Society of Experimental Psychologists
Faculty House, Columbia University
April 15-16, 2016

John Anderson (Saturday 2:35 PM)
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Hidden Stages of Cognition Revealed in Patterns of Brain Activation

To advance cognitive theory we need to be able to parse the performance of a task into its significant mental stages. A new method is described that uses fMRI brain activation to identify when participants are engaged in different cognitive stages on individual trials. The method combines multi-voxel pattern analysis (MVPA) to identify cognitive stages and hidden semi-Markov models (HSMM) to identify their durations. I will report a test of the method's ability to localize experimental factors to their appropriate stages.

Ed Awh, Kirsten Adam, Josh Foster, Ed Vogel (Friday 4:45 PM)
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New evidence for item limits in visual working memory

Although there is a strong consensus that there are sharp limits for storage in working memory (WM), there is disagreement over the simple question of whether subjects ever fail to store an item in a WM task. Zhang and Luck (2008) pushed this debate forward by developing an analytic approach that provided strong evidence for random guessing in a test of recall from WM. But debate has continued with alternative models that account for the same empirical pattern by positing the existence of very low precision memories. Here we present new evidence from a whole report procedure in which subjects recall all items in each trial, and indicate whether they are guessing with each response. Subjects have excellent meta-knowledge. They report guessing approximately half of the time with a set size of six items, and the rate of self-reported guessing precisely tracks the guess rate estimated with Zhang and Luck's mixture model. Indeed, when subjects claim they are guessing, a parameter-free model that endorses guessing wins against the leading models that eschew item limits. Finally, we present novel evidence for guessing from an orientation WM task in which the empirical pattern generated by guesses can be clearly distinguished from one generated by low precision memories. Thus, we conclude that WM storage is subject to sharp item limits.

Ellen Bialystok (Friday 10:15 AM)
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Bilingualism as a Form of Experience-Dependent Plasticity

It is now well accepted that plasticity is a lifelong feature of the brain and that intense experience can impact both brain structure and cognitive processes. Evidence for the role of experience in shaping brain and cognitive systems has been reported for formal education, music training, video game playing, juggling, and spatial navigation, among other activities. A large body of evidence also shows that lifelong bilingualism affects both brain structure and cognitive function, effects that have been demonstrated across the lifespan. Some of the research, however, has become controversial because these effects are notoriously difficult to find in studies with young adults. I will review the argument for bilingualism as a form of experience-dependent plasticity, explain the mechanism for its impact on brain and cognitive systems, and address some of the complexities in this research that make it difficult to find these effects with young adults.

Irving Biederman, Eshed Margalit, Bosco Tjan, & Manan P. Shah (Saturday 12:15 PM)
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What is actually affected by the scrambling of objects when localizing LOC?

The lateral Occipital Complex, LOC, an area that has been shown to be critical for shape perception (James et al. 2003), is comprised of the Lateral Occipital Cortex (LO) and the Posterior Fusiform (pFs). It is defined (localized) as the region that shows greater fMRI activation when viewing intact objects compared to their scrambled versions (resembling texture). But scrambling a) reduces the familiarity of the objects, b) destroys the integrity of the parts, and c) leaves the relations among the parts undefined. We assessed the potential effects of familiarity, with strict control for low-level features, by modeling familiar objects, such as a chair or a lamp, and then rearranging the relations among the parts to produce novel, intact objects. By scattering the intact parts—but not breaking them up (as done in scrambling)—we could assess whether the reduced activation of LOC by scrambling an image of an object can be attributed to the loss of parts, the loss of the relations between the parts, or both, with different effects perhaps localized to different regions of LOC.

Intact objects, whether novel or familiar, both yielded equivalent activation throughout LOC, which was markedly greater than the activation produced by scrambling. In LO, intact objects (both novel and familiar) produced equivalent activation to scattered parts, suggesting that this area of LOC does not code interpart relations. However greater activation in pFs was evidenced by intact objects compared to scattered parts, suggesting that this region of LOC is sensitive to relations between parts.

Todd Braver (Friday 2:10 PM)
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Motivation and Cognitive Control

Classically, studies focused on the computational and neural mechanisms of cognitive control have tended to emphasize the "cognitive" dimensions of this construct. However, in recent years, this perspective has shifted towards one in which the engagement of cognitive control is construed as a motivationally dependent process, in which control costs (i.e., effort) are weighed against incentive value. I will suggest a theoretical framework in which the midbrain dopamine system and its targets play a central role, potentially driving motivationally-triggered shifts in cognitive control mode. I will present some experimental findings consistent with this framework, which: a) highlight the productive utility of motivationally focused cognitive control studies; b) reveal motivationally based distinctions between proactive and reactive control; and c) treat cognitive control engagement as an economic decision-making process.

Marvin Chun (Friday 10:35 AM)
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Decoding and Predicting Attention

Major advances in functional magnetic resonance imaging (fMRI) have given psychologists and neuroscientists unprecedented access to the workings of the human mind. Incorporating tools from machine learning and computational vision, we are using fMRI to decode attention salience maps from natural scenes (O'Connell et al., in prep). In a separate project to quantify attention, functional network analyses of whole brain functional connectivity allow us to fingerprint individual differences in sustained attention tasks (Finn et al., 2015; Rosenberg et al., 2015). Our models can also serve as neuromarkers to predict ADHD symptoms and the effects of Ritalin. fMRI can decode and predict behavior with increasing power and sophistication.

Nelson Cowan (Saturday 4:10 PM)
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The Use of Knowledge and Reasoning in Visual Working Memory

I will point out some basic ways in which knowledge and reasoning can contribute to performance in working memory tasks. The examples have to do with procedures in which an array of objects is presented and then, in a test display, changes in the array are to be detected. In the first study, any number of array colors could change from the studied array to a test array. The pattern of results suggests that participants overestimated how many items they had in working memory, and were biased by that erroneous information. They essentially reasoned that "If a lot of changes occurred, I would have noticed them given my good working memory, but I noticed few; therefore few items must have changed." In a second study, an array of colored shapes included only one instance of each color and each shape per array. A subsequent single-item probe was sometimes drawn from the array but, when it was not, it consisted of a color from

the array misbound to the shape of a different object from the array. When participants did not recognize the probe, only some of them appear to have used reasoning to infer the probe's absence from the array. This could be inferred if its color was known to have been bound to a different shape, or if its shape was known to have been bound to a different color. Other individuals appear to have guessed randomly when they didn't recognize the probe. In short, knowledge and reasoning help determine our working memory of what we just saw, more for some folks than for others.

Fergus Craik (Saturday 3:50 PM)
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Recognition without awareness: mechanisms and implications.

It has been known for some time (e.g. Adams, 1957) that people can make perceptual decisions with above-chance accuracy despite claims that they are guessing. The present paper shows evidence for this effect in word recognition using 4-alternative forced-choice tests, some of which contained no target word. The data of interest are cases in which a target was present and was correctly chosen despite participants' judgments that they were simply guessing. With regard to mechanism, the main factor associated with different levels of recognition without awareness in the present studies was a variable criterion for the subjective state accompanying selection of the "guess" option, depending on the overall difficulty of the recognition test. The results are discussed in terms of the distinction between implicit and explicit memory.

Emanuel Donchin (Friday 4:05 PM)
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"The Brain as a Finger" -- the current status of the P300 Brain-Computer Interface (BCI).

The P300BCI was invented 25 years ago (Farwell and Donchin, 1988) as a tool intended to serve the needs of "locked in" patients, such as patients suffering from ALS. These patients suffer total paralysis and, yet, their minds remain essentially functional. The P300BCI makes it possible for such patients to achieve almost full communication. in this talk I will review the current status of BCI's in general, and the P300BCI in particular. The challenges that must be addressed before the P300BCI can become a routine clinical tool will be examined.

Michael S. Fanselow, Sarah Hersman & Franklin B Krasne (Saturday 11:55 AM)
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Context Representations, the Hippocampus and Acetylcholine

In order for fear contextual fear conditioning to proceed animals must explore the environment to form a representation of the context. This process depends on the hippocampus. We have recently proposed a model that suggests that the hippocampus uses a Bayesian weight of evidence rule to determine if the environmental features sampled warrants retrieval of a past representation or the creation of a new representation. This model predicts many of the previously reported empirical observations for contextual conditioning. I will describe methods where we can enhance contextual fear conditioning by optogenetically driving cholinergic inputs to the hippocampus. I'll also describe techniques for the real-time measurement of hippocampal cholinergic activity using implantable choline biosensors.

K-P Thai, J. Y. Son, & **Robert L. Goldstone** (Friday 9:55 AM)
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The Simple Advantage in Perceptual and Categorical Generalization

Recent research in relational learning has suggested that simple training instances may lead to better generalization than complex training instances. We examined the perceptual encoding mechanisms that might undergird this Simple advantage by testing category and perceptual learning in adults with simplified and traditional (more complex) Chinese scripts. In Experiment 1, participants learned Chinese characters and their English translations, performed a memorization test, and generalized their learning to the corresponding characters written in the other script. In Experiment 2, we removed the training phase and modified the tests to examine transfer based purely on the perceptual similarities between simplified and traditional characters. We found the simple advantage in both experiments. On the basis of the results of these two experiments, we propose a simple process model to explain the perceptual mechanism that might drive this simple advantage, and in Experiment 3 we tested novel predictions of this model by examining the effect of exposure duration on the simple advantage. We found support for our model that the simple advantage is driven primarily by differences in the perceptual encoding of the information available from simple and complex instances. These findings advance our understanding of how the perceptual features of a learning opportunity interact with domain-general mechanisms to prepare learners for transfer.

Stephen Grossberg (Saturday 10:20 AM)
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Towards Solving the Hard Problem of Consciousness:
The Varieties of Brain Resonances and the Conscious Experiences that they Support

The hard problem of consciousness is the problem of explaining how we experience qualia or phenomenal experiences. To solve this problem, a theory of consciousness needs to link brain to mind by modeling how brain mechanisms give rise to conscious experiences, and specifically how the emergent properties of these brain mechanisms map onto parametric properties of

psychological data. This article summarizes evidence that Adaptive Resonance Theory, or ART, accomplishes this goal. ART is a cognitive and neural theory of how advanced brains autonomously learn to attend, recognize, and predict objects and events in a changing world. ART has predicted that "all conscious states are resonant states" as part of its specification of mechanistic links between processes of consciousness, learning, expectation, attention, resonance, and synchrony. It hereby provides functional and mechanistic explanations of data ranging from individual spikes and their synchronization to the dynamics of conscious perceptual, cognitive, and cognitive-emotional behaviors. ART has now reached sufficient maturity to begin classifying the brain resonances that support conscious experiences of seeing, hearing, feeling, and knowing. The talk will review various of these resonances, how they interact, and some of the psychological and neurobiological data that they explain. The talk will also mention some resonances that do not become conscious, and why. It will also clarify why not all brain dynamics are resonant in terms of the complementary organization of cortical processing streams.

Keith J. Holyoak (Saturday 11:15 AM)
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Relational Reasoning with Rational Numbers

The standard number system includes several distinct types of notations, which differ conceptually and afford different procedures. Among notations for rational numbers, the bipartite format of fractions (a/b) enables them to represent two-dimensional relations between sets of discrete (i.e., countable) elements (e.g., red marbles/all marbles). In contrast, the format of decimals is inherently one-dimensional, expressing a continuous-valued magnitude (i.e., proportion) but not a two-dimensional relation between sets of countable elements. These differences in format and conceptual structure are reflected in both behavioral and neural patterns associated with different types of rational numbers. Decimals naturally align with continuous quantities, whereas fractions align with discrete quantities. Magnitude comparisons are made more quickly with decimals than fractions, but fractions are advantageous for relational reasoning with discrete (or discretized) quantities. Processing a fraction evokes a different pattern of neural activity in the intraparietal sulcus than is triggered by decimals or whole numbers. Individual differences both in relational knowledge of fractions and in magnitude processing with decimals predict degree of early success in algebra. Implications for quantitative reasoning and education will be discussed.

David E. Huber and Patrice Rusconi (Saturday 1:55 PM)
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A perceptual habituation account of the attentional blink

The Attentional Blink (AB) is a temporary deficit for a second target (T2) after a first target (T1)

in rapid serial visual presentation. Current AB theories suppose this deficit reflects attentional gating but here we examined whether the AB can be explained without reference to attention. On our account, the AB reflects neural habituation for the perceptual representations that detect the appearance of a target. The nROUSE model of Huber and O'Reilly (2003) explains repetition priming deficits through neural habituation and we examined whether this model can also explain the AB. In two experiments, we examined the interaction between repetition priming and the AB with pre-T2 and post-T1 repetition priming (Experiment 1) and with repeated distractors (Experiment 2). Using default parameters, the nROUSE model predicted these results, as well as the 'spread of sparing' and the elimination of this effect reported by Chen and Zhou (2015).

Michael Kahana and Youssef Ezzyat (Friday 11:30 AM)
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Electrophysiological biomarkers of episodic memory

Human memory is highly variable across items and lists. To uncover the neural correlates of this variability we examine recordings from indwelling electrodes as neurosurgical patients studied and subsequently recalled word lists. These data have revealed that both narrow-band brain oscillations and broad-band power fluctuations recorded during study predict subsequent recall. Here we report multivariate analyses that reveal a widely distributed topography of high-frequency activity (70-100Hz) during memory encoding that accurately predicts subsequent recall. If variability in network physiology accounts for variability in behavior, we should be able to modulate the electrophysiology to alter behavior. We thus electrically stimulated hypothesized memory structures during the encoding a subset of memoranda in a delayed recall task. Stimulation produced a broad range of behavioral outcomes along the axis from impairment to facilitation. This variability in behavioral response turned out to be highly predictable on the basis of the multivariate biomarkers described above. Stimulation was most likely to improve memory when the biomarker signaled poor memory and it produced the greatest impairments when the biomarker signaled good memory. Across the regions stimulated, the stimulation-induced change in the multivariate biomarker predicted whether memory would be improved or impaired by focal electrical stimulation.

Charles Kemp and Terry Regier (Friday 3:10 PM)
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Word meanings across languages support efficient communication

Why do languages have the semantic categories that they do? I propose that language supports efficient communication and that systems of categories show the imprint of selective pressure for this function. Following Rosch and others, I will argue that good systems of categories are simple, which minimizes cognitive load, and informative, which maximizes communicative

effectiveness. These two constraints compete against each other, and I will suggest that semantic systems in the world's languages tend to achieve a near optimal tradeoff between these two constraints. To support this idea I will present analyses of kin categories and color categories across languages, and will also address the notorious topic of Eskimo words for snow.

Judith F. Kroll (Saturday 4:30 PM)
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How speaking two languages may change your mind

At each point in the life span, there is evidence that bilingualism changes minds and brains to be more open to learning, more cognitively flexible, and more resistant to cognitive decline. But what do bilinguals do with language that creates these changes? An initial answer to this question was provided by the observation that the bilingual's two languages are continually active, creating a need to resolve cross-language competition. The hypothesis was that the mental juggling required by cross-language activation created expertise beyond language itself to fine tune the mechanisms of cognitive control that supported language selection. More recently, we have come to see that the answer to this question is not quite so simple because bilinguals use language in many different ways that may have distinct consequences for cognition. In this talk I report a set of recent studies to illustrate the ways that bilinguals regulate the use of their two languages that may come to change their minds.

Carol Lynne Krumhansl (Saturday 10:00 AM)
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Listening niches over the century

"Cascading reminiscence bumps"(Krumhansl & Zupnick, Psychological Science, 2013) reported the results of a survey documenting intergenerational transfer of musical preferences from parents to contemporary young adults. The parents' music (from their own late adolescence and early adulthood, the typical "reminiscence bump") was associated with positive emotions and strong autobiographical memories in their children. I will report the results of a new survey using 100 years of top hits and 6 decades of music listeners. We trace how listening niches have changed over time, where listening niches are characterized by the decade of the music, the age of the listener, with whom they are listening, the context, and the music media. All generations listened to their parents' music with their parents and also exhibit the typical "reminiscence bump". However, earlier generations, unlike contemporary young adults, listened to very different music with their friends growing up than with their parents. Across the generations, however, preferences were found for the music of the 40's, 60's, and 80's which might be attributable in part to developments in music technologies in those decades.

Gordon Logan (Friday 5:25 PM)
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Different (Key)Strokes for Different Folks: How standard and nonstandard typists balance Fitts' law and Hick's law

We watch with amazement as the guitarist shreds the fretboard, the pianist tickles the ivories, and our fingers dance over the computer keyboard. The dazzling speed and effortless grace disguises the difficulty of the underlying choice process, which has to map 10 fingers onto 120-124 positions on the guitar neck, 88 keys on the piano, and 60-100 keys on the computer keyboard. The choice is constrained by two fundamental laws: Fitts' law relates movement time to distance and is optimized by recruiting more fingers. Hick's law relates choice time to the number of alternatives and is optimized by recruiting fewer fingers. To achieve high levels of performance, something has to give. Fitts' law is immutable (the distances don't change) but Hick's law bends with practice in consistent environments. Learning reduces the cost of adding more fingers. Thus, performers who use more fingers and use them more consistently should reach higher levels of performance than practitioners who use fewer fingers less consistently. We tested this prediction in skilled typewriting, comparing *standard typists*, who use the standard QWERTY mapping consistently, to *nonstandard typists* who depart from it by using fewer fingers or using fingers inconsistently. Nonstandard typists typed slower and less accurately than nonstandard typists, especially when they couldn't see the keyboard. Tests for hierarchical control showed that nonstandard typists know as little about how they type as standard typists, suggesting the same degree of automaticity with poorer performance. The results have interesting implications for teaching typing and other skills. Nonstandard typing may be good enough for jazz.

Randi Martin (Friday 9:35 AM)
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The role of task complexity in mediating relations of whole brain modularity to task performance

Recent work in functional neuroimaging has been directed towards understanding the interactions between brain regions involved in networks supporting task performance. Graph-theoretic approaches have been applied to obtain measures of network organization. The measure focused on here is modularity - which is the strength of connections of brain regions within a network relative to those between networks. Prior work has shown significant relations between individuals' degree of modularity and behavioral task performance, though the direction

of these relations has varied across studies. The present study addressed a proposal derived from work in theoretical biology (Chen & Deem, 2015) which predicts that highly modular networks are preferred for the performance of simple tasks at short time scales whereas networks with lower modularity (and higher between-network connections) are preferred for the performance of complex tasks at longer time scales. The present work addressed this proposal, deriving modularity from functional correlations among regions during resting state fMRI. In line with predictions, a positive correlation was obtained between modularity and performance on a simple attention orienting task and a negative correlation was obtained between modularity and performance on a complex working memory span task.

Chen, M., & Deem, M. W. (2015). Development of modularity in the neural activity of children's brains. Physical Biology, 12, 016009.

Dom Massaro (Saturday 2:55 PM)
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Multiple Influences on Vocabulary Acquisition: Parental Input Dominates

How spoken language is acquired has been an active area of inquiry in linguistic, psychological and speech science. New advances in this controversial field are promising given the recent accumulation of large databases of children's speech understanding and production, as well as various properties of words. This talk explores the contribution of a variety of potential influences on vocabulary acquisition including difficulty of articulation, iconicity, log parental input frequency, syntactic category, imagery, and concreteness. Although all of the variables have some impact at various ages and in various analyses, partial correlations and multiple regressions indicate that parental input in terms of child directed speech has by far the largest influence. Multiple regressions with these variables give a fairly complete account of spoken vocabulary acquisition.

Barbara Mellers (Friday 1:50 PM)
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University of Pennsylvania

Using Level Playing Fields to Improve Human Predictions

I report the highlights of four recent forecasting tournaments designed to uncover the most accurate ways possible to crowd source and aggregate numerical forecasts. Over 20,000 participants from around the world estimated the likelihood of geopolitical events ranging from pandemics and military conflicts to international agreements and refugee flows. Participants were randomly assigned to experimental conditions that tested elicitation methods (surveys vs prediction markets), social dynamics (independent vs collaborative forecasters who worked in small teams) and training in probabilistic reasoning. Deeper experiments of the top 2% of forecasters helped us understand the reasons for their extraordinary performance – levels of

accuracy that exceeded U.S. intelligence analysts predicting the same events with classified information. Improvements in forecasting accuracy came from behavioral insights about important human skills and traits, task insights about environments that were most conducive to learning, and statistical insights about which aggregation rules worked best.

Janet Metcalfe (Saturday 9:20 AM)
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Learning from Errors

It has often been thought that to be effective, performance during the processes involved in knowledge acquisition should be error-free. Some (but not all) Skinnerians have proposed that people and animals alike should be trained in a errorless manner. This assumption, though, has some adverse consequences including a reluctance to encourage students to actively generate possibilities and explore, because in so doing they are likely to commit errors. In contrast to this assumption, an increasing number of cognitive studies indicate that the commission of errors—as long as those errors are corrected-- results in enhanced learning. The literature in support of errorful learning, along with exploration of possible mechanisms for error correction, will be discussed.

Lynn Nadel (Saturday 11:35 AM)
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Targeting Forgetting During Sleep

It is known that specific memories can be reactivated during sleep, and as a function of that reactivation are typically strengthened. We wondered if sleep reactivation could be used to weaken memories. To test for this we taught participants a "forget" signal, that we then used during a sleep session in which recently learned objects were being selectively reactivated by playing the sounds associated with them. These sounds had been paired with the visual presentation of the objects during learning. We found that playing a forget tone caused a significant drop in recall of those objects then being reactivated during sleep. This result has clear potential for clinical application, and it contributes to our growing understanding of the ways in which sleep contributes to memory dynamics.

Nora Newcombe (Saturday 10:55 AM)
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Development of Episodic Memory: Which Dog Did I See-- and Where and When Did I See It?

Episodic memory relies on memory for the relations among multiple elements of an event (relational memory) and the ability to discriminate among similar episodes (pattern separation). However, research on pattern separation has been done primarily with young and older adults. In this talk, I will describe new tasks designed to assess both relational memory and pattern separation, which we used with 4- and 6- year-olds and young adults. On both tasks, 4-year-olds performed significantly worse than 6-year-olds and adults, whereas 6-year-olds and adults performed comparably, supporting the idea that changes in these processes account for the final offset of childhood amnesia. The two tasks did not correlate with each other in any age group, suggesting that they may be distinct processes.

Robert Nosofsky (Friday 3:45 PM)
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Qualitative Contrast Between Mixed-State and Variable-Resources Models of Visual Change Detection

Visual working memory is severely limited in its capacity. "Slots" models explain the capacity limit in terms of an all-or-none limit on the number of items that can be retained in memory: If an item is not retained, then the observer is forced to guess regarding its identity. Variable-resources models explain the limit by assuming that memory representations become increasingly variable if resources must be shared among multiple items, but there is no true guessing state. In this work, I develop an experimental paradigm that yields a sharp qualitative contrast between the predictions from important versions of these models. In brief, the paradigm relies on the idea that "variable memory" is conceptually distinct from an "absence of memory". The results strongly favor the mixture of memory-plus-guessing states assumed in the standard slots models.

Suparna Rajaram (Friday 11:50 AM)
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Stony Brook University

Social transmission of memory: Learning and remembering in groups

As social animals, people spend a majority of their lives learning and remembering with others. Couples, friends, families, study groups, work teams, and even cultures and societies constantly reconstruct the past together. Research on group memory has mainly progressed in the domains of history, anthropology, sociology, and social psychology whereas cognitive research on memory has focused on individuals working in isolation. The last decade brought about a major change in this divide where psychological scientists have begun to apply cognitive approaches to study how people remember in groups and how these group processes reciprocally shape the post-collaborative memory of each group member. I will present research from my lab that elucidates the cognitive bases of costs and benefits in memory arising from shared

remembering, the cascading effects of these changes that shape post-collaborative memory, and the social transmission of memory.

Lynne Reder (Saturday 9:00 AM)
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Constructing new knowledge: The interplay of familiarity, discrimination, partial-matching and working memory

In 12 hour-long sessions, subjects searched for different Chinese characters in a visual display of visually similar Chinese characters. Performance improved with practice but the rate of improvement was affected by the visual similarity of the other items in the display, such that learning was faster when the discrimination was more difficult. Subjects were better able to learn novel combinations of Chinese characters when the characters that comprised the novel pairs were more familiar. This learning advantage, based on more trials of visual search, did not hold when the other Chinese characters in the visual display were randomly selected from the set of all stimuli. Performance on an N-back task showed that less familiarized characters consumed more working memory than more familiar characters and that this effect was not based solely on a differential encoding advantage. We take these results as evidence that learning of novel chunks requires visual discrimination so that the learner cannot rely on partial-matching. However, when the stimuli to be encoded exhaust working memory resources, the learner may be obliged to fall back on partial matching to better known knowledge structures in order to perform the task at all.

Valerie F. Reyna, Rebecca B. Weldon, and Deanna Blansky (Friday 2:50 PM)
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Young, Hungry, and Risky: Relationships between Rewards and Representations in the Development of Risky Choice

Traditional approaches to the development of risky choice emphasize an imbalance between hot and cold cognition. The notion is that adolescents are more sensitive to rewards and are more likely to make decisions in a drive state, and, therefore, take more risks than adults. Fuzzy-trace theory acknowledges the effects of rewards and drives, but emphasizes developmental changes in mental representations of decision options that shape effects of rewards and drives. To test competing hypotheses, we compared adolescents and adults and varied whether they were hungry or not, as well as the size of food (candy) or money rewards. They completed risky-choice tasks for gains and losses (with real incentives to receive or lose candy and money) and we induced reliance on verbatim vs. gist representations; they also rated the reward value (liking

and wanting) for all outcomes. Larger rewards were rated higher in liking and wanting than smaller rewards, and hunger increased reward values. Contrary to expectations of traditional approaches, adolescents and adults took fewer risks when hungry and fewer risks for larger rewards. As predicted by fuzzy-trace theory, risk taking depended on frame, which changed with age: Adults showed great framing differences—avoiding risk for gains and seeking risk for losses—compared to adolescents. Relationships among rewards, drive states, and risk taking across age groups will be discussed, examining how cognitive and motivational factors combine to shape risk taking.

Robert Sekuler (Friday 4:25 PM)
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Brandeis University

Ensemble statistics seem to be everywhere: What good do they do?

In many different conditions, subjects extract ensemble or summary statistics from complex spatial or temporal displays. Usually, this fact is revealed by explicitly instructing subjects to extract such statistics. However, we find that even when unbidden to do so, subjects often extract and rely on such statistics when making perceptual judgments. I will describe several studies of this phenomenon and identify some of the circumstances in which such statistics are helpful.

Richard Shiffrin (Saturday 9:40 AM)
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A Bayesian metric for network similarity

A Bayesian-inspired metric is proposed for the similarity of two networks of possibly different sizes, each consisting of nodes and links, the nodes and links possibly having associated strengths. The nodes are labeled so which nodes and links are shared, and which non-shared, are known. The metric is based on a ratio: The probability that the two networks are generated by a common master network, divided by the probability that the two networks are generated by two different (but similar) master networks. In each case the observed networks are generated by random sampling from the master network(s). An approximation is used to name the algorithm computationally efficient and usable for very large networks.The method can also be used to align unlabeled networks by finding an alignment that maximizes similarity.

Robert Siegler (Friday 9:15 AM)
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Numerical Development

The historian Arnold Toynbee asked: "Does history have unifying themes, or is it just one damn thing after another?" In this talk, I pose Toynbee's question in the context of numerical development, and conclude that it does indeed have a unifying theme: Progressive broadening of the ranges and types of numbers whose magnitudes can be accurately represented. Development of numerical magnitude knowledge proceeds from non-symbolic to symbolic numbers, from small to large whole numbers, and from whole to rational numbers. Precise magnitude representations are important not only for their own sake but also because they are correlated with, predictive of, and causally related to other important numerical competences, such as arithmetic. Educational issues raised by the theory will also be discussed.

George Sperling (Friday 12:30 PM)
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Visual Attention

Abstract: TBA

John Staddon (Saturday 3:30 PM)
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The Pigeon and Prospect Theory

Operant learning involves selection by reinforcement from a repertoire of 'emitted' activities. A simple model along these lines, the cumulative effects model (CEM), can explain many aspects of non-temporal learning, such as the initial phase of acquisition, regression effects, improvement across discrimination reversal and 'choice' between identical probabilistic schedules. A popular model for human choice behavior is prospect theory, a hybrid with a cognitive 'front end' followed by an expected-utility back end. The model is both incomplete, because the front-end is ill-specified, and inadequate because it fails to account for individual differences and some group preferences. Kahneman's 'fast-slow- distinction hints that that the selection/variation approach is a better way to understand both human and animal choice behavior.

Josh Tenenbaum (Friday 12:10 PM)
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Massachusetts Institute of Technology

Three principles for one-shot learning:
Compositionally, causality and learning-to-learn

At a time when machine learning and artificial intelligence are making great strides, it is worth considering which essential human learning abilities remain elusive for machines.
People learning new concepts can often generalize successfully from just a single example, yet machine learning algorithms typically require tens or hundreds of examples to perform with similar accuracy. People can also use learned concepts in richer ways than conventional AI algorithms—for action, imagination, and explanation. I will present a computational model that captures these human learning abilities for a large class of simple visual concepts: handwritten characters from the world's alphabets. The model represents concepts as simple programs that best explain observed examples under a Bayesian criterion. On a challenging one-shot classification task, the model achieves human-level performance while outperforming recent deep learning approaches. I will also present several "visual Turing tests" probing the model's creative generalization abilities, which are indistinguishable from human behavior in fine-grained ways. Psychologists have been fascinated by one-shot learning for many decades; philosophers, for centuries. Personally, I have been studying one-shot learning since my PhD dissertation in the late 1990's. But this is the first time when I believe it is fair to say that we have a model which satisfyingly explains how humans can learn a large class of real-world concepts (albeit simple ones), from just a single example. More generally, I will discuss how our model instantiates three principles — compositionally, causality, and learning-to-learn — which should be broadly valuable in explaining human learning and conceptual abilities across many domains. I will also provide pointers for how all SEP researchers can freely access our "Omniglot" dataset, comprising 20 examples each of more than 1500 different handwritten characters in 50 alphabets. These 30,000 images could be useful to many researchers studying perception, attention, memory, or motor planning — not only those interested in inductive learning. (This is joint work with Brenden Lake and Ruslan Salakhutdinov.

Herbert Terrace (Friday 2:30 PM)
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A Modest Proposal for The Evolution of Language.

Given that language is uniquely human, how can the theory of natural selection explain its origins? It has been argued that recent advances in our understanding of the phenotype for language have greatly clarified its evolution. It has also been claimed that language evolution "will remain one of the great mysteries of our species". Chomsky has recently defended both positions. He argues that language is uniquely human because of our ability to use *merge* and *recursion* to generate an essentially infinite number of sentences, -an ability he attributes to a "simple rewiring of the brain" about 100,000 years ago. That hypothesis is contrary to the generally held view that behavioral variation is a prime mover of evolutionary changes. Although Chomsky's computational model can account for the syntactical ability of people who know language, it doesn't account for the origin of words, which, as he acknowledged, must have evolved before syntax. There is now ample knowledge of early mother-infant exchanges that sets

the stage for the emergence of words and a plausible scenario for the development of words in *Homo erectus*.

Nicholas Altieri, Jennifer J. Lentz, **James T. Townsend**, and Michael J. Wenger
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The McGurk Effect: An Investigation of Attentional Capacity Employing Response Times

This paper proposes a novel approach to assess audiovisual integration for both congruent and incongruent speech stimuli using reaction times (RT). The experiments are based on the McGurk effect, in which a listener is presented with incongruent auditory-visual speech signals. A typical example involves the auditory consonant /b/ combined with a visually articulated /g/, often yielding a perception of /d/. We quantify the amount of integration relative to the predictions of a parallel independent model as a function of attention and congruency between auditory and visual signals. We assessed RT distributions for congruent and incongruent auditory and visual signals in a within-subject signal detection paradigm under conditions of divided versus focused attention. Results indicated that listeners often received little benefit from congruent auditory visual stimuli, even when such information could have improved performance. Incongruent stimuli greatly degraded performance in divided and focused attention conditions. Our findings support a modality specific model of auditory-visual integration with interactions between auditory and visual channels.

Michael T. Turvey (Friday 5:05 PM)
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Perception-Action Without a Nervous System

The single-cell microscopic species Difflugia (a shelled amoeba) exhibits complex forms of perception-action well expressed by its building and predatory abilities. Each individual in each genus constructs from scratch a testate (a portable shell) by first collecting in its interior a minimal number (e.g., 300) of grains of sand, silica, etc. of sufficiently different sizes satisfying particular ranges. It then separates the collected materials by size and proceeds to assemble the testate (unique to its genus) via a graduated sequence of selecting, ordering, and uniting materials into a composite whole that is the testate. When encountering a rotifer, an organism with a thick gelatinous covering, Difflugia tuberspinifera determines, by means of probing with several

pseudopods, the organism's orientation, length, and how it is to be eaten. In timely fashion, tuberspinifera orients to the foot-end where the sheaf can be prised open (by using the elaborate teeth-like entrance to the testate) and the rotifer can, as a consequence, be ingested. These abilities raise a variety of questions, both general and specific. For example: "How can a non-neuronal system behave like a neuronal system?" "How can a system of indefinitely many degrees of freedom become a task-specific system of relatively few degrees of freedom?" "How can Difflugia assemble and control with precision the pseudopod motions required for building and hunting?" These abilities absent nervous system invite clarification of the distinction between general physical principles and biological mechanisms as the basis of perception and action. They present a very special theoretical challenge.

Barbara G Tversky (Saturday 1:35 PM)
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Thinking with the Body and the World

Spatial thinking pervades our lives. It uses the body and the world to think and to communicate. It has more direct connections to thought than language and and often succeeds where language is inadequate. Spatial thinking has its own structure, different from language and arguably a basis for language. Recent work in our lab will support these claims.

Joe W. Tidwell, **Thomas S. Wallsten**, and Don A. Moore (Saturday 4:50 PM)
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Eliciting and Aggregating Forecasts of Continuous Variables in The Real World

Last year at SEP we presented laboratory research, now published in *Decision* (http://dx.doi.org/10.1037/dec0000047), on developing methods for modeling and aggregating continuous probability distributions from relatively few discrete judgments by individual forecasters. This presentation describes two experiments on continuous-variable forecasting of real sociopolitical events. Experiment 1 included 382 forecasters randomly assigned among 3 conditions that differed in how cut points were placed on the continuum to create bins for the purpose of eliciting probability judgments. Over an 8-month period they received 127 forecasting questions, 106 of which were *when* questions. The remaining 21 concerned proportions or quantities. An example of the former is "When will the European Commission, the European Central Bank, or the IMF next agree to release any bailout funds to Greece?" An example of the latter is, "What will be the highest end-of-day close for the U.S. dollar-Chinese renminbi exchange rate between 1 October 2014 and 1 February 2015?" Experiment 2 included 155 forecasters randomly assigned to either of two conditions that differed in whether the bins remained fixed or changed over the course of a forecasting problem. This study lasted six months

and included 70 of the *when* questions. In both experiments, individuals forecasted on as many questions as they wished and revised their forecasts whenever they wanted.

We fit continuous probability distributions to individuals' discrete forecasts on a daily basis and aggregated the modeled forecasts into consensus distributions within conditions. We present participation rates and accuracy scores as a function of the various conditions, summarize what we have learned and some of the remaining open issues. A two-word summary for the abstract: Very encouraging.

Elke U. Weber (Friday 11:10 AM)
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Risk as Feelings and Perception Matters: Psychological contributions on Risk and Risk Taking

This talk will review some of my contributions to the topic of risk, which have had the following goals: (a) building descriptive theory and models about human perceptions of risk and actions in the face of risk and uncertainty, (b) applying these psychological theories and insights to explain economic puzzles or so-called anomalies, that is observed deviations in reported reactions or behavior from what the rational models would predict; and (c) designing choice environments that capitalize on human strengths and minimize the impacts of human shortcomings to help people achieve their long-term goals in domains that range from pension investments to environmental decisions.