Talk Session 1

Melina R. Uncapher

From Negative to Positive: Harnessing the Ventral Parietal Attention System to Promote Rather than Detract from Episodic Encoding

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Efforts to characterize the neural mechanisms of episodic encoding have primarily focused on the medial temporal lobe (MTL) and prefrontal cortex (PFC), however neuroimaging studies often reveal effects in posterior parietal cortex (PPC) alongside those in MTL and PFC. Indeed, a recent meta-analysis (Uncapher & Wagner, in prep) demonstrated that PPC is consistently implicated in successful encoding, such that the extent to which PPC mechanisms are engaged during an experience is predictive of subsequent memory for the experience. Dual-attention theories of lateral PPC function posit that dorsal (superior parietal lobule and intraparietal sulcus) and ventral (inferior parietal lobule and temporo-parietal junction) PPC subregions support 'top-down', goal-directed attentional allocation and 'bottom-up' capture of attention by unexpected or salient stimuli, respectively. When viewed through the lens of attention, the dorsal PPC correlates of encoding can be interpreted to signify that dorsal attention mechanisms facilitate episodic encoding. By contrast, ventral PPC activation has been shown to correlate negatively with subsequent memory. The present functional MRI study sought to determine whether ventral PPC mechanisms can facilitate rather than detract from encoding, specifically when event information is captured in a bottom-up manner. Participants were scanned while incidentally encoding stimuli in a variant of the Posner cueing paradigm. On each trial, participants were cued (leftward or rightward pointing arrow) to expect a stimulus in one of two spatial locations (left or right of central fixation). Stimuli—line drawings of real and nonsense objects—appeared in the cued location ('valid' trials) with .82 probability and in the non-cued location ('invalid' trials) with .18 probability. Participants judged whether the stimulus was a real or a nonsense object. Approximately 10 min post-scanning, recognition memory for the real objects was assessed. Behavioral results indicated that participants allocated goal-directed attention to the cued location, as revealed by longer reaction times during invalid vs. valid trials. Additionally, subsequent memory for both validly- and invalidly-cued objects was well above chance. The fMRI data revealed enhanced activity in dorsal PPC regions during the cue period (suggestive of top-down attentional allocation), and in ventral PPC regions for invalidly- vs. validly-cued objects (suggesting bottom-up attentional capture). Activation in ventral PPC correlated with the later mnemonic fate of the object, being greater during trials for which the object would be later recognized vs. forgotten. Critically, the magnitude of this subsequent memory effect was larger for objects that appeared in the unexpected vs. expected location. These findings indicate that, when recruited, bottom-up attention mechanisms subserved by ventral parietal cortex can enhance the capture of event information in episodic memory.

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Theodore Zanto

Neural suppression of irrelevant information underlies optimal working memory performance

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Our ability to focus attention on task-relevant information and ignore irrelevant distractions is reflected by differential enhancement and suppression of neural activity in sensory cortical regions (i.e., top-down modulation). Such selective, goal-directed modulation of activity may be intimately related to memory, such that the focus of attention biases the likelihood of successfully maintaining relevant information by limiting interference from irrelevant stimuli. Despite recent studies elucidating the mechanistic overlap between attention and working memory (WM), the neural relationship between selective attentional modulation of early visual processing during WM encoding and subsequent recognition performance has not yet been established. Here, we provide neurophysiological evidence in humans that successfully ignoring distracting information is associated with optimal WM recognition, whereas attention to relevant information is not linked to enhanced performance. Moreover, modulation of visual cortex activity associated with WM performance occurs very early in visual processing, within 200 ms of stimulus onset. The differential impact of attending and ignoring information on subsequent recognition was replicated for two types of feature-based memory: motion direction and color hue. These results provide direct neural evidence that in healthy young adults, ignoring irrelevant information is the principle factor for optimal WM performance.

Rachel Diana

Source memory: Unitized vs. nonunitized encoding

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Source memory has previously been associated with either parahippocampal cortex and hippocampal activation (e.g. Ranganath et al., 2003 and Davachi et al., 2003) or perirhinal cortex activation (Staresina & Davachi, 2006). The experiments that found these patterns of activation emphasized different types of processing at encoding. Diana et al. (2008) demonstrated that different encoding tasks, applied to identical stimuli, altered the degree to which item and source information are unitized (i.e. combined into a single representation with the source information encoded as a feature of the item). Unitization increased the contribution of familiarity to source memory responses. Based on the BIC model (Diana et al., 2007), we predicted that retrieval of unitized and nonunitized sources would involve different medial temporal lobe subregions. Results from an fMRI experiment indicate that recollection of a nonunitized source involves the hippocampus and parahippocampal cortex, while recollection of a unitized source also involves perirhinal cortex. Perirhinal cortex was the only medial temporal lobe region that was significantly active during familiarity-based retrieval of unitized source information.

Poster Session 1

Anne Berry

Improvement in working memory is modulated by plasticity in processing distractions

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Working memory (WM) performance is impaired by the presence of distraction. Accordingly, more efficient processing of distracting information with practice may lead to enhanced WM performance. To explore the role of practice on the impact that distracting stimuli has on WM performance, we studied young adults with electroencephalography (EEG) recordings as they performed motion direction, delayed-recognition tasks. One task was presented without distraction, while two tasks had a distractor introduced during the interval of memory maintenance; the distractors were either to be ignored, or required a perceptual discrimination. We show that WM performance was disrupted by both types of distractors, but that this distractor-induced disruption was abated across a single experimental session through learning. WM accuracy and response time improved in a manner that could be predicted by the changes in early neural measures of distractor processing in visual cortex. Furthermore, spectral analyses of midline frontal theta revealed diminished power during distractor processing with practice, indicative of enhanced neural efficiency of prefrontal top-down control. These results suggest that practice-related plasticity of distractor processing exerts a positive influence on WM performance, highlighting the importance of filtering irrelevant information and the dynamic interactions that can exist between neural processes of perception, attention and working memory during learning.

Deanna Novak

Sleep Enhances Memory for Locations of Arousing Pictures

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Sleep improves performance on a wide range of memory-dependent tasks supporting its role in memory consolidation. Further, there is evidence that some types of arousing declarative memories may be preferentially consolidated over a period of sleep compared to non-arousing declarative memories. The current study investigates if location memory, a type of memory that tends to be initially enhanced due to arousal, is further enhanced by sleep. In two experiments, participants learned the locations of pictures in one session and then returned twelve hours later either after sleeping or without sleeping (Experiment 1) or twenty-four hours later after sleeping (Experiment 2) to complete a recall test of the Session-1-picture locations. Consistent with previous studies, which have investigated other types of memory, sleep was associated with an enhancement in location memory. Moreover, consistent with initial differences in encoding between arousing and non-arousing events, this enhancement was greater for arousing objects than for non-arousing objects, at least for participants who slept 6 hours or less. This was true even after controlling for differences in interference that occurs over wake periods and time of day.

Diane Marian

Dynamic Expressions Bias the Evaluation of Neutral Faces

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Visual illusions have been studied for centuries because they are useful tools for investigating top-down influences on perception. Here, we discuss an emotional illusion in which facial expressions are perceived differently depending on their context. We constructed short video clips of dynamic expressions by morphing faces from happy to neutral or from angry to neutral. Participants rated the initial expression of a face, watched the face change to a neutral expression, and then rated the ending expression. The ending neutral faces were judged as displaying the emotion opposite that of the initial expression. These results demonstrate a context-based illusion in which neutral faces seem to display different emotional expressions depending upon their prior appearance and movement. In many respects, this illusory effect is comparable to visual illusions in which a perceptual feature, such as size, color, or orientation is affected by surrounding context.

Els van der Helm

Sleep on it to get the details!

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Introduction: Although the benefit of sleep on procedural memory consolidation is well established, the role of sleep in declarative memory processing remains incomplete, and may depend on more subtle aspects of the task, beyond simple free recall. Using a nap paradigm, here we test the hypothesis that sleep specifically consolidates hippocampal-dependent aspects of episodic memory. We therefore investigated the differential impact of wake and sleep on the offline consolidation of ITEM versus CONTEXT episodic memory components.
Methods: Participants (n=27) studied two lists of 50 words at 12 noon. The first and second word lists were each associated with a different set of contextual cues, making each list distinct (different screen presentation location, study room orientation and view for the participants). After this study session, subjects were assigned to either a Nap group (n=13) or a No-Nap group (n=14). The Nap group subsequently obtained a 90min nap opportunity (1:00PM), recorded in the sleep laboratory, while the No-Nap group remained awake. At 6:00PM, all subjects returned for a recognition test, where the original studied items were presented, together with intermixed foils (new items). For each recognition trial, subjects made two possible responses 1) indicating whether the item was old or new (measure of ITEM memory), and 2) if old, which study list did the item come from, first or second (measure of CONTEXT).
Results: The No-Nap and Nap group did not significantly differ in their performance for ITEM memory (d-prime: 1.60 and 1.75 respectively, p=0.71). In contrast, relative to the No-Nap group, there was a significant offline consolidation benefit for CONTEXT memory following sleep in the Nap group (Proportion Correct: 0.80 and 0.88 respectively, p=0.04). Furthermore, within the Nap group, the extent of CONTEXT memory retention was strongly and significantly correlated with the amount of Stage-2 NREM sleep obtained during the nap (r=0.57, p=0.04); no association was found with ITEM memory. Most interestingly, CONTEXT memory not only correlated with the amount of Stage-2 NREM in the Nap group, but a specific electrophysiological signature of NREM – sleep spindles. These correlations were most consistently found in the left hemisphere, particularly left prefrontal electrode sites (r=0.72, p<0.01).
Conclusions: Here we demonstrate that sleep preferentially benefits more hippocampal-dependent aspects of episodic memory, and less so extra-hippocampal-dependent components, clarifying the specificity of sleep-dependent memory processing. Moreover, it was not that a lack of waking activity (i.e. total sleep time) enhanced memory, but rather a select sleep-stage type (stage-2 NREM), and specific physiology wave-form (sleep-spindle) correlated with these hippocampal-memory benefits. Thus, sleep is not simple a passive state of minimal interference, but instead a unique neurobiological theater allowing for the proactive modulation of episodic memory consolidation, potentially driven by specific electrophysiological sleep oscillations.

Ian M. Messenger

Ten-month-old infants can localize changes in visual short-term memory: An eye-tracking study

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Visual short-term memory (VSTM) develops rapidly between 6 and 10 months. Infants' VSTM is assessed using *change detection*. Infants are shown streams in which a collection of objects (i.e., colored squares) appears briefly (500 ms), disappears briefly (300 ms), and then reappears. This cycle continues and infants' looking at the streams is recorded. Conclusions about infants' VSTM are drawn from their looking at *changing streams* (i.e., streams in which one or more objects changes from cycle to cycle) as compared to *non-changing streams*. This task has revealed dramatic changes in infants' ability to detect changes (as indicated by their watching changing streams more than non-changing streams) in object color, location, and so on. Although this task has been important for revealing infants' developing VSTM, the conclusions we can draw from it are limited—we know infants *detect* changes, but not whether infants recognize which objects changed or whether they can localize those changes. In the present study, we examined these aspects of infants' VSTM using eye-tracking.

We assessed change detection in 6 10-month-old infants using an ASL pan/tilt eyetracker. Each infant received up to 18 trials with the following sequence: two squares of different colors briefly appeared (500 ms), disappeared briefly (300 ms), and then reappeared and remained on the screen 3,000 ms. On each trial, when the objects reappeared, one had changed colors (the left object on 50% of the trials). The question was this: Would infants look longer at the changed item than at the non-changed item? We measured infants' fixation both objects and calculated a *change preference* by dividing their fixation to the changed object by the total amount of looking to the two objects. If infants not only detected that there was a change, but also detected which object changed (and localized that a change) they will have a change preference score that is greater than chance (.50).

Infants significantly fixated the changed square more than the unchanged, $t(5) = 3.08$, $p = 0.027$, two-tailed, suggesting that they not only could detect the, but also that they can determine which of the two objects changed and where the change occurred. These results are significant because previous research demonstrated that infants are *sensitive* to changing displays, but not *why* or *what* about those displays draws infants' attention. Our data suggests that infants' performance in previous tasks reflects their ability to detect and locate which object has changed.

Jacob Bollinger

Pre-stimulus alpha power reflects anticipation of both stimulus category for complex objects and task goals

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Our everyday experience reveals that events can often be anticipated prior to their occurrence. Recently it has become clear that neural activity prior to the appearance of a visual stimulus may be important for efficient processing of feature and spatial information as well as subsequent performance in a task that utilizes this information. This stimulus preparation is a form of top-down modulation and the following experiment was designed to reveal the nature of anticipatory modulation for stimulus category of complex real-world objects in the setting of different cognitive demands. 64-channel electroencephalographic data was collected from 19 participants aged 18-27 while they performed a series of tasks designed to modulate expectation of stimulus category and working memory utilization. The three tasks were: 1) Stimulus-Known Identification (SKID, anticipate face stimuli and identify the gender of the face) 2) Stimulus-Known Working Memory (SKWM, anticipate face stimuli and hold in mind for a 7 sec delay) and 3) Stimulus-Unknown Working Memory (SUWM, anticipate stimuli of unspecified category – faces or scenes, and hold in mind for a 7 sec delay). Participants were cued with task instructions prior to the onset of each trial. Participants performed these three tasks with equivalent accuracy such that difficulty was equated. Pre-stimulus alpha power (8-14Hz) in posterior electrodes showed differential modulation across tasks such that SKWM>SUWM ($p<0.05$) and SKWM>SKID ($p<0.05$).
These results reveal that both expectation of a specific category and the task to be performed, influence pre-stimulus activity measures.
In addition to modulating pre-stimulus activity, significant modulation of the N170 ERP (face cues) was observed such that amplitude was modulated across stimulus-known tasks (SKWM>SKID; $p<0.05$) and the latency was modulated across working memory conditions (SUWM>SKWM; $p<0.05$).
The relationship between anticipatory activity modulation, working memory, and incidental long-term memory are now being explored.

Keywords: Top-down Modulation, Anticipation, EEG, alpha

John Olichney

Long-lasting effects of a visually-enhanced study condition on the N400 and P600 components

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Background: The P600, a late positive Event-related potential (ERP), has been linked to memory encoding and retrieval processes. The N400 component, an index of semantic processing load, has also been related to verbal learning and memory. While much is known regarding the modulation of the P600 and N400 by repeating stimuli within an experimental session, little has been published on the ERP correlates of long-term learning (lasting hours to days). Thus, we designed a visually enhanced study condition (VESC) in which color photographs of objects semantically congruous or incongruous with a given category were studied for 3.5 hours over the 7 days preceding the ERP session.
Methods: Ten normal subjects (5 male, mean age =22.4) were studied with 32 channel ERPs (bandpass= .016-100 Hz) and behavioral measures. One-half of the stimuli were semantically congruous and half were incongruous. One-third of the stimuli presented were from the VESC. Both studied and unstudied stimuli had a 67% probability of repeating within the experiment (10-140 seconds later). The ERP data were submitted to ANOVAs (within-subject factors included Latency, Congruity, Study and Repetition).
Results: Prior visual study resulted in a large (> 5μV) decrease of the P600 amplitude elicited by the initial presentation of congruous words. The amplitude of this decrement correlated with subsequent recall and recognition (r's = .65-.68). For incongruous words, a study x latency interaction was present [$F=8.4$, $p=0.01$] which indicated smaller N400 and smaller P600s to studied items. For unstudied new words, as expected, larger N400s were elicited by incongruous than congruous words [$F=16.6$, $p=.003$]. However, for the initial presentation of studied words, the N400 congruity effect was absent [$F=0.14$, $p=0.72$]. Free recall for the experimental stimuli was most strongly correlated with the P600 word repetition effect amplitude ($r=.84$, $p=.002$). Cued recall and recognition were strongly correlated with the N400 repetition effect amplitude (r's =.91 and .86; p's < 0.001).
Conclusions: Prior study of color photographs had a major effect on ERPs obtained more than 12 hours later. Both the N400 and P600 components showed sensitivity to the VESC. These data suggest that study of visual materials resulted in effective binding of long-lasting semantic associations, even for incongruous material usually difficult to learn and recall.
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Luke Jenkins

fMRI correlates of long term temporal order memory

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Data from patients with frontal lobe lesions, who show normal item memory but impaired memory for temporal order, suggest a dissociation between item and order memory. In addition, recent neuroimaging work has specifically implicated the dorsolateral prefrontal cortex in short term memory for serial order. In this fMRI experiment, we investigate the encoding mechanisms underpinning long term temporal order memory. We hypothesize two complimentary systems: one responsible for coarse temporal memory, which operates over longer timespans and is largely dependent on contextual cues, and one responsible for fine temporal memory, which operates over shorter timespans and encodes the item-to-item associations necessary for remembering exact serial order. Subjects were scanned while performing a serial order working memory task. Four common objects were presented, followed by an 8 second delay and a probe for the serial position of one of the objects. Following scanning, subjects were tested for temporal memory of the object stimuli. To test coarse temporal memory, subjects were shown one object from each of the encoding trials and asked to indicate approximately when in the experiment this object was seen by marking its position on a horizontal line. To test fine temporal memory, subjects were shown the remaining three objects from each trial and asked to recall the order in which the objects were originally presented. Encoding trials were sorted based on coarse and fine temporal memory accuracy. Preliminary analyses reveal a network of active regions associated with both coarse and fine temporal memory, including the dorsolateral prefrontal cortex. Further analyses will examine the commonalities and differences between the networks associated with coarse and fine temporal memory.

Talk Session 2

Amy Finn

Developmental changes in prefrontal and hippocampal connectivity during working memory: a longitudinal fMRI study

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Prefrontal (PFC) grey matter wanes throughout adulthood, and while total hippocampal volume does not change after childhood, regional changes have been observed. Classically, the PFC supports working memory (WM) whereas the hippocampus supports long-term-memory (LTM). This distinction, however, has recently become blurred: the PFC is involved in LTM and the hippocampus in WM, but only when information to be held in WM is novel or complex. Given that PFC development is late, young adolescents may recruit compensatory areas for WM. In particular, they may recruit hippocampus. We scanned 10 female adolescents longitudinally—mean age 15 years for scan 1 (S1) and 18 for scan 2 (S2). During the scans, participants viewed either 2 or 6 upper-case letters for 2 seconds, followed by a 13.2 second delay period, and responded as to whether a lower-case letter matched one of the encoding letters. Adolescents recruited hippocampus during S1 but not during S2**.** PFC was recruited for both scans, but this activity was correlated with behavior only during S2. Connectivity analyses additionally show that hippocampal and PFC activity were correlated during S1, but not S2. The hippocampus may therefore be part of the PFC-parietal network during early stages of development.

Karinna Hurley

Developmental Change in Infants' Visual Short-Term Memory for Location

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Infants' visual short-term memory (VSTM) capacity for object identity (color) and the binding of color and location develop dramatically from 6 to 7 months (Oakes et al., 2006; Ross-Sheehy et al., 2003). We used a change-preference task (Oakes et al., 2006; Ross-Sheehy et al. 2003) to examine developmental changes in VSTM for location. Four-, 6-, 8-, and 12-month-old infants (N = 94) sat in front of two computer monitors. During each of 6 20-s trials, two stimulus streams (each with the same number of circles) were presented. In each stimulus stream, an array of 1 to 3 highly distinguishable colored circles appeared for 500 ms, disappeared for 300 ms, and then reappeared (this cycle repeated for 20 s). On each trial, a *changing* stream (the location of a different randomly chosen circle moved to a randomly chosen location each time the array reappeared) and a *non-changing* stream were presented side-by-side. There were two trials at each set size.

We calculated each infants' *change preference score* at each set size by dividing looking to the changing stream by the looking to both the changing and non-changing streams at each set size (equal looking at the two streams will result in a score near chance, .50). Younger infants' (4 and 6 months) change preference score was greater than chance only at set size 3, $t(47) = 3.04$, $p = .004$, $d = .44$ Their change preference was not different from chance at set size 1, $t(47) = .31$, *ns*, or set size 2, $t(47) = 1.21$, *ns*. Older infants' (8 and 12 months) change preference scores were significantly greater than chance at set size 1 $t(46) = 4.21$, $p = .001$, $d = .62$, set size 2 $t(46) = 6.67$, $p = .001$, $d = 1$, and set size 3 $t(46) = 5.20$, $p = .001$, $d = .79$.

Thus, older infants detected the change at more set sizes than did younger infants, and infants younger than 6 months have a limited ability to detect changes in location. Infants' encoding of object *location* in VSTM, however, differs from their encoding of object *identity*. Younger infants detect a change in identity only at set size one (Ross-Sheehy et al., 2003). In contrast, the 4- and 6-month-old infants in this study detected location changes only at set size 3. Note that although the array contained three items, only *one* item changed location. Thus, if infants were encoding the array holistically (e.g., the pattern of circles as a configuration) the change in a single item would have been detectable. At set sizes 1 and 2, a change in the location of one of the items did not result in a change in the configuration. Thus, although the same developmental time-course is observed for infants' encoding of location and identity, there are differences (at least in infants 6 months and younger) in how infants encode these features in VSTM.

Jesse Rissman

Classifying the mnemonic status of single items based on distributed fMRI activity patterns

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While the brain responds differently when it experiences a novel sensory stimulus as compared to a previously encountered stimulus, conventional functional magnetic resonance imaging (fMRI) data analysis approaches, utilizing univariate statistics to compare voxel activity levels across task conditions, cannot reliably capture these mnemonic effects on single trials. We sought to exploit the wealth of information represented in distributed fMRI activity patterns, using a multi-voxel pattern analysis approach to decode the mnemonic status of individual stimuli. Prior to scanning, participants studied 200 color photographs of human faces. Subsequently, participants were scanned while they made recognition memory decisions about the 200 studied faces intermixed with 200 novel faces. For each test face, participants indicated whether they 1) recollected having studied the face, 2) were highly confident they studied it, 3) thought they studied it, 4) thought they did not study it, or 5) were highly confident they did not study it. After fMRI data preprocessing, we trained a back-propagation neural network classifier model to detect brain activity patterns that maximally differentiate encounters with studied stimuli from those with novel stimuli. The classifier was iteratively trained on 90% of the dataset with the remaining 10% of trials used to assess the classifier's ability to generalize its "knowledge" to new data. Using this approach, the trained classifier achieved above-chance classification of the objective mnemonic status of the test stimuli (i.e., studied vs. unstudied). This effect held even when the training set equated the number of studied and unstudied stimuli given each subjective response, effectively de-correlating objective mnemonic status from subjectively experienced memory strength. Separately derived classifier models exhibited a significant ability to classify the subjective status of stimuli (i.e., perceived memory strength) and to differentiate recollection-based responses from familiarity based responses. The neural signatures of these various mnemonic states were explored by extracting the 'importance value' of each voxel to a particular classification outcome. Despite the highly distributed nature of the underlying representations, classification outcomes were largely tied to activity levels in a core set of prefrontal, parietal, medial temporal, and visual association regions. The implications of these results for understanding the neural signals mediating human recognition memory will be discussed.

Talk Session 3

Karen Taylor

Evidence for stimulus-specific contributions of MTL structures to recognition memory for faces and scenes

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We have previously demonstrated that whereas amnesic patients with broad medial temporal lobe (MTL) damage show impaired recognition memory (RM) for faces and spatial scenes, patients with circumscribed hippocampal lesions show a selective preservation of face RM. We proposed that the selective RM deficit associated with hippocampal damage was the result of specialization within the MTL according to stimulus category, with the hippocampus and perirhinal cortex playing essential roles in scene and object processing respectively. An alternative explanation, however, which follows from dual-process models, is that scene RM is more dependent on hippocampally-mediated recollective processes, whereas RM for faces can be adequately supported by familiarity signals in adjacent cortical regions; i.e. it is the type of memory process, rather than nature of stimuli, that best explains the division of labour in the MTL. In order to investigate these two hypotheses, we conducted an fMRI study involving RM for faces and scenes, which included a remember/familiar (R/F) decision to assess recollection and familiarity. Our analyses focused on three regions of interest (ROIs): hippocampus, parahippocampal and perirhinal cortex and we optimized coverage of these regions using a novel dual-echo sequence. Analysis of the study phase revealed an interaction between stimulus and memory in the hippocampus and parahippocampal cortex, such that activity in these regions positively correlated with subsequent memory for scenes but not for faces. Main effects of stimulus were observed in all ROIs during both study and test: the perirhinal cortex was more active for faces than scenes, whereas the hippocampus and parahippocampal cortex showed the reverse effect. Considerable overlap between these functional effects and the areas of common damage in the hippocampal amnesics was observed for the main effect of scenes versus faces, but not for the interaction, suggesting that the impairments observed in these patients may have been caused by disruption to the formation of spatial representations, rather than impairments in scene-specific mnemonic processes. Further contrasts failed to reveal any evidence for a division of labour within the MTL according to contributions to recollection versus familiarity. Rather, the results suggested that all of these regions may make some contribution to both processes. To summarize, these findings add to the growing body of evidence suggesting that MTL regions can be dissociated according to their contributions to the formation of representations of different stimulus categories.

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Ben Hutchinson

Parietal contributions to episodic memory retrieval and visuo-spatial attention

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Episodic retrieval is a multi-process act that has long been known to depend on the medial temporal lobe and prefrontal cortex. More recently, a large body of neuroimaging evidence indicates that lateral posterior parietal cortex (PPC)—including the intraparietal sulcus and inferior parietal lobule—is engaged during event remembering. Given the rich literature demonstrating PPC involvement in visuo-spatial attention, a debate has emerged over the degree to which PPC activations during episodic retrieval can be understood as reflecting the engagement of parietal attentional processes during remembering. Resolution of this debate may partially come from within-subject analysis of the overlap between parietal correlates of episodic retrieval and (a) topographically organized maps of spatial attention within the intraparietal sulcus (IPS1-IPS4) and (b) ventral parietal structures implicated in bottom-up (reflexive) attentional orienting. To this end, the present functional MRI study examined the relationship between recognition memory and visuo-spatial attention effects in parietal cortex at the single-subject level. During the memory task, subjects encoded visually presented words, and were scanned during a subsequent recognition memory test that probed item recognition and source recollection. In a separate session, subjects performed (a) a covert visuo-spatial attention task that mapped topographically organized regions along the IPS that subserve goal-directed visuo-spatial attention, and (b) a reflexive (Posner cuing) attentional orienting task that engaged ventral parietal cortex. While the fMRI episodic retrieval data revealed mnemonic effects in IPS and IPL, initial analyses suggest that the localization of these IPS effects were predominantly non-overlapping with the IPS regions demonstrating topographically organized spatial attention maps. Additionally, ventral parietal regions recruited during the memory task were largely distinct from regions elicited by target detection during the Posner cuing task. Taken together, these findings suggest a possible anatomical and functional distinction between mechanisms associated with episodic retrieval and processes of top-down and bottom-up spatial attention.

Ellen Klostermann

Right Posterior Parietal Cortex Activity During Successful Retrieval of Non-Linguistic Auditory Stimuli

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In fMRI and ERP studies, successful recognition performance has been associated with left-lateralized activity in the posterior parietal cortex (PPC). Here, we investigated recognition performance, and particularly the lateralization of PPC activity, for short, agrammatical music stimuli (Blackwood, 2004), which are largely processed in the right hemisphere. For both study and test phases, participants closed their eyes and listened to music clips presented through electrodynamic, noise-suppression headphones. During the study phase, participants made pleasantness judgments. At test, participants made old/new recognition judgments with high/low confidence ratings. Right but not left hemisphere PPC activity was observed during the successful retrieval of these agrammatical music stimuli. This finding suggests that the PPC activity in previous studies has been left-lateralized because they used verbal or verbalizable stimuli. This data further suggests that both the right and left PPC are involved in successful memory retrieval.

Poster Session 2

Chung-Hay Luk

Action-Outcome Associations encoded in Primate PFC and Working Memory

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In a dynamic environment an action that satisfies a particular goal can often change. Hence, to select the most appropriate action, it becomes necessary to actively update remembered contingencies between actions and goals (through action-outcome [AO] associations). Several studies implicate prefrontal cortex (PFC) in this process of outcome-guided action selection. The medial PFC (MPFC) appears to be particularly important for the implementation of AO behavioral control. It has the appropriate anatomical connections, as it receives strong limbic inputs and connects with cingulate motor areas[1]. Lesions of MPFC impair the ability to use outcomes to guide actions, in both rats[2] and monkeys[3]. In addition, when the monkey is performing a task that requires both AO and stimulus-response associations, MPFC neurons tend to encode the AO association while lateral PFC (LPFC) encodes the stimulus-response associations[1]. Taken together, these results have led to the suggestion that MPFC is particularly important for outcome-guided action control[4]. However, past studies have typically held the AO contingency constant across many trials thereby taxing long-term memory processes. In contrast, LPFC is primarily involved in online control requiring working memory[3,5,6] so one might not expect it be involved when AO contingencies are static for many trials. Thus, in this study we compared neuronal firing in LPFC and MPFC of one awake, behaving rhesus monkey, while he performed a task that requires him to monitor AO contingencies on a trial-by-trial basis. This is a stronger test than previous studies, since the constantly changing AO contingencies will tax online control, which is a more appropriate test of whether LPFC neurons encode AO information. We found that both LPFC and MPFC did indeed encode AO information.

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Cynthia M. Funes

A Comparison of Verbal Learning and Memory in Alzheimer's Disease and Frontotemporal Dementia

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Across the literature, patients with Alzheimer's disease (AD) have been observed to exhibit significantly greater impairments on memory tasks in early stages of the disease than patients with Frontotemporal Dementia (FTD). Early symptoms of FTD tend to manifest as behavioral problems, personality changes and difficulties with tasks requiring executive functioning. The purpose of the current study was to examine learning and memory patterns in patients in the relatively mild stages of AD and FDT. Eight patients with FTD and 8 AD patients matched in disease severity with use of the Mini Mental State Exam participated. All patients were in the relatively mild stage of-AD and FTD, (MMSE>22). Eight healthy older adults also served as controls. All participants were administered the California Verbal Learning Test-II Short Form (CVLT-II SF). This shortened version of the CVLT-II requires participants to learn a list of 9 items over four learning trials. They are then required to recall the items freely after a brief (30-second) delay, a long (10-minute delay, and are cued to recall items with categorical membership of the items. Additionally, they are also presented with a forced choice recognition trial. One-way ANOVAs were performed in order to examine differences between the groups on the CVLT-II SF outcome variables. The analyses revealed that learning slope of FTD patients was significantly poorer than normal controls, but not AD patients. At recall, patients with FTD again performed quite poorly—in fact, poorer than normal controls and equivalent to AD patients. In contrast, on the recognition memory portion, FTD patients committed similar number of false positive errors relative to normal controls , whereas AD patients committed significantly greater number of such errors than normal controls (p values <.05). As has been previously observed in the literature, AD patients demonstrated a "flat learning rate," poor immediate and delayed recall, and poor recognition memory (i.e., higher number of false positive errors). Interestingly, FTD patients produced a similarly poor learning slope and recall as AD patients, with performance in these areas significantly worse than normal controls. However, FTD patients were not found to differ significantly from normal controls in their ability to distinguish target words from foils, suggesting that their recognition memory is relatively more intact than AD patients. This lends some support for the idea that FTD patients benefit from the recognition paradigm, and that their difficulty is most profound in free retrieval of information. In contrast, AD patients display no benefit from the recognition paradigm, suggesting that they were not able to initially acquire the information.

Fred Barrett

Music-Evoked Nostalgia: Affect, Memory, and Personality

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Nostalgia is related to positive and negative emotions, and autobiographical memories. Randomly selected excerpts of popular music were used to evoke nostalgic and non-nostalgic autobiographical memories. The relationships between mood, personality factors, and nostalgic, affective, and mnemonic experiences, were estimated using mixed-model regression analyses. From song to song, strength of nostalgia was predicted by song familiarity, autobiographical salience, number of positive and negative emotions experienced, the experience of mixed emotions, positive initial mood state, and nostalgia proneness. These effects were mediated by nostalgia proneness and dimensions of the Affective Neurosciences Personality Scale (ANPS), but not by factors of the Big Five Inventory (BFI). Between-subjects variation in nostalgia proneness was related to the SEEK dimension of the ANPS and by the Neuroticism sub-scale of the BFI. Memory content was shown to vary between nostalgic and non-nostalgic memories. Association of positive, negative, and mixed emotional experience with nostalgic experience, as well as the predictive value of PLAY, SEEK, ANGER and SADNESS of the ANPS demonstrate a complex affective structure behind nostalgic experience that is not adequately represented by bi-dimensional models of affect.

Gwen Lawson

Manipulating Preparatory Control to Understand the Relationship Between Behavioral and Neural Priming

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Past stimulus processing results in behavioral facilitation (priming) and decreased neural activity (repetition suppression) during repeated stimulus processing. Recent evidence indicates that past experience can result in learning at multiple levels: stimulus, stimulus-decision mappings, and stimulus-response mappings. For example, Race et al. (2008) manipulated these levels of learning using a conceptual priming task in which subjects classified nouns according to one of two classification rules: a size decision (e.g., "smaller than a 13" box?") or a composition decision (e.g., "organic?"). In a study phase, subjects classified items three times according to the same rule. At test, the same items were presented a fourth time in one of three conditions: either classified according to the same rule as at study (Within-Task), classified according to the alternate rule but requiring the same response as at study (Across-Task Response-Repeat), or classified according to the alternate rule and requiring the opposite response (Across-Task Response-Switch). Novel stimuli that had not been primed at study served as baseline items. Thus, learning at the stimulus level (present in all repeated conditions) could be compared to learning at the stimulus-decision level (present only in the Within-Task condition) and to learning at the stimulus-response level (present in both the Across-Task Response-Repeat and Within-Task conditions). Analyses revealed three dissociable patterns of repetition suppression in distinct left fronto-temporal regions. Interestingly, though stimulus-level repetition suppression was observed in fusiform, middle temporal, and anterior VLPFC even when decisions and responses switched (i.e., in Across-Task Response-Switch trials), stimulus-level behavioral priming was not observed in this condition. This complex relationship between behavioral and neural measures of priming may indicate that facilitated processing at the stimulus level is offset by conflict at the stimulus-decision or stimulus-response levels. The present behavioral studies tested this hypothesis by manipulating the cue-to-stimulus interval (CSI) using the same task-switch repetition-priming paradigm. By allowing more time for rule-based anticipatory task preparation prior to stimulus presentation, longer CSI's could reduce interference from conflicting stimulus-decision/stimulus-response associations. Experiment 1 revealed that provision of a 600-ms CSI dramatically reduced the associative-switch cost, such that behavioral priming due to stimulus-level was now apparent (i.e., for Across-Task Response-Switch trials). Experiment 2 further investigated the relationship between task set preparation and behavioral priming by including a shorter (300 ms) CSI condition to determine duration of preparation time needed to overcome interference from conflicting learned associations. The implications of stimulus-decision and stimulus-response conflict for mapping behavioral measures of repetition priming to neural measures of repetition suppression will be discussed.

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Ian Ramsay

Effect of Schizophrenia on Subsequent Memory Performance During Item-Specific and Relational Memory Tasks

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Background: A previous fMRI study showed that relational processing and subsequent memory performance could be increased by having subjects reorder items during a working memory delay (Reorder), versus simply maintaining them in working memory (Rehearse). Although patients with schizophrenia have generalized memory deficits, relational processing may be particularly compromised. One hypothesis is that patients fail to establish relationships between items during encoding, leading to reduced memory performance. Remember/Know (R/K) studies have also suggested greater patient impairment in recollection versus familiarity. This behavioral study tests the prediction that patients will show reduced relational processing, leading to a specific impairment on the reorder task.
Methods: Working memory performance was examined during fMRI while 15 patients and 14 controls performed rehearse and reorder WM tasks: on 'rehearse' trials subjects maintained a set of 3 objects across a 12 second delay in anticipation of a memory probe for serial position of the items; on 'reorder' trials participants rearranged a set of 3 items based on perceived weight and maintained this information in anticipation of a memory probe for serial order of items in the rearranged set. Following scanning, subjects were given a recognition test in which they had to discriminate new from old items, and provide 6-point confidence ratings to allow for receiver operator characteristic (ROC) analysis.
Results: Both groups understood the task and performed above-chance on rehearse and reorder working memory tasks. In healthy control subjects task effects (Reorder>Rehearse) were present for recollection (R), but not familiarity (d-prime). Consistent with previous R/K studies, patients were impaired on both tasks for recollection, but not for familiarity. Finally, to assess the benefit of associative processing, the proportion of trials in which all 3 objects were retrieved (3-item correct) was calculated for both conditions. As in the previous study, 3-item correct was higher in controls for reorder versus rehearse. There was no such task effect in patients, who were specifically impaired on the reorder condition.
Conclusion: This study demonstrates a successful translation of a cognitive neuroscience paradigm developed in healthy undergraduates to the clinical study of patients with schizophrenia. In accordance with our prediction of reduced relational processing in schizophrenia, patients did not benefit from the relational processing demand of the reorder condition to increase their subsequent 3-item memory performance. This deficit also appeared to be specific to recollection but not to familiarity-based retrieval. These results provide groundwork for interpreting fMRI results, and encourage further translational memory studies of schizophrenia.

Kristen E. Lyons

Age Differences in Recollection- and Familiarity-based Memory Errors

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We examined developmental differences in two types of memory errors: backward causal-inference errors (i.e., falsely remembering having viewed the non-viewed cause of a previously viewed effect), and gap-filling errors (i.e., falsely remembering having viewed a script-consistent event that was not actually encountered). Previous research suggests that these errors are generated by distinct memory processes. Backward causal-inference errors are supported by recollection, whereas gap-filling errors are supported by familiarity (Hannigan & Reinitz, 2001). Given that familiarity stabilizes around age 7 while recollection continues to improve through middle childhood (Brainerd, Holliday, & Reyna, 2004; Ghetti & Angelini, 2008), we hypothesized that age differences in these errors would parallel these trajectories.

Methods: Participants (N = 120; 6-, 7-, 9-, 10-, and 18-year-olds) viewed a series of photographs belonging to four common scripts (e.g., going to the restaurant). Each series included an "effect" photograph (e.g., wiping up water from a table) whose "cause" photograph was not presented (e.g., spilling a glass of water). After a delay, participants completed an old/new recognition test that included script consistent and inconsistent photographs, as well as "cause" photographs, whose effect photograph had been viewed during encoding, and "cause-control" photographs, whose effect photograph had not been viewed.

Results: Hit rates were comparable across age groups, F (4, 115) = 1.15, p = .33, η_p^2 =.03. The main dependent variables of interest, however, were the rates of backward causal-inference and gap-filling errors, and confidence ratings associated with the two error types.

Corrected error rates for backward causal-inference errors (i.e., false alarms to cause distracters minus false alarms to cause-control distracters) and gap-filling errors (i.e., false alarms to script-consistent distracters minus false alarms to script inconsistent distracters) were entered into a 5 (Age: 6-year-olds vs. 7-year-olds vs. 9-year-olds vs. 10-year-olds vs. 18-year-olds) X 2 (Error: Backward causal-inference vs. Gap-filling) ANOVA. As predicted, a significant interaction between age and error was observed, F (4, 115) = 3.79, p < .01, η_p^2 = .12. Age-related increases in backward causal-inference errors were observed, F (4, 115) = 3.19, p < .05, η_p^2 = .10. In contrast, no age differences were observed in gap-filling errors, F (4, 115) = 1.77, p = .14, η_p^2 = .06.
Confidence ratings associated with two error types were compared in a 5 (Age: 6-year-olds vs. 7-year-olds vs. 9-year-olds vs. 10-year-olds vs. 18-year-olds) X 2 (Error: Backward causal-inference versus Gap-filling) ANOVA. A significant age by error interaction was observed, F (4, 96) = 2.59, p < .05, η_p^2 = .10. Whereas adults were more confident when making backward causal-inference errors compared to gap-filling errors, the opposite was true for 6-year-olds, ps <.05; older children's confidence ratings did not significantly differ between the two error types.

Discussion: Results suggest that age-differences in recollection and familiarity contribute to age-differences in false-memory formation: Whereas familiarity-based memory distortions were relatively stable from middle childhood through adulthood, recollection-based memory distortions increased with age. Moreover, results suggest that the subjective experience of falsely recollecting non-presented items becomes increasingly vivid as recollection develops.

Michael T. Rubens

Variations in task difficulty dissociate activity in prefrontal cortex and medial temporal lobe during working memory encoding

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Introduction: Previously, our group found that subjects engaged in a working memory (WM) task performed worse with greater task difficulty (i.e. when distraction was present in comparison to trials with no distraction). Interestingly, a surprise post-experiment long-term memory (LTM) test demonstrated that subjects recognized pictures from the more difficult WM condition with greater accuracy[1]. This suggests that individuals may encode information differently on tasks that are more challenging. In order to test this hypothesis, the current experiment utilizes functional magnetic resonance imaging (fMRI) to evaluate the brain regions and network interactions that may underlie the dissociation between WM and LTM performance.
Methods: Subjects and Recording: 22 Subjects (18-35 years old) participated.
The experiment was performed on a Siemens 3T Trio Magnetom.
Procedure: Subjects performed a match/no match delayed-recognition task in which they encoded a face and held it in memory over a 7 (short delay) or 18 (long delay) second delay period, after which they compared it to a probe face. The conditions were as follows: Baseline (short delay loosely-paired, no distraction)—encoded and probe faces were loosely paired during non-match trials (based only on gender), Tight-Pairing (short delay, no distraction)—non-matching encoded and probe faces were tightly paired (i.e. similar facial features, race, gender, head angle etc.), Distraction (loosely-paired with distraction)—identical to the Baseline condition, however, a distracting (irrelevant) face was shown for 1 second in the middle of the delay period, and Long-Delay (loosely-paired, no distraction), identical to the baseline task except the length of the delay period.
Results: Behavioral results displayed a decrease in WM performance with distraction, increased delay length and tighter stimulus pairing in comparison to the Baseline condition ($p<0.05$). Similar to our previous finding, a surprise LTM post-experiment recognition test revealed that subjects remembered stimuli from the Tight-Pairing, Distraction and Long-Delay conditions better than the Baseline condition ($p<0.05$). The neural data shows that in the more challenging WM tasks (faced with distraction or more similar cue and probe images), subjects recruit more medial temporal lobe (MTL, $p<0.001$ uncorrected).
Conclusions: These results suggest that when WM task demands are low, subjects have limited recruitment of MTL, possibly do to a different encoding strategy such as rehearsing presented stimuli using a visual sketchpad, leading to better WM accuracy and worse LTM accuracy. However, during more difficult trials, subjects greatly recruit the MTL, resulting in better LTM accuracy. Additionally, in the Tight-Pairing condition, the magnitude of hippocampal activation during encoding correlated with subsequent LTM ratings ($p<0.005$).
These findings shed light on the relationship between the brain regions involved in stimulus encoding during a WM task with regard to task demands.
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Talk Session 4

Indre Viskontas

Human medial temporal lobe neurons respond preferentially to personally-relevant images

Indre V. Viskontas, Rodrigo Quian Quiroga and Itzhak Fried

People with whom one is personally-acquainted tend to elicit richer and more vivid memories than famous people with whom one does not have a personal connection. Recent findings from neurons in the human MTL have demonstrated that individual cells respond selectively and invariantly to representations of famous people (Quiroga et al., 2005). Observing these cells, we wondered whether photographs of personally-relevant individuals such as family members might be more likely to generate such responses in the MTL. To address this issue, we recorded the activity of neurons in the human MTL while patients viewed photographs of varying personal relevance: previously-unknown faces and landscapes, familiar but not necessarily personally-relevant faces and landscapes and finally photographs of the patients themselves, their families and the experimenters. Our results indicate that firstly, personally-relevant photographs are more likely to elicit selective, excitatory responses in MTL neurons.. Secondly, while cells in the hippocampus proper show selective excitatory responses with equal likelihood to photographs of familiar faces, regardless of their personal relevance, selective cells in the parahippocampal and entorhinal cortex seem to prefer personally-relevant images over generic famous faces.

Matthew S. Cain

When Practice Doesn't Make Perfect: Practice-Induced Task Switching Costs

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In tasks involving cognitive control, one common experimental design is to intermix trials of different types using different stimuli or instruction sets. Some tasks, such as the antisaccade task, have large, asymmetric carryover effects from one trial to the next. That is, performance on the current trial is influenced by the task demands of the previous trial. Other paradigms, such as those using arbitrary manual stimulus-response (S-R) mappings, have not shown such carryover effects. While general task history and task switching effects have been investigated extensively, the differences between tasks that do and do not show carryover effects have been largely unexplored. In this study we trained two groups of participants on a two-choice shape discrimination task. One group had no delay between training and testing while the other group had at least one day between the two. Participants were tested on a version of the task where they had to switch between the S-R mapping they had practiced and a reversal of that mapping based on a color cue. For both groups, the novel S-R reversal trials were slower and more error prone than trials with the practiced mapping. There was also a cost for switching from one mapping to the other. The no-delay group's switch costs were symmetric between mappings. In contrast, the group with a day's delay between training and test showed an asymmetry of switch costs with a larger cost when switching from the new task to the practiced task than from the practiced task to the new task. The pattern of results seen in the delay group is similar to that seen in antisaccade and anti-response tasks, indicating that asymmetric task switching effects may require both asymmetric task practice and adequate time for consolidation processes to act.

Brice Kuhl

Reward- and Interference-Based Modulations of Memory: Joint Contributions of Prefrontal and Mesolimbic Structures

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Declarative memory formation is known to be influenced both by interference from competing memories as well as motivational factors such as the anticipation of reward. While interference has a deleterious effect on episodic encoding and frequently elicits activation in left ventrolateral prefrontal cortex (VLPFC), reward anticipation has recently been shown to facilitate encoding through engagement of mesolimbic structures. Although reward anticipation and the presence of interference have distinct effects, the extent of interactions between the neural systems engaged by each remains unclear. In the present study, we used functional MRI to characterize neural responses related to reward anticipation and mnemonic interference in the context of a paired associate memory task. During scanning, each paired associate encoding trial was preceded by a cue indicating the potential reward if the pair could be later remembered (either 'high' or 'low' reward trials). Moreover, while some pairs were entirely novel, others contained elements previously associated with other stimuli (no interference vs. interference trials, respectively). Behaviorally, subsequent cued recall was superior for pairs preceded by a high reward cue at encoding relative to pairs preceded by a low reward cue. In addition, pairs that suffered interference were more poorly remembered than those without interference. Consistent with our hypotheses, during associative encoding (a) anticipation of reward was accompanied by engagement of mesolimbic structures, including midbrain and ventral striatum, whereas (b) mnemonic interference elicited activation in VLPFC. Critically, successful memory formation—as indexed by subsequent cued recall success—was related to the magnitude of activation in both mesolimbic and VLPFC regions, indicating that these regions jointly influence encoding. Moreover, mesolimbic structures modulated by reward were also sensitive to the presence of interference, while prefrontal areas modulated by interference were also sensitive to reward, suggesting potential interactive effects between reward and interference effects. These data indicate that mesolimbic and prefrontal structures collectively support declarative memory formation by promoting gains associated with reward and mitigating losses associated with interference.

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Emily C. Jacobs

Hormonal and genetic influences on prefrontal cortical function

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Dopamine transmission within the prefrontal cortex is critical for tasks dependent on working memory. The PFC is extremely sensitive to fluctuations in DA—both insufficient and excessive dopaminergic activity impairs PFC function. Taking into account an individual's basal level of PFC DA is essential for predicting DA's effect on cognitive processes. Individual differences in PFC DA stem in part from genetic polymorphisms that alter the efficiency of DA's metabolic pathway. A polymorphism within the COMT gene produces an enzyme with four times greater activity. Individuals with the less active enzyme (met/met) have increased PFC DA relative to individuals with the more active enzyme (val/val). Estrogen also impacts the DA system by amplifying DA transmission. Thus, performance on tasks that depend on precise levels of PFC DA may vary throughout the cycle as estrogen levels rise and fall. Importantly, these effects may not be measurable unless individual variation in baseline DA levels is accounted for. This study investigates the effects of estrogen on the performance of DA-dependent tasks as a function of COMT genotype. Female subjects were pre-selected for COMT genotype and tested on two occasions, when estrogen levels are at their peak and trough. Subjects completed two WM tasks during an fMRI scan. Preliminary analyses suggest hormone by genotype interactions at the behavioral and neurobiological level.