Talk Session I

Bradley Voytek

Societal Correlates of Frontal-dependent Executive Functions

Executive functions are a hallmark of human cognition. These functions, including working memory and cognitive control, rely upon a healthy, intact prefrontal cortex. Working memory and cognitive control deficits—along with frontal lobe dysfunction—are observed in diseases such as ADHD and autism, which are the developmental disorders most strongly associated with executive functioning (as indexed by brainSCANr.com). Despite decades of research on executive functioning little is known about its societal importance or relevance. Here we analyze data from Lumosity, an online suite of cognitive tasks. Using data from over 300,000 unique participants playing either an n-back working memory task or a Flanker cognitive control task, we examine how state-by-state differences in executive functioning relate to a variety of societal, cognitive, and mental health factors. We find that working memory from 314,893 unique participants clusters with IQ, health, high school graduation rate, and addiction levels whereas cognitive control and reaction time from 312,821 unique participants cluster with car accident fatalities and ADHD. These results demonstrate the potential for massive online data collection to bridge public health and policy, behavior, neuroscience, and psychology via population-wide inquiries into cognitive functioning.

Justin Kantner

Optimizing recognition decisions under uncertainty

Optimal responding in a recognition memory test requires knowledge of (or sensitivity to) the base rate of old items, yet heuristically distributing responses according to this base rate is a suboptimal strategy for nearly all recognizers. Past research indicates that, even in the presence of corrective feedback, participants neither set criterion appropriately when base rates are unequal nor shift criterion adequately when base rates change over course of a test. To maximize their proportion of correct responses, individuals should calibrate response bias with recognition sensitivity, exercising a more extreme bias when sensitivity is poor. We report experiments testing whether participants can be trained to respond optimally with novel forms of feedback that emphasize criterion appropriateness rather than response accuracy.

Michael Vendetti

Interference Resolution within Analogical Reasoning Modifies Memory

Analogical reasoning is used for making comparisons between two domains that share an underlying relational structure. Our study shows that inhibition moderates mental representations within analogies. 52 University of California, Los Angeles Psychology undergraduates (10 males, avg. age: 20 yrs) solved trials consisting of (1) a four-term (A:B::C:D) analogy problem containing four characters and four dimensions related to the visual properties of these characters (i.e., color, height, gender, and width), (2) a brief distractor task, and (3) a recognition memory task. Participants were instructed to solve the analogy on the highlighted dimension. The other three dimensions contained two congruent relative to their decision for solving the analogy, and one incongruent. Memory probes were either identical, or were changed based on the relevant, congruent, or incongruent dimension. Repeated Measures ANOVAs were run for memory accuracy and response time (RT). Memory was significantly worse for the incongruent dimension as indicated by proportion correct ($F(2,102) = 3.819$, $MSE=0.024$, $p<0.025$) and d' analyses ($F(2,102)=3.282$, $MSE=0.297$, $p<0.042$). RT was significantly slower for incongruent ($F(3,141)=3.215$, $MSE=203684$,

p<0.032). Interference resolution during the solving of analogy problems increased endorsements of incongruent memory probes due to inhibition of interfering relational information.

Peter Cook

Delayed Alternation in Wild California Sea Lions With Naturally Occurring Hippocampal Damage

Each year, many hundreds of sea lions are exposed in the wild to domoic acid, an algal toxin and glutamate agonist. Exposure can lead to mossy fiber sprouting in the dentate gyrus, medial temporal seizures, and serious hippocampal damage. Because many of these animals come to shore in distress and are sourced to rehabilitation facilities for treatment, they are available short-term for study, thus representing a unique natural model for low-impact behavioral neuroscience. Between 2009 and 2011, 30 wild sea lions were brought from The Marine Mammal Center in Sausalito to University of California's Long Marine Lab, where they completed training and testing in a delayed alternation task. After completion of behavioral testing, each animal's brain was imaged in vivo via MRI. All animals were then returned to The Marine Mammal Center for further treatment or release, as warranted. Brain images were acquired in an oblique plain perpendicular to the long axis of the hippocampus—hippocampal volumes were calculated by manual tracing, and normalized against total brain volume to provide a measure of possible atrophy for each animal. Here we report comparisons between hippocampal damage and performance in the delayed alternation task.

Poster Session I

Akalka Barath

Synaesthesia, Working Memory, and Autism

Does synaesthesia have broader effects on cognitive functioning? In particular, synaesthesias in which sequences such as the counting numbers induce impressions of colors or spatial locations could enhance working memory by increasing the distinctiveness of items to be remembered. An additional proposal is that a link between synaesthesia and memory, and between synaesthesia and autism, could underlie the phenomenon of memory savantism in autism spectrum conditions (ASC). Here we test these proposals with a large database probing synaesthesia-related phenomena in an unbiased sample. We found that working memory is, surprisingly, worse in synaesthetes with sequence-color synaesthesia, but that this negative relationship is mitigated in those who additionally have sequence-space synaesthesia. Further, we found no relationship between ASC and any form of synaesthesia. These results suggest that synaesthesia is unlikely to explain exceptional memory in autism; that tests of cognitive abilities in synaesthetes must carefully consider sub-populations of synaesthetes; and that synaesthesia may be, if anything, a liability for working memory.

Kristin Flegal

Brain mechanisms of successful recognition through retrieval of semantic context

Kristin E. Flegal, Alejandro Marín-Gutiérrez, J. Daniel Ragland, & Charan Ranganath

Behavioral research suggests that reinstating the context of a past episode can facilitate retrieval of items studied in that context, and conversely, that an inappropriate context cue can impede retrieval. Here, we used event-related fMRI to identify brain regions involved in context retrieval and to disentangle these effects from brain activity more

generally related to item retrieval. Prior to scanning, participants encoded sentences containing pairs of semantically-related words. In the scanner, participants made recognition judgments for three trial types, all consisting of a target word preceded by a studied cue word. On Congruent Cue (CC) trials, the cue and target words were studied in the same sentence context. On Incongruent Cue (IC) trials, the cue and target words were studied in different sentence contexts. On Foil trials, the cue word was followed by an unstudied target word. We predicted that reinstating the study context would facilitate recognition of target items on CC trials, as compared IC trials. Consistent with this prediction, recognition accuracy was higher for CC trials than for IC trials, and response times for recognized items were faster on CC trials than on IC trials. Analyses of fMRI data revealed that activity in MTL regions was sensitive to retrieval success and contextual congruency.

Christine Godwin

EEG Correlates of Spontaneous Thoughts and their Introspection-Based Psychic Determinants

Christine A. Godwin, Mark W. Geisler, & Ezequiel Morsella

Spontaneous thoughts can arise from past memories (Andrews-Hanna et al., 2010), future tasks (Morsella et al., 2010), and environmental cues (Berntsen, 1996). The core of spontaneous thought flow has been attributed to long-term memory processes, many of which are not consciously accessible (Christoff et al., 2004). However, most people have experienced spontaneous thoughts triggered by various cues (Berntsen, 1998). In Study 1, we show that when asked to introspect the number of cues, or "links" leading to a spontaneous thought, participants (n = 104) report a minimal number of links per thought and attribute approximately half of their thoughts to the external environment. In Study 2, we examine the electrophysiological correlates of these thoughts: Participants (n = 20) pressed a button upon experiencing a thought and were then queried regarding the number of links per thought and whether the thought arose from stimuli in the environment or from internal mental processes. Electroencephalogram (EEG) within the alpha (8 – 13 Hz), beta (13 – 30 Hz), delta (1 – 5 Hz), and theta (4 – 8 Hz) bands leading up to participants' reported thoughts was analyzed. These findings and their implications in the default mode network, memory processes, and the stream of consciousness are discussed.

Iain Harlow

Success and Precision: An Important Distinction in Recollection

Episodic recollection is a crucial component of cognition, linking the present self with past experience. Recent evidence suggests recollection is a thresholded process, supporting conscious retrieval of detailed memories when successful, but it is not an infallible window into the past. Impairments in recollection, such as those associated with aging, could result from either less frequent or less precise recollection. Here we build on previous work, using response errors on a cued recall task to separately measure the probability and precision of recollection. Additionally, participants made two concurrent but distinct confidence ratings on each trial, based on 1) the probability that they successfully recollected a cued location, and 2) the precision of the location information recalled. A distinct pattern of responses results: on any given trial, participants either recollected the target location with considerable (but variable) precision, or they retrieved no location information at all. Importantly, participants could dissociate between recollection engagement, and the quality of recollected information. Probability confidence reliably predicted whether locations were recollected, while precision confidence instead predicted the precision of location information. Future work should distinguish between the engagement and quality of recollection; as demonstrated here, simple confidence ratings can provide useful insights into both properties.

Jennifer Kong

Screening for Memory Disorders in the Community: Results from a National Program

Jennifer Y. Kong[1]; Eric J. Hall[2]; J. Wesson Ashford[1,3]; Peter J. Bayley[1]
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The Alzheimer's Foundation of America (AFA) sponsors "National Memory Screening Day", which is held each November to coincide with "National Alzheimer's Disease Awareness Month". This event promotes early detection of memory problems, including Alzheimer's disease and related dementias, and encourages appropriate intervention. This event has been conducted since 2003, and on this one day in 2010 approximately 60,000 participants were evaluated at more than 2,300 sites. Screenings are conducted as free and confidential face-to-face evaluations by qualified health-care professionals, who are free to select from among all available memory screening tests. Communications to health-care professionals include educational materials on dementia, care giving, and healthy aging, as well as information on three recommended screening tools: the Mini-Cog, GP-Cog, and MIS (Memory Impairment Screen). This poster will review the survey data collected from the year 2010, which includes demographic data, health profiles, answers to relevant questions about how the participants perceived their own memory concerns, and related interactions with their own health-care providers. Data analyses will also be presented for a sample of these subjects regarding screening results by type of screening tool.

Laura Libby

Representation of object sets and spatial configurations in the human medial temporal lobes

Laura A. Libby1, Deborah E. Hannula2, Laura L. Kelly3, Charan Ranganath1,3
1Department of Psychology, University of California, Davis, 2Department of Psychology, University of Wisconsin, Milwaukee, 3Center for Neuroscience, University of California, Davis

Several models have proposed that the perirhinal cortex (PRC) is preferentially involved in the representation of single objects, whereas the parahippocampal cortex (PHC) is preferentially involved in the representation of spatial or contextual information. Recent studies have shown that these areas are recruited during working memory (WM) tasks when performance is associated with successful retention of information about spatial configurations of objects across short delays (Hannula and Ranganath, 2008). In the current study, we used BOLD fMRI-based multivoxel pattern analysis to identify brain regions that independently code for object set and spatial configuration information. Eighteen participants were scanned while performing a WM task that required maintenance of the relative locations of multiple objects. On each trial, four objects (drawn from a collection of nine possible objects) were presented simultaneously on a three-dimensional grid, each in one of nine possible locations. After an 11-second delay, a viewpoint-rotated test stimulus was presented, and participants indicated whether the object-location relations were intact or reconfigured. Searchlight analysis revealed that activation patterns in PRC, along with temporal polar and ventrolateral prefrontal cortices, were more correlated across trials with overlapping object sets, independent of spatial configuration. Additionally, activation patterns in PHC, as well as posterior hippocampus, retrosplenial cortex, and lateral occipital complex, were more correlated across trials with overlapping spatial configurations, independent of object content. These results support distinctions between PRC and PHC involvement in object and spatial memory, and additionally suggest that some brain regions that differentially interact with PRC and PHC (Libby et al., 2012) code for corresponding information content.

Samuel Lockhart

White matter injury is associated with visual search behavior independent of global slowing in aging

Lockhart SN, Roach A, Luck S, Geng J, Carmichael O, DeCarli C

Current evidence suggests that normal age-related declines in performance of tasks tapping cognitive functions such as visual attention may be mediated by frontal cortex dysfunction and disruption of connections within a frontoparietal (top-down) control network. Others have argued these declines can largely be accounted for by increased global slowing of speeded brain processes. We investigated whether age- and vascular-related differences in white matter injury, measured by white matter hyperintensities (WMH), mediate age-related differences in performance on processing speed and spatial search tasks, which measure global slowing and attentional control, respectively. We tested 19 young and 38 cognitively normal older adults on a speeded task and on search tasks tapping top-down and bottom-up visual attention. Our results confirm previous reports that increased age is associated with increased global slowing and with impaired visual attention measured by slowed search performance. Additionally, amongst elders, global WMH volume is significantly associated with impaired visual attention, but not related to global slowing. The results suggest that age-related attentional control declines may represent deficits in more fundamental cognitive processes but are also strongly associated with increased age and white matter injury. Future research will investigate tract-specific relations between frontoparietal white matter injury, speed, and attentional control.

Keith Main

Cognitive testing and DTI analysis of veterans with traumatic brain injury (TBI) and post-traumatic stress disorder (PTSD).

Nearly two-thirds of injured US soldiers sent from Iraq to Walter Reed Army Medical Center have sustained a traumatic brain injury (TBI). Many of these servicemen and women are also diagnosed with post-traumatic stress disorder (PTSD). This study investigates the co-occurrence of TBI and PTSD in Veterans seen at The War Related Illness and Injury Study Center (WRIISC) at the VA Palo Alto. METHODS: Participants (n = 34; TBI = 28; PTSD only = 8; TBI/PTSD = 26; healthy controls = 10) were scanned in a 3T GE MRI (high-resolution T1 anatomical, 30 direction DTI sequence) and completed a battery of neuropsychological tests focusing on cognitive control and memory. DTI data were analyzed with custom software for the creation of tensor maps, identification of white matter tracts, and the extraction fractional anisotropy values (FA) values. RESULTS: Pilot results revealed a decrease in average FA in patients with TBI + PTSD compared to those with PTSD only. CONCLUSIONS: Current results suggest that TBI + PTSD patients may have neurological damage in key fiber tracts beyond that of individuals with only PTSD. Further research is needed to evaluate the implications of this difference in terms of health outcomes for Veterans.

Jin-Chen Yang

Abnormal fMRI Word Repetition Effects in Mild Cognitive Impairment

Jin-Chen Yang, Jason R. Taylor, Shiaohui Chan, David P Salmon, Vicente Iragui-Madoz, Marta Kutas, John M. Olichney

Decreased word repetition effects in a word repetition paradigm have proven to be highly sensitive to early Alzheimer's disease. In the current study, word repetition effects in mild cognitive impairment (MCI) patients were examined with fMRI. Eight amnestic MCI patients and 11 normal elderly participated in the study. New-Old BOLD responses in the left hippocampus and left parahippocampal gyrus (PHG) showed significant correlation with subsequent memory test scores. Compared to controls, the MCI group had smaller word repetition effects in the left fusiform gyrus, PHG, medial temporal gyrus (MTG), superior temporal gyrus (STG) and anterior cingulate cortex (ACC). Group comparisons on magnitude of New-Old responses in region-of-interest (ROI) revealed that the norm

elderly group had larger response in left MTL, while MCI patients had larger activation in right MTL. These results suggest that a distributed neural circuit of left-hemisphere structures important for successful verbal memory encoding is impaired in MCI patients, who displayed reduced New> Old BOLD responses as well as a loss of the normal "HERA" (Hemispheric Encoding/Retrieval Asymmetry) pattern.

Talk Session II

Mee-Kyoung Kwon

Six-to eight-month-old infants' visual short-term memory (VSTM) capacity

Mee-Kyoung Kwon & Lisa Oakes
University of California, Davis

Three experiments using a change detection paradigm examined the development of VSTM capacity in 6- to8-month-old infants. In Experiment 1, 32 6- and 32 8-month-old infants were simultaneously presented with two image streams – one changing and the other non-changing - on a computer monitor. In each stream, one or two complex object(s) appeared for 500 msec, disappeared for 300 msec, and then reappeared. This cycle continued for 20s. In changing streams, one randomly chosen item changed. In non-changing streams, none of the object(s) changed. Eight-month-olds preferentially looked at the changing stream when there were one or two objects in each stream, whereas 6-month-olds preferentially looked at the changing stream only when there was one object. Experiments 2 and 3 provided evidence that 6-month-old infants' failure to detect a change at set size 2 was not due to either the short exposure time or the complexity of stimuli. Six-month-olds (n=55) only preferred the changing side for set size 1, when either the complex objects used for Experiment 1 (Experiment 2) or simple color squares (Experiment 3) were visible for 1000 mesc on each cycle. Our findings suggest that there are substantial developmental changes in 6- to 8-month old infants' VSTM capacity.

Sahar M. Yousef

Cholinergic enhancement improves visual short-term memory performance

Sahar M. Yousef, Summer L. Sheremata, Rachel K. Kaneta, Michael A. Silver

Visual short-term memory (VSTM) has a capacity of 4 ± 1 objects, and previous studies have shown that consolidation takes approximately 50 ms/item. In patients with mild cognitive impairment, pharmacologically increasing synaptic levels of acetylcholine (ACh) facilitates VSTM by boosting the rate of information processing (Bublak et al. (2011) *Neurobiology of Aging*). We therefore hypothesized that cholinergic enhancement would improve VSTM performance in healthy subjects. We increased synaptic ACh levels by administering the cholinesterase inhibitor donepezil in a placebo-controlled, double blind crossover design. Subjects performed a change detection task with colored squares, and consolidation was disrupted by subsequent presentation of a visual mask. The effects of donepezil were assessed for set sizes based upon each subject's measured VSTM capacity (K). We found that cholinergic enhancement improved VSTM performance. Our results are consistent with a role of ACh in regulating VSTM.

Heidi Baumgartner

Color-Location Binding in Infants' Visual Short-Term Memory

Heidi A. Baumgartner, Fred Barrett, Steven J. Luck, & Lisa M. Oakes

Binding of color to location in Visual Short-term Memory (VSTM) rapidly develops in the first year (Oakes et al., 2006, 2009). Here, we assessed infants' binding in VSTM using a one-shot change detection task similar to tasks used to study adult VSTM (e.g., Luck & Vogel, 1997).

We presented 24 10-month-old infants with change detection trials with the following sequence: 500 ms sample array of two colored squares (e.g., orange and green), 300 ms retention period, 3000 ms test array of two squares. One of the items in the test array was a new color (e.g., purple replaced green). On *bind* trials the familiar item also changed locations (e.g., *orange* on the left during sample, on the right during test); therefore both items had changed (one changed color, the other changed location). On *change* trials the familiar item remained in the original location; therefore only one item changed.

On *change* trials, infants preferred the new color, $t(23) = 4.75$, $p < .0001$, two-tailed. On *bind* trials infants did not prefer the new color to a familiar color in a new location, $t(23) = .40$, $p = .69$. Thus, infants appeared to store color-location bindings in VSTM.

Talk Session III

Jessica Cohen

Variability in intrinsic brain organization is related to variability in behavior

The recent application of graph theory to neural data has provided powerful tools to quantify the brain's large-scale intrinsic organization. However, little data exists relating these graph theoretical metrics to behavior, which could lead to an understanding of the functional relevance of large-scale brain organization. The goal of this study was to determine how variability in brain organization relates both to specific cognitive operations as well as to general measures of cognitive state.

We collected resting state data in healthy young adults undergoing fMRI at two time points. After each resting scan, participants completed a battery of cognitive tasks outside of the scanner, including a working memory (WM) span, a digit symbol substitution task (DSST), and a Stroop task. We applied graph theoretical tools to calculate modularity, small worldness, and other measures of network organization across the entire brain.

We found that lower modularity and small worldness were consistently associated with better performance in all tasks. This result was consistent across testing sessions. These results imply that modularity and other graph theoretic measures may reflect a general brain state that influences information processing across multiple cognitive domains. Future analyses will examine the relationship between specific networks and behavior.

Andrew Watrous

Frequency-specific increases in network connectivity characterize correct spatiotemporal memory retrieval

The medial temporal lobes, prefrontal cortex, and parts of parietal cortex form the neural underpinnings of episodic memory, which involves remembering both where and when an event occurred. Yet how these three key regions interact during retrieval of spatial and temporal context remains largely untested. Here, we employed simultaneous electrocorticographical recordings across multiple lobular regions, employing phase synchronization as a measure of

network connectivity, while patients retrieved spatial and temporal context associated with an episode. Successful memory retrieval was characterized by greater global connectivity compared to incorrect retrieval, with the MTL acting as a convergence hub for these interactions. Spatial vs. temporal context retrieval resulted in striking differences in both the spectral and temporal patterns of network interactions. These results emphasize dynamic network interactions as central to episodic memory retrieval, providing novel insight into how multiple contexts underlying a single event can be recreated within the same network.

Nathia Suthana

Deep brain stimulation of human entorhinal area increases hippocampal theta-gamma coupling

Suthana NA, Tchemodanov N, Knowlton BJ, and Fried I

Evidence suggests that coupling between the phase of theta (4-8 Hz) and the amplitude of gamma (> 30 Hz) oscillations, termed phase-amplitude cross frequency coupling (CFC), may be important for hippocampal dependent memory. We recently showed a memory benefit for spatial locations learned during deep brain stimulation (DBS) of the entorhinal area compared to locations learned without stimulation. In the current study, we calculated the theta-gamma CFC of previously acquired EEG data from 4 patients with implanted depth electrodes. To determine hippocampal CFC, we calculated the strength of coupling between theta (4-8 Hz) phase and gamma (70-80 Hz) amplitude by combining them and computing the modulation index (M) compared to a distribution of decoupled surrogate M values [3]. We found a significant increase in CFC for stimulation ($p < 0.05$) and non-stimulation learning trials ($p < 0.05$) with a significantly higher CFC during stimulation compared to non-stimulation trials (stim > non-stim, $p = 0.019$). These results suggest that DBS of the entorhinal area that enhances memory results in substantial coupling between hippocampal theta and gamma oscillations and supports the idea that theta-gamma coupling is associated with optimal learning in humans.

Brooke Roberts

Effects of theta entrainment on source memory

Neural oscillations in the theta band (4-8 Hz) are evident in field potential recordings from the hippocampus, and many computational models suggest a role for these oscillations in episodic memory. Furthermore, recent work using scalp electroencephalography (EEG) suggests that spontaneous fluctuations in theta oscillations just prior to the onset of a retrieval cue can predict accurate source memory retrieval. This result provides promising evidence linking theta activity to episodic retrieval, but it is not clear whether these oscillations play a direct role or whether they are epiphenomenal. In the current study, we aimed to test whether visual and auditory stimulation, designed to directly manipulate theta activity, could affect source memory performance. Healthy undergraduates studied lists of words, and in each block of trials, subjects indicated whether or not each item corresponded to a living thing ("animacy" task) or they indicated whether each word corresponded to something that is man-made ("man-made" task). Following the study blocks, subjects in the "theta entrainment" group (n=24) were exposed to flickering lights and auditory binaural beats presented at 5.5 Hz. Subjects in the control group (n=21) were instead exposed to white noise during the retention interval. Next, both groups completed a retrieval test in which they made item- (old or new?) and source- (studied in "animacy" or "man-made" task?) recognition judgments. Results indicated similar accuracy for item recognition between the experimental (theta entrainment) and control (white noise) groups; however, source memory was significantly enhanced following entrainment at 5.5 Hz when compared to white noise (ANOVA: $F[1,43]=4.297$; $p=0.044$). Although the observed effects were subtle, they are consistent with the idea that theta oscillations play a direct role in promoting successful episodic memory retrieval. Follow-up studies are planned to further explore the effects of theta entrainment on memory and EEG.

Poster Session II

Mariam Aly

From memory to perception: The medial temporal lobe and visual discrimination

Recent work has suggested that the medial temporal lobe (MTL) plays a critical role in high-level perception. This conclusion is based on neuroimaging results and patient results indicating that MTL damage leads to deficits on visual perception tasks. We have shown, however, that visual discriminations can be based on two independent processes: a threshold state process of perceiving specific details, or a continuously-graded strength process of knowing based on global match. Perceiving and knowing are characterized by different subjective experiences, they are functionally dissociable, and they show distinct temporal dynamics. In the current study, we tested patients with MTL damage and used fMRI in healthy individuals to examine the role of the MTL in perceiving and knowing. We found that perceiving is not dependent on the MTL, but judgments of knowing are. Thus, impaired high-level perception in patients with MTL damage may be a result of impaired relational or global processing, while item-specific or local processing is spared.

Ben Bowles

Neural correlates of familiarity-only experiences

'Familiarity-only' experiences refer to situations in which a name or face seems familiar based on previous life exposure, but at the same time cannot be semantically identified. While they are common in daily life and have been studied empirically in relation to models of person recognition, little is known about their neural correlates. One possibility is that they engage the same areas involved in successful semantic identification, but to a lesser extent. Given they are characterized by a subjective sense that no semantic knowledge is recallable, however, alternatively they may engage other areas, perhaps those related to assessing available memory evidence or decision uncertainty. In the first stage of our event-related fMRI experiment, participants indicated whether famous and fictional names were 'unfamiliar', 'familiar-only', or whether they could be semantically identified. To provide leverage on the brain regions involved in successful semantic access, in a later stage participants made occupation forced-choice decisions for different famous names, while also indicating occupation response confidence separately. As expected, 'identify' responses engaged regions widely implicated in semantic retrieval. Apart from small areas of overlap in the left prefrontal and middle temporal cortices, however, 'familiarity-only' responses engaged a distinct network, including the bilateral insula, the bilateral caudate, and the dorsal medial prefrontal cortex. Further analyses of these regions in relation to the second experimental phase suggests they may play a general role in contributing to feelings of uncertainty during attempted but unsuccessful semantic access.

Amy Frithsen

Successful subsequent memory is associated with deactivation of the right hemisphere during encoding

Frithsen, A. & Miller, M.B.

The current study used functional magnetic resonance imaging (fMRI) to determine what brain regions are associated with successful (compared to unsuccessful) encoding. Thirty subjects studied a total of 304 words and were later given a recognition memory test consisting of 608 words (half studied, half novel). Memory was tested using a remember-know paradigm as well as a source memory paradigm. The analysis compared brain activity associated with items that were subsequently recognized (hits) to items that were subsequently forgotten (misses). Using this standard approach, small and unreliable effects were found in the left prefrontal cortex. However, there was a robust deactivation (compared to baseline) found for subsequent hits. Deactivation centered around the inferior parietal lobe and continued superiorly into the superior parietal lobule and inferiorly into the medial temporal

lobe. Right superior prefrontal regions were also shown to have a robust deactivation to subsequent hits compared to baseline. This deactivation was clearly attenuated for subsequent misses. Although the precise cognitive mechanism driving these deactivations is still somewhat unclear, these results suggest that more research should be aimed at investigating this issue.

Luke Jenkins

Multi-voxel pattern distinctiveness at encoding predicts accurate recency discrimination.

Previous work in neurophysiology and computational modeling suggests that the similarity and dissimilarity of neural representations at encoding may support temporal organization in episodic memory. In this event-related fMRI study, we used representational similarity analysis to investigate whether the dissimilarity of representations at encoding predicted accurate recency discrimination at retrieval. Participants were scanned while viewing a series of object photographs, which were presented at 6 s intervals. Each encoding period was followed after a 30 s filled delay by a recency test, during which pairs of previously viewed objects were presented. Participants were told to indicate which of the two objects had appeared earlier and to rate how confident they were in their response. We predicted that items recalled in the correct order would be associated with more dissimilar multi-voxel patterns at encoding, and a preliminary whole-brain searchlight analysis comparing high-confidence correct pairs with incorrect pairs found this effect to be significant in the right inferior parietal.

Brian Lopez

Development and aging interact with such cognitive and personality factors in their influence on criterion placement during an fMRI recognition memory task.

Previous research has shown that a wide range of factors can affect the placement of a decision criterion in a recognition memory task. Furthermore, retrieval of episodic memories and criterion shifting involve distinct brain regions that are engaged differentially across individuals depending on unique characteristics and strategies. In this study we attempted to quantify how development and aging interact with such cognitive and personality factors in their influence on criterion placement during an fMRI recognition memory task. Test items were presented in conditions of high and low target probability to late adolescents, young adults, and healthy elderly individuals. On average, participants applied a more liberal criterion in the high target probability condition and a more conservative criterion in the low target probability condition. The degree of shifting between a liberal and conservative criterion was quite variable across participants. However, on average there were not significant differences in target discrimination ability or criterion placement between groups. Furthermore, all groups similarly recruited frontoparietal regions typically associated with memory retrieval. Despite similar task-related activity and behavior, there were significant differences in inter-subject variability between groups with elderly adults being the most variable, followed by late adolescents, then young adults. We examined how personality and cognitive characteristics, brain connectivity, task performance and strategy, and other factors explained this variability, with different factors emerging as significant predictors of the observed variability for each group

Joshua Phillips

Theta Power Modulation of Rule Guided Encoding in Schizophrenia

Phillips, J., Ranganath, C., Ragland, J.D.

In a previous fMRI study employing the Context Maintenance Encoding Task (CMET) individuals with schizophrenia were impaired using rules to guide encoding of target versus nontarget stimuli, linked to dorsolateral prefrontal

dysfunction. The current EEG study measured theta band (~ 4-8 Hz) during CMET to examine broader network activity. Fifteen controls and sixteen patients alternated between two conditions: 1) "Fixed Rule" – make living/nonliving judgment and remember all words. 2) " Variable Rule" – make living/nonliving judgment only if word is a target (e.g., male voice), otherwise (e.g., female voice) "skip" the word. Recognition was tested for all of the words. Time-frequency transformations were performed using EEGLab with the complex Morlet wavelet function. Delay period (0-1000ms) for the theta frequency range was analyzed using a -200-0 ms baseline and a Gaussian kernel with a constant c of 3. Bootstrap procedures revealed that the only group differences were during high context maintenance (variable rule minus fixed rule), with patients showing reduced theta band activity. Results converge with previous fMRI findings in suggesting that encoding deficits in schizophrenia are most prominent under high cognitive control conditions. EEG data suggest that disrupted oscillatory activity in the theta range may be contributing to these control deficits.

Alexandra Roach

Heterogeneity of functional connectivity reductions in normal cognitive aging

A. E. Roach*, S. N. Lockhart*, J. He, E. Fletcher, P. Maillard, C. G. Schwarz, C. DeCarli, O. Carmichael

Previous research has demonstrated that functional connectivity (FC) among nodes in distributed brain networks is reduced in aging and neurodegenerative disease, based on resting-state functional MRI (rs-fMRI). However, there are few investigations of heterogeneity among network connections in terms of their peak strength in young adulthood, the time course of reductions with age, and relationships with brain structure. We collected structural MRI and rs-fMRI data from 40 young adults and 67 elders. We calculated global gray matter (GM) volumes, white matter hyperintensity (WMH) volumes, and fractional anisotropy (FAnorm, a measure of white matter integrity) from T1-weighted, FLAIR, and diffusion tensor MRI. fMRI image preprocessing and FC analyses identified a set of functionally inter-correlated regions traditionally referred to as the default mode network (DMN): posterior cingulate (PCC), medial prefrontal (MPF), and right and left inferior parietal (RIP, LIP) cortices. FC values for 6 pairwise connections among these regions were calculated and Z transformed. To explore the magnitude of connectivity reductions with age, we normalized each elderly FC (FCnorm) by dividing by corresponding average young FC. We then used principal components analysis (PCA) to analyze patterns of covariance among the pairwise connectivity reduction values among elders. FC among distinct node pairs was heterogeneous in the young, but was substantially reduced in all 6 connections among elders with MPF-PCC connections showing the greatest reduction (44% of young mean on average). PCA suggested that the set of 6 pairwise connectivities was well explained by a single principal component representing global, coordinated reductions to all 6 connections. Within elders, associations between FCnorm and age, GM, and WMH were not significant. In healthy aging, functional connectivity among all pairs of DMN nodes may reduce in a coordinated fashion from heterogeneous peak young adult values. These connectivity reductions do not co-occur with brain structural changes in a straightforward or linear way. It is critical to understand the biological basis of age-related network connectivity reductions, which may reflect diverse biological processes of brain aging.

Matthew Sacchet

Frontal lobe contributions to deterministic and probabilistic learning: Evidence for dissociable feedback-related processes

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Prefrontal cortical regions contribute to episodic and feedback-based incremental learning, differentially interacting with the medial temporal lobe (MTL) and striatum, respectively. In event-related potentials (ERPs), the feedback-

related negativity (FRN) is sensitive to feedback, and the P300 (or P3) to decision making processes. In the current study we explored deterministic and probabilistic learning by computing frontal ERPs. During a trial, subjects viewed a scene and predicted results, which was followed by feedback regarding their prediction accuracy. Scenes predicted outcomes with 70% or 100% accuracy. ERPs were computed for frontal electrodes. FRN and P3 components were larger for negative vs. positive feedback ($p<0.005$ and $p<0.01$, respectively). Comparing positive feedback ERPs as a function of early vs. late learning revealed that initially (block 1) the FRN and P3 components did not differ across stimuli conditions ($ps>0.40$). By contrast, after training the FRN was larger for stimuli that deterministically predicted outcomes (block 4 $p<0.005$; block 5, 6 $ps<0.001$), whereas the P3 was larger for stimuli that probabilistically predicted outcomes (block 3 $p<0.001$; block 4 $p<0.0005$; blocks 5, 6 $ps<0.0001$). These data reveal distinct biological signatures that evolve over the course of deterministic and probabilistic learning, reflecting two different patterns of interaction between prefrontal cortex and the MTL/striatum as associations are acquired.

Talk Session IV

Danielle King

Lateral posterior parietal activity during source discrimination of memories of high and low perceptual vividness

The parietal old/new effect is the finding that lateral posterior parietal cortex (PPC) regions are more active during recognition of studied items compared to correct rejection of new items. In a previous study we found that recognition of previously perceived events elicited a robust parietal old/new effect, whereas recognition of imagined events did not. This suggests that lateral PPC may be involved in retrieval of real, but not imagined events. Alternatively, because memories of real events contain more perceptual details than memories of imagined events (Johnson et al. 1993), this region could be specifically involved in representing perceptual details, which would account for source-based differences in activity. In the present study, we tested whether differences in perceptual vividness could explain source-based differences in retrieval activity. Subjects perceived and imagined object images (high vividness) and sentences (low vividness) in response to a cue word. At test, they decided whether items were previously perceived, imagined, or new. The results revealed that lateral PPC activity was again modulated by source. However, this difference could not be accounted for by a difference in vividness as the high vividness condition was associated with greater activity than the low vividness condition in occipital, but not parietal regions.

Maureen Ritchey

Cortical systems representing context in episodic memory

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Episodic memory depends critically on the ability to bind item and context information during encoding. In addition to the hippocampus, neuroimaging results have suggested that the parahippocampal (PHC) and retrosplenial (RSC) cortices are reliably engaged during episodic recollection and memory for context. We used fMRI to test the extent to which the PHC and RSC are involved in memory for associations between items and contexts, as compared with memory for associations between items and their features. Participants were scanned while they read a series of sentences that associated an object with information about its appearance (e.g., "The apple is bumpy"), spatial context (e.g., "The mug is in the science lab"), or situational context (e.g., "The book is a birthday gift"). Memory for

object-detail pairs was assessed during a post-scan forced-choice associative recognition task. Consistent with our predictions, item-feature and item-context trials were associated with different patterns of neural activity. In particular, the PHC, RSC, medial prefrontal cortex, and lateral parietal cortex were more active during item-context than item-feature encoding. These regions were investigated further via representational similarity analysis, in which spatial patterns corresponding to individual trials are compared and related to information shared across trials. Preliminary results corroborated the hypothesis that the PHC and RSC are sensitive to context information. We propose that these findings reflect the contributions of a cortical system that constructs and maintains models of context.

Michael Cohen

Activity in brain regions associated with deep semantic encoding predicts enhanced memory for high-value items

Michael S. Cohen, Jesse Rissman, Alan D. Castel, Barbara J. Knowlton

Previous neuroscience work examining how value affects memory (e.g., Adcock et al., 2006) has focused on the role of the midbrain dopaminergic reward system in potentiating memory for valuable items via functional connections between the reward system and the hippocampus. However, people may also strategically control encoding strategies to enhance memory for more valuable items. We used fMRI to examine neural activity at encoding that would predict subsequent free recall for words. Each word was preceded by an arbitrarily assigned point value. Participants went through multiple study-test cycles, with feedback on their point total at the end of each list, allowing for further sculpting of strategy use. We found that during presentation of the word, high-value remembered items were associated with enhanced activity in semantic processing regions, including left inferior frontal and left temporal cortices, relative to both low-value remembered items and high-value forgotten items. This suggests that deep semantic processing, likely via an explicit strategy, is critical for enhancing memory for valuable items in this paradigm. It is notable that older adults are particularly proficient at utilizing value in this type of paradigm (Castel et al., 2002); thus, implications for aging will also be discussed.

Kazumasa Tanaka

Reactivation of hippocampal and neocortical networks during memory consolidation

Episodic and contextual memories are encoded within hippocampal and neocortical circuits. Retrieving these memories is assumed to involve reactivation of neural ensembles that were wired together during learning. While it has been possible to follow the activity of individual neurons shortly after learning it has not been possible to examine their activity days and weeks later during memory retrieval. The current experiments addressed this issue by using transgenic mice to tag neurons with a long lasting, activity dependent form of GFP during context fear conditioning. In these animals, activation of the c-fos promoter leads to the expression of an H2B-GFP fusion protein that is stable for several months after induction. Using these mice, we found a large network of neurons in the hippocampus and neocortex that were active during learning and subsequent memory retrieval 2 days later. Reactivation was contingent on memory retrieval as it was not observed when animals were trained and tested in different environments. When memory was retrieved several weeks after learning, reactivation patterns were altered in the hippocampus but remained stable in the cortex. These results may suggest that memory circuits are reorganized after learning in the hippocampus but not in the cortex.