compared to those in fatiguing status (RPE≥18). Despite the unsurprising increase in heart rate, there were no other consistent physiological changes when the subjects reported approaching exhaustion. This preliminary study suggests that the complete characterization of fatigue

and fatigability demands a multifactorial and comprehensive approach, which might require including the central nervous responses, and integrating emerging technologies (e.g., high-density EEG and EMG) and advanced analysis techniques (e.g., estimating instantaneous heart dynamics using stochastic processes). Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the NIOSH/CDC.

Topic Area: PERCEPTION & ACTION: Motor control

F122 Perceptual Uncertainty Attenuates Implicit Motor Adaptation

Jonathan Tsay¹, Darius Parvin¹, Guy Avraham¹, Hyosub Kim¹, Zixuan Wang¹, Richard Ivry¹; ¹University of California, Berkeley

During motor learning, the nervous system uses error information to improve future movements. When the error information is noisy, the learning rate reduces. Within the framework of optimal sensory integration, this reduction is attributed to a weaker error signal (Burge et al., 2008). Given recent work showing the operation of multiple sensorimotor learning systems, we re-examined the effect of perceptual uncertainty, using a visuomotor rotation task that isolates error-induced changes to the operation of implicit adaptation. Participants made reaching movements with feedback rotated by an invariant angle from the target location. Although participants are informed of this non-contingent form of feedback, they show a robust change in reach direction. To manipulate perceptual uncertainty, the feedback was either a cursor or a cloud of dots that were sampled from a two-dimensional Gaussian (sd = 10 deg). The effect of uncertainty was verified in a perceptual discrimination task. In the visuomotor adaptation task, perceptual uncertainty attenuated learning functions when the perturbation was small (3 deg), but had no effect when the perturbation was large (30 deg). This interaction suggests that sensory noise may not weaken the strength of the error signal as suggested by models of optimal integration, but adds uncertainty to the perceived error location. With small errors, the perceived location on some trials may fall on the opposite side of the actual centroid of the stimulus and thus reduce overall learning. Such sign reversals would not be expected with large errors.

Topic Area: PERCEPTION & ACTION: Motor control

F123 Speech Movements of Adults with Parkinson's Disease and with and without Deep Brain Stimulation

Ignatius Nip¹, Burke Mathes¹; ¹San Diego State University

Parkinson's Disease negatively affects the dopamine-producing neurons of the substantia nigra impairing cognition, language, and speech production. The speech system is affected by rigidity, bradykinesia, and reduced muscular control similar to the limb systems. Deep Brain Stimulation (DBS), has been an effective treatment for over thirty years and clinical benefits abound in the literature citing decreased dependency on medication, improvements on motor scores, quality of life and activities of daily living. However, mixed findings have been reported on the effect of DBS on speech including individuals who improved, worsened, or observed no effect on speech production. The current study examines the effect of DBS on speech movements in this population. It was hypothesized the lip and jaw movements would be larger and faster for those with PD and no DBS and that in the participants with PD and DBS, movements would be larger and faster with the DBS on than off. Six participants with PD and no DBS and nine participants with PD and DBS repeated "Buy Bobby a puppy" in habitual, loud, and clear speech while being recorded using optical motion capture. Participants with PD and DBS completed the tasks with the DBS on and off. Lip and jaw movements were larger and faster for the group with PD and DBS as compared to those with PD and no DBS. Additionally, coordination between the lips were greater for the group with PD and DBS. Loud and clear speech were produced with larger movements and faster speeds for all participants.

Topic Area: PERCEPTION & ACTION: Motor control

F124 The effect of passive sound attenuation in an altered auditory feedback paradigm

Matthias K. Franken¹, Robert J. Hartsuiker¹, Nicolas Bourguignon¹, Petter Johansson², Lars Hall², Andreas Lind^{1,2}; ¹Ghent University, ²Lund University

A popular technique to investigate the role of auditory feedback in speech production has been to alter auditory feedback (AAF) in real time so that speakers hear their productions perturbed. In response, speakers compensate by shifting their speech output in the opposite direction. Current theory suggests this is caused by a mismatch between expected and observed feedback. A methodological issue is the difficulty to fully isolate the speaker's hearing so that only AAF is presented to their ears. Most research groups make use of commercial headphones that do not always offer much passive sound attenuation (PSA). As a result, participants may be presented with two simultaneous signals. If this is true, an alternative explanation for responses to AAF is that these may be due to a comparison between the two signals (AAF and the true feedback). The aim of the current study was to investigate this alternative hypothesis by varying the amount of PSA. An experiment (N=49) was carried out where participants vocalized while auditory feedback was unexpectedly pitch-shifted by either -25, +25, -100 or +100 cents. The feedback was received through three pairs of headphones, with varying amounts of PSA. The results suggest that participants compensated for the unexpected pitch shifts. In addition, their response scaled with the manipulation magnitude. However, the responses to unexpected pitch shifts were not affected by the different levels of PSA, suggesting that these results are in line with current theory's hypothesis that responses are due to a mismatch between observed and expected feedback.

Topic Area: PERCEPTION & ACTION: Motor control

F125 Tracking Differential Activation of Primary and Supplementary Motor Cortex Across Timing Tasks: An fNIRS Validation Study

Ali Rahimpour¹, Daniel Comstock¹, Luca Pollonini², Ramesh Balasubramanian¹, Heather Bortfeld¹; ¹University of California, Merced, ²University of Houston

Functional near-infrared spectroscopy (fNIRS) provides an alternative to fMRI for assessing superficial cortical hemodynamics. Here our goal was to establish the utility of fNIRS for tracking recruitment of the motor network during performance of different timing behaviors. We measured relative changes in cortical hemodynamics in 10 healthy adult volunteers while they performed a finger tapping task previously performed using fMRI (Jantzen, Steinberg, & Kelso, 2004). The task involved two forms of right-hand, tone-guided (1 Hz) tapping, synchronous and syncopated, across two phases, paced tapping to the metronomic tone (10 trials) directly followed by continued tapping without the tone (10 trials) at the established pace. Hemodynamic responses were averaged across the four conditions of this 2 (synchronous/asynchronous) x 2 (pacing/continuation) design and compared. Task-induced brain activation manifested as significant increases in oxygenated hemoglobin concentration ([oxy-Hb]) across the motor network. Primary sensorimotor cortex, supplementary motor area (SMA), premotor cortex (PMC), and inferior parietal cortex were recruited, with the amplitude of responses directly related to complexity of the task (syncopated tapping producing broader overall activation and higher amplitude activation than synchronous tapping). The broader activation included contralateral SMA, left PMC, and bilateral inferior frontal gyri. Aside from decreased activity in auditory-related regions when the tone was not present, no differences in activation emerged between pacing and continuation phases. Accuracy of the timing of participant tapping was also tracked and analyzed.

Topic Area: PERCEPTION & ACTION: Motor control

F126 Competition-dependent ground activation in object perception: Evidence for inhibitory competition and/or predictive coding?

Laura Cacciamani¹, Rachel M. Skocypec², Colin Flowers², Diana Perez², Mary A. Peterson²; ¹California Polytechnic State University, San Luis Obispo, CA, ²University of Arizona, Tucson, AZ

When two regions share a border, they often compete such that the winning side is perceived as the figure and the losing side as a shapeless background. Previous neuroimaging work found that activation in the cortical representation of the ground is lower when a familiar configuration suggested there loses the competition for figural status—a finding attributed to inhibitory competition mediated by feedback from higher levels (e.g., the perirhinal cortex, PRC). However, without a baseline condition, this result could be explained as reduced predictive error due to past experience with the familiar configuration, either alone or in addition to feedback-mediated inhibition. We presented task-irrelevant novel silhouettes in the upper right visual field while participants performed a difficult task at fixation. The silhouettes were designed such that insides were perceived as figure; the vertical groundsides either depicted a portion of a familiar object (“high-competition” condition, named due to the groundside match to object memories) or a novel shape (“low-competition” condition). A third “baseline” condition consisted of rectangles with no notable cross-border competition due to a lack of articulated borders. BOLD results showed lower activation for high- vs. low-competition grounds in extrastriate areas, but importantly, greater activation in both of these conditions vs. baseline—a finding consistent with inhibitory competition within a predictive coding framework. A Granger causality analysis further revealed that effective connectivity from the PRC to V2 (ground) was greater for high-competition than for both low-competition and baseline—evidence supporting the role of feedback in these low-level representations.

Topic Area: PERCEPTION & ACTION: Vision

F127 Learned social values modulate representations of faces in the fusiform face area

Ariana M. Familiar¹, Alice Xia¹, Sharon L. Thompson-Schill¹; ¹University of Pennsylvania

Values drive our behavioral choices. Ample research has explored the cognitive and neural underpinnings of value-based computations related to decision-making. However, behaviorally relevant values that we associate with real-world objects are often not monetary. For instance, social values associated with specific people are crucial for social behaviors and interactions. Social value processing has been shown to recruit the same neural systems as reward values, yet how social values are associated with person-specific information processed in separate systems, such as facial identity, remains to be established. The present study examined changes in neural representations in face-selective visual areas due to social value learning. Over four days, participants learned combinations of social (generosity) and reward (point) values orthogonally assigned to different naturalistic face images. We found that before and after value learning, the similarity of activity patterns (measured with fMRI) evoked by viewing the faces was related to their perceptual similarity in the left, but not right, fusiform face area (FFA). After learning, pattern similarity in the right FFA was related to social value as well as a post-learning index of preference to interact with a person in a future cooperative game, but was not related to reward value. These findings show how learned social values can influence representations in face-selective brain regions thought to primarily encode visual information, and provide a potential neural mechanism for the association of social and visual information relevant to propensities in future social behavior.

Topic Area: PERCEPTION & ACTION: Vision

F128 Neural Processing of Abstract Art Paintings is Influenced by their Spatial Frequencies

Gregor Uwe Hayn-Leichsenring¹, Franziska Hartung¹, Anjan Chatterjee¹; ¹University of Pennsylvania

Visual pattern recognition is partly based on an analysis of the spatial frequencies of an image. It is hypothesized that high spatial frequencies (HSFs) are processed predominantly in the left hemisphere, while low spatial frequencies (LSFs) are processed predominantly in the right hemisphere. Abstract art can have a wide distribution of spatial frequencies. This diversity combined with their artistic appeal and a lack of semantic content makes them an ideal probe to investigate the relation between spatial frequencies and aesthetics. We objectively categorized abstract art paintings according to image properties: (A) paintings with relatively more HSFs and, subsequent, high complexity (e.g., abstract expressionist paintings) and (B) paintings with relatively more LSFs and low complexity (e.g., color field paintings). HSF art paintings were described as more interesting than LSF art paintings in a behavioral study. In a functional MRI experiment, we tested whether abstract art paintings with HSFs or LSFs activate different brain areas when people evaluate them for liking. Participants (N=34) viewed and evaluated images of abstract art paintings while undergoing fMRI. While there were no statistically significant specific activations for LSF art paintings as compared with HSF art paintings, HSF art paintings evoke a frontoparietal activity pattern especially in the left hemisphere including areas in the superior occipital gyrus, middle temporal gyrus and anterior cingulate gyrus. Our results partially confirmed the laterality in processing spatial frequencies hypothesis, with a left predominant response to HSFs in abstract art.

Topic Area: PERCEPTION & ACTION: Vision

F129 Spatial receptive field of convolutional units in deep neural network reconstructed by spike-triggered covariance method

Yoshiyuki Shiraishi¹, Tatsuya Mori¹, Hiromichi Sato^{1,2}, Tomoyuki Naito²; ¹Graduate School of Frontier Biosciences, Osaka University, ²Graduate School of Medicine, Osaka University

The internal representations in deep neural network are not understood very well, so called notorious ‘black box problem’. To clarify the internal representations in deep convolutional neural network (DCNN), in this study, we applied reverse correlation technique commonly used in systems neuroscience, and reconstructed spatial receptive field structures of convolutional units in a DCNN. First, we measured tuning curves of all convolutional units in vgg16 (well trained DCNN by object recognition task) to Cartesian gratings and natural images. We found that the multimodality index of orientation tuning curves increased in the middle and higher layers comparing to lower layers. This character was similar with well-known neural properties of monkey and cat visual cortex. Dissimilar from the visual neurons, about 30% of units in the highest layer responded only to grating stimulus. Then, we estimated spatial receptive field structures of the convolutional units by spike-triggered-average (STA) and spike-triggered covariance (STC) methods. In the lower layers, reconstructed spatial receptive fields from both methods explained the tuning curves of units to grating stimuli and natural images well. In contrast, in the higher layers, receptive fields reconstructed only from STC can explain the tuning curves of the units. Our results suggest that the STC can be a significantly useful method for clarifying the internal representations in deep convolutional neural network.

Topic Area: PERCEPTION & ACTION: Vision

F130 Spontaneous fluctuations of pupil size and brain rhythms covary at rest

Cortical brain activity underlies a number of varying non-cortical authorities. These can act to regulate cortical excitability and thus bias our momentary perception, cognition, and in consequence, our behavioural performance. One such global influence arises from the reticular activating system, specifically the locus-coeruleus-norepinephrine (LC-NE) circuit that controls arousal. This circuit is normally difficult to access directly with neuroimaging but is linked with changes in pupil size. We have exploited this link in resting-state MEG recordings (7 min) to simultaneously assess LC-NE activity via concurrent eye tracking. In a source-level whole-brain analysis we correlated local power envelopes of rhythmic activity in canonical frequency bands (2 – 128 Hz) with slow-varying (< 1 Hz) spontaneous fluctuations in pupil size (diameter). Our approach uncovered a range of correspondences across frequency bands. The most pronounced effect was a correlation of oscillatory power expanding across alpha-beta frequency ranges (peak at 16 Hz) with an occipito-parietal topography, implicating LC-NE in the regulation of visual processing. Our findings therefore describe how slow spontaneous variations in momentary arousal (LC-NE) may bias relatively fast-paced rhythmic activity in cortex, and possibly its function in perception and cognition.

Topic Area: PERCEPTION & ACTION: Vision

F131 The human visual system spontaneously computes approximate number

Ché Lucero¹, Colin Quirk², Susan Goldin-Meadow², Edward Vogel², Daniel Casasanto¹; ¹Cornell University, ²University of Chicago

In a previous EEG experiment, we showed that an unconscious representation of number arises in the visual cortex. Here, we tested the automaticity of visual number processing by determining whether the visual system responds to the numerical content of stimuli even when number is task-irrelevant. Subjects (N=14) saw dotcloud stimuli alternating in numerical content at 15 Hz. The dotclouds were backwards-masked; each dotcloud was displayed for 16 ms, with 33 ms between stimulus onsets. Backward masking preserves feedforward processing of the stimuli while selectively disrupting reentrant feedback to visual cortex. When the numerical ratio between alternating dotclouds was greater than 1.1, we observed a 15 Hz SSVEP centered over midline occipital sensors. The strength of the SSVEP depended on the numerical content of the stimuli even when non-numerical spatial information was controlled, indicating subjects were sensitive to number per se. Because the backward-masking of the stimuli disrupts reentrant feedback, the number-sensitive SSVEP probably arises in visual cortex during the initial feedforward sweep without input from higher-order areas such as the intraparietal sulcus or prefrontal cortex. Our previous experiment showed similar SSVEPs, but subjects were asked to judge the dotclouds' numerosity at the end of each trial, explicitly orienting them to the numerosity of the stimuli. By contrast, here, subjects were asked only to attend to the dotclouds. Number can be computed unconsciously and spontaneously by visual cortex, consistent with the proposal that number is a primary perceptual attribute of visual stimuli.

Topic Area: PERCEPTION & ACTION: Vision

F132 Topographical correspondences between deep neural network and human brain visual cortex

Yalda Mohsenzadeh¹, Caitlin Mullin¹, Benjamin Lahner¹, Aude Oliva¹; ¹Massachusetts Institute of Technology

Research at the intersection of computer vision and neuroscience has revealed hierarchical correspondence between layers of deep neural networks (DNNs) and cascade of regions along human ventral visual cortex. Recently, computer vision work has uncovered emergence of human interpretable

concepts within layers of DNNs trained to identify objects and scenes. In the current study, we asked whether DNN layers and brain regions share topographical correspondence. We acquired fMRI data while participants (N=15) viewed 156 natural images organized in categories of faces, animals, objects, and scenes and performed an orthogonal vigilance task. Using representational similarity analysis, we compared convolutional layers of a DNN trained for object and scene recognition with neural representations in human brain visual regions. Results reveal the emergence of a brain-like topographical organization in the layers of the DNN, such that layer-units with central-bias were associated with brain regions with foveal tendencies (e.g. fusiform face area), and layer-units with selectivity for image backgrounds were associated with cortical regions showing peripheral preference (e.g. parahippocampal place area). The emergence of a categorical topographical correspondence between DNNs and brain regions suggest these models are a good approximation of the perceptual representation generated by biological neural networks.

Topic Area: PERCEPTION & ACTION: Vision

F133 Cognitive and neural effects of real-world geospatial education on deductive reasoning

Robert Cortes¹, Dinh Nhi¹, Emily Peterson², Adam Weinberger¹, Richard Daker¹, Bob Kolvoord³, David Uttal⁴, Adam Green¹; ¹Georgetown University, ²American University, ³James Madison University, ⁴Northwestern University

Spatial thinking and deductive reasoning are critical for success in STEM fields. Moreover, according to the mental models theory, deductive reasoning depends on spatial thinking. Although spatial thinking ability has been shown to be malleable with appropriate training, spatial interventions are frequently examined in laboratory settings, and spatial thinking is not typically taught in schools. In the present study we examined the effects of taking a year-long high school course, the Geospatial Semester (GSS), during which students engaged in solving real-world spatial problems using Geographic Information Systems (GIS) technology. Participants were 190 high school students (79 GSS, 111 comparison) who completed computerized versions of a deductive reasoning task before and after the end of the school year. A subset of the students (n=61) completed the tasks in an MRI scanner. Behavioral results indicate that there was a significant effect of participation in the GSS course on deductive reasoning. Neural results indicate that GSS students showed increased activation in the parietal cortex during the deductive reasoning task; this increased activity was related to increased spatial ability and spatial habits of mind. Functional connectivity analysis showed increased connectivity to motor and parietal cortices during the task. Altogether, these results indicate that GSS students may have adopted a more spatial strategy for solving reasoning problems, which resulted in improved performance. These findings demonstrate that high school courses that educate students in geospatial technologies and spatial thinking can provide meaningful improvements in deductive reasoning, which may then translate into future achievement in STEM.

Topic Area: THINKING: Reasoning

F134 Diffusion markers of dendritic density and arborization in gray matter predict differences in intelligence

Erhan Genç¹, Christoph Fraenz¹, Onur Güntürkün¹, Rex Jung²; ¹Biopsychology, Department of Psychology, Ruhr University Bochum, Germany, ²Department of Psychology, University of New Mexico, Albuquerque, New Mexico, USA

Previous research has demonstrated that individuals with higher intelligence are more likely to have larger gray matter volume in brain areas predominantly located in parieto-frontal regions. These findings were usually interpreted to mean that individuals with more cortical brain volume possess more neurons

and thus exhibit more computational capacity during reasoning. In addition, neuroimaging studies have shown that intelligent individuals, despite their larger brains, tend to exhibit lower rates of brain activity during reasoning. However, the microstructural architecture underlying both observations remains unclear. In this study we assessed microstructural brain anatomy within a large sample of 259 healthy individuals using advanced multi-shell diffusion tensor imaging also known as neurite orientation dispersion and density imaging (NODDI). Further, we conducted a culture-fair matrix-reasoning test in order to measure fluid intelligence. We found that higher intelligence is related to lower values of dendritic density and arborization. We were able to cross-validate our results with data from 506 individuals provided by the Human Connectome Project. Most likely, these findings demonstrate that the neuronal circuitry associated with higher intelligence is organized in a sparse and efficient manner, fostering more directed information processing and less cortical activity during reasoning. In conclusion, this study substantially extends our knowledge about the biological basis of human intelligence differences, by providing insights to efficient information processing during reasoning at the level of axons or dendrites.

Topic Area: THINKING: Reasoning

F135 Implicitly Negative Messages Weaken Social Cognitive Reasoning In Female Breast Cancer Patients

Alexander N. Sokolov¹, Marina A. Pavlova¹, Diethelm Wallwiener¹, Sara Y. Brucker¹, Elisabeth Simoes¹; ¹Eberhard Karls University of Tübingen Medical School & University Hospital, Tübingen, Germany

In daily life, we face emotionally significant (positive and negative) information that profoundly affects our subsequent behavior. Previous research shows that this effect varies across genders: negative information impedes social cognitive reasoning ability in healthy population with a much greater impact on women (e.g., Pavlova et al., 2014). However, it is unknown if and to what extent female patients with threatening diseases such as oncologic ones, are vulnerable to negative information. Here, we examine whether negative information affects performance on a social reasoning task in female patients with breast cancer (BC), one of the most common types of cancer in women. Four separate groups of participants, patients and matched healthy controls (in total, 80 participants; mean age, 50 years), were administered the task either with standard neutral instruction or with an additional negative message. Performance was worse in patients and healthy participants who received negative information compared to those who did not receive such information. Moreover, under influence of negative information, BC patients scored not only lower than controls, but also lower than BC patients without information. For the first time, the results show a strong impact of negative information on social reasoning abilities in BC patients. The outcome shows that even experimental manipulation of negative information in the snapshot laboratory setting weakens social cognition in female patients. The findings offer novel insights on care related cognition and reasoning, fostering better treatment outcomes in many devastating diseases.

Topic Area: THINKING: Reasoning

F136 Relational reasoning and the neural correlates of science and maths problem-solving during adolescence

Annie Brookman-Byrne^{1,2}, Denis Mareschal^{1,2}, Andy Tolmie^{2,3}, Iroise Dumontheil^{1,2}; ¹Birkbeck, University of London, ²Centre for Educational Neuroscience, ³UCL Institute of Education

Early adolescence is a period when individuals work towards compulsory exams in science and maths. Relational reasoning, the ability to detect meaningful patterns, matures through adolescence. The unique contributions of verbal analogical and non-verbal matrix relational reasoning to science and maths problem-solving are not well understood, yet this could lead to

recommendations for teaching and learning. Functional magnetic resonance imaging (fMRI) data were collected during a science and maths problem-solving task, and participants (N=36, 11-15 years) also completed relational reasoning, verbal IQ, and executive function tasks. The aims were (1) to identify the neural correlates of science and maths problem-solving during adolescence, (2) to investigate whether individual differences in relational reasoning abilities associated with the behavioural and neural correlates of science and maths problem-solving, and (3) to test whether individual differences in executive functions or verbal IQ may account for these associations. Maths accuracy and verbal IQ were the only measures showing improvement with age. Higher verbal analogical reasoning associated with higher accuracy and faster reaction times in science and maths, and higher activation in the left anterior temporal cortex during maths problem-solving. Higher non-verbal matrix reasoning associated with higher science accuracy, higher science activation in regions across the brain, and lower maths activation in the right middle temporal gyrus. These associations mostly remained significant when individual differences in verbal IQ and executive functions were taken into account. The findings indicate the potential importance of supporting both types of relational reasoning in science and maths learning and problem-solving during adolescence.

Topic Area: THINKING: Reasoning

F137 Sleep and creativity: differential effects on abstraction and analogical reasoning

Sofia Pereira¹, Natalie Gunasekara¹, Scott Lowe², Mark van Rossum², Penelope Lewis¹; ¹Cardiff University, ²University of Nottingham

Creativity is thought to rely on mental operations such as abstraction and analogical reasoning. Sleep can facilitate insight and problem solving, yet its effect on abstraction and analogical reasoning remains to be explored. Therefore, our goal was to determine if sleep can enhance performance on abstraction and analogical reasoning tasks. Our within-subject experimental design included two tasks for assessing abstraction (the UK Clinical Aptitude Test (UKCAT) and a modified version of the Synthetic Visual Reasoning Task (SVRT-Abs)) and two tasks for assessing analogical reasoning (the Geometrical Analogies Task (GAT) and the SVRT (SVRT-AnR), with a 12 h retention interval of either wakefulness or sleep. Unlike the SVRT-Abs, the UKCAT was administered without any training or feedback. After the retention interval and first retest (retest1), participants were retrained and retested a second time on the SVRT (retest2). Using a 2 (sleep/wake) by 3 (test/retest1/retest2) repeated measures ANOVA, we found that performance on the SVRT-Abs was significantly superior after sleep compared to wake (session effect: $p < 0.001$, condition*session interaction: $p = 0.014$, simple main effects at test: $p = 0.550$, retest1: $p = 0.005$, retest2: $p = 0.179$), whereas no difference between conditions was observed on the UKCAT. No benefit from sleep was observed on the GAT or the SVRT-AnR either. These results support a role for sleep in abstraction within the SVRT. However, the absence of any effect on the UKCAT suggests that sleep's impact is contingent on feedback during training, whereas analogical reasoning may be sleep-independent.

Topic Area: THINKING: Reasoning

F138 The Similar Situations Task: Measuring Differing Levels of Reasoning Using Scene Analogies

Analogical reasoning—our ability to abstract relational similarities between situations despite surface-level differences—varies between individuals; however, current analogy tasks are often not difficult enough to capture variability in performance across healthy and clinical populations. To address this challenge, we developed a scene analogy assessment called the Similar Situations Task (SST). The SST presents participants with a source scene in which two sets of items interact in distinct relations. One or two arrows direct participants to encode specific items and their relational roles. Next, a target scene is presented and participants must select an item, if any, that is in a similar relational situation to the arrowed item(s) in the source scene. Difficulty is increased by the presence of perceptually and relationally distracting items. Performance on the SST was extremely variable and three performance levels (low, medium, and high) were established to understand differences in analogical reasoning. Low performers were most susceptible to distracting elements in target scenes, especially when relational load was expected to be low. Medium performers demonstrated decreases in accuracy and accurate self-judgment of responses (calibration) with increases in relational load. High performers did well on all problem types and were therefore less susceptible to distracting items and high relational loads. Furthermore, SST performance related to verbal reasoning, visual-spatial working memory, and relational abstraction. These results suggest that the SST involves cognitive abilities that support analogical reasoning and provides sufficient levels of difficulty to capture variability in relational reasoning abilities.

Topic Area: THINKING: Reasoning