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Organizer: George Sperling, University of California, Irvine

ABSTRACTS

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John Antrobus
City University of New York

A Connectionist Word Recognition Model of Implicit Priming of the Target and Foils
Authors: J. Antrobus, B. Sundaram, Y. Shono, M. Duff, R. Farahani, & C. Tarshish

Using a forced-choice (FC) recognition procedure, Ratcliff and McKoon (R&M, 1997) found that priming biases word recognition accuracy when the FC alternatives are similar (died/lie) to one another, but *not when dissimilar* (died/sofa, N=16). Arguing that this difference is incompatible with existing priming models because they posit a change in the representation of the primed word, R&M proposed a counter (random walk/diffusion) model that was not tied to any perceptual features.

Using the same FC procedure, but holding baseline accuracy to .75, we find that dissimilar priming (N=177) is smaller than similar (N=200) - but not absent. A simple leabra connectionist word recognition model that simulates priming of a target or foil word by adding activation to the representation of that word, shows that, as R&M claimed, "priming" can bias recognition of *both* similar and dissimilar targets. But the bias magnitude is smaller for dissimilar words so that for any primed word there is some level of independent activation that will bias a similar *but not a dissimilar* word. This weaker dissimilar effect is due to the greater distance between their basins of attraction in the landscape of word attractors.

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Benjamin Backus
SUNY College of Optometry

Proposal for a New Treatment of Strabismus

In the middle of the 20th century, strabismus and other binocular disorders were treated using a device called a synoptophore (or amblyoscope). Treatment consisted of whole field binocular synchronous light flashes, and/or instructing patients to look at binocular stimuli until the stimuli had a desired appearance (such as spots, presented to one eye, appearing on the side of a deer, presented to the other). This treatment did not garner wide support among clinicians. Instead, a preferred treatment is surgery that physically rotates the eye by changing the effective lengths of the eye muscles. This surgery does sometimes restore binocular function, but for the most part it treats the symptom. Strabismus is usually central in origin. Fixation and motility during monocular viewing are often excellent, with an eye turning only when both eyes are open (accordingly the target of synoptophore treatment was the CNS, not the eye). Two major scientific advances have occurred to improve synoptophore treatments: we have better models of binocular neurons' receptive fields, and we can, at least in principle, control binocular stimulation with good accuracy and precision in both eyes simultaneously in patients who cannot fixate binocularly. I will review the old theories and treatments for strabismus and describe a proposed new treatment.

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Farran Briggs
University of California, Davis

Spatial Attention Modulates Synaptic Efficacy in the Geniculocortical Circuit
Authors: F. Briggs & W. M. Usrey

Spatial attention has been shown to modulate the firing rate and trial-to-trial variability of neuronal activity in early visual cortical neurons; the mechanisms underlying these effects, however, are not known. Here we report preliminary data suggesting that spatial attention increases the synaptic efficacy of geniculocortical communication. In an awake-behaving monkey, we semichronically implanted stimulating electrodes in the lateral geniculate nucleus such that we could stimulate the synaptic inputs to individual identified geniculocortical-recipient neurons recorded in layer 4C of primary visual cortex (V1). During the spatial attention task, the animal was instructed to attend to optimal gratings placed within or outside the receptive fields of the recorded geniculocortical-recipient neurons. Within 150 msec prior to a contrast change to the attended stimulus, the time window in which attention is thought to reach its peak, we stimulated the geniculocortical inputs to the recorded postsynaptic neurons in V1. Importantly, stimulation levels were set such that half of the stimulation trials resulted in postsynaptic spikes. We found that the majority of geniculocortical-recipient neurons demonstrated an increase in the probability of postsynaptic spiking in response to stimulation during trials in which the subject attended to the stimulus within the recorded neuronal receptive field. Attentional increases in geniculocortical synaptic efficacy correlated with attentional modulation of overall firing rate during the peak attentional window. Finally, there is evidence of some cell-type specificity in overall firing rate modulation by attention, as well as attentional modulation of synaptic efficacy. These results provide the first evidence that spatial attention modulates neuronal activity at the synaptic level and provide clues as to the mechanisms by which attention influences neuronal communication.

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Angela Brown
Ohio State University

The Measurement of Infant Contrast Sensitivity
Authors: A. M. Brown & D. T. Lindsey

Normal human infants have reduced contrast sensitivity compared to adults because of immaturities in the ascending visual pathway, likely in the form of large amounts of added intrinsic noise. This reduced contrast sensitivity, together with known morphological immaturities of the infant cones, accounts for a wide range of immature visual performance in normal infants. It is not known to what extent visual performance is limited further by contrast insensitivity in infants and children with visual disorders, because there is no sensitive, reliable, valid, and established test of contrast sensitivity in patients who cannot read the Pelli-Robson eye chart.

Here, we propose such a test. Rather than measuring the several parameters of the full contrast sensitivity function (CSF) using sine wave gratings at several spatial frequencies, we propose using a single, very low spatial-frequency square-wave grating to measure the maximum of the CSF, without knowing at what spatial frequency it occurs. The key insight is that the amplitude of the harmonics in a square wave varies inversely with spatial frequency, whereas their packing density varies directly with spatial frequency. Therefore the spatial frequency channels all receive approximately equal stimulation: the low spatial frequency channels detect fewer, higher-amplitude harmonics, whereas the high frequency channels detect more, lower-amplitude harmonics. The Quick pooling formula predicts that the overall response will be dominated by the most sensitive channel, which is nearest the peak of the CSF. Thus, if the square-wave stimulus has a low enough spatial frequency, its contrast sensitivity value is a measure of the maximum sensitivity of the visual system.

A clinical test based on a very low spatial frequency square wave will allow the clinician to measure the maximum of the contrast sensitivity function in a single measurement, without knowing the spatial frequency at which it occurs. We anticipate that a test of the maximum of the CSF will provide an important measure of the overall visual performance of infant, toddler, and handicapped patients who cannot read an eye chart.

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Thomas A. Busey
Indiana University

Features and Strategies Used by Latent Print Examiners

Latent print examinations can be difficult visual comparisons since they are often performed on very degraded and partial fingerprints. Visual detail that is useful for individualization or exclusion can take the form of minutiae, ridge flow, or clusters of other features that have yet to be documented. We approach this problem by collecting eye gaze data from latent print examiners and novices to determine those features that capture fixations. Under time-limited viewing conditions,

experts show more consistency than novices in terms of the locations they visit. In addition, their eyes move toward matching locations faster and more accurately. The image content (pixels) of fixated regions can also be analyzed to determine the characteristics of the ridge detail that attracts the gaze of experts, and we discuss various machine-learning approaches that separate experts from novices.

Patricia Cheng
University of California, Los Angeles

Are Preschoolers Humean or Kantian Reasoners?
Authors: P. Cheng, M. Liljeholm, & C. Sandhofer

Two dominant approaches to evaluating cause-and-effect relations are the associative Humean approach and causal Kantian approach. The former underlies most current statistical methods. Our analysis shows that these approaches imply a difference in how the *uniformity of causal influence* -- the unchanging nature of the forces of change -- is defined: on observable events (Humean), or on causal influences (Kantian), which are unobservable. We investigated which definition humans naturally adopt by testing how preschool children chose actions to achieve a goal. The Kantian definition is more logically consistent than the Humean one for testing hypotheses on causal relations, but requires more complex calculations involving multiplication with fractions. Our experiments show that preschoolers are Kantian, suggesting that the abstract concept of the uniformity of causal influence is precisely and innately encoded, and the human causal-learning process is implicit and rational.

Rosie Cowell
University of California, San Diego

Simulating Memory: Do Amnesics Forget Because Old Things Look New, or Because New Things Look Old?
Authors: R. Cowell, T. Bussey, & L. Saksida

Object recognition is the canonical test of declarative memory, the type of memory impaired by damage to the medial temporal lobes of the brain (e.g., in certain types of amnesia and in Alzheimer's Disease). Animal studies of object recognition memory have indicated a critical role for perirhinal cortex (a subregion of the medial temporal lobe) in declarative memory. I will present a neurocomputational model of object recognition memory in perirhinal cortex. A central assumption of the model is that perirhinal cortex stores representations of the conjunctions of visual features possessed by complex objects. The model claims that object recognition memory fails when perirhinal cortex is damaged because these conjunctive object representations are compromised. Thus, unlike prevailing theories of amnesia, the model contains no special "module" for memory that malfunctions in amnesia; it suggests simply a loss of the visual representation of an object that would normally be located in the region of brain damage. The model accounts for the classic findings concerning impaired recognition memory following perirhinal cortex damage. In addition, it makes novel predictions, for example that brain damage causes a subject to forget not because familiar objects appear new, but because new objects appear familiar. I will present simulation results demonstrating this novel prediction and others, along with the results of a lesion study in rats that tested and confirmed this prediction.

Peter Dixon
University of Alberta

Dyadic Digit Oscillation, or Finger Wiggling With a Partner

Subjects performed coordinated, left-right finger movement either bimanually or with a partner. In keeping with previous research, individual bimanual coordination was easier with instructions to perform mirror-image oscillations than with instructions to perform parallel oscillations (in which both fingers move right at the same time and then left at the same time). Coordination with a partner was generally more difficult. When performed with a partner, however, the difference

between mirror-image and parallel oscillations was not observed. Indeed, in some cases, the parallel oscillations condition was easier. I hypothesize that the coordination depends on how the movement targets are coded in terms of the dynamic spatial environment and that this environment is represented differently for individuals and for dyads.

Barbara Doshier
University of California, Irvine

Precision of Representations in Spatially Cued Attention.

Mark Frye
University of California, Los Angeles

Motion Perception in Drosophila
Authors: M. Frye & J. Apteekar

You are a vision machine. Spatial and temporal patterns of photoreceptor activation feed onto neuronal circuits that perform computations to evoke each of your most elaborate visual perceptions. How do sophisticated visual computations emerge from specific neuronal microcircuits? We address this question in flies because the speed and robustness of visual motion processing in flies is unmatched in the animal kingdom. A housefly can alter its course within 40 milliseconds of a pursuit target image being displaced on its retina – a complex neuromechanical cascade that includes stimulus detection, motion processing, sensory-motor transformation, and biomechanical output. Such extreme sensory-motor performance levels highlight the functional algorithms for biological motion coding. We use electronic “virtual reality” flight simulators to formally characterize how fruit flies (1) stabilize their visual gaze against perturbations of panoramic optic flow, and (2) actively chase down interesting visual objects. In short, we will show you how to fly a fly.

Xiaoping Hu
Emory University

Neuroimaging Investigation of Neural Effects of Prenatal Cocaine Exposure
Authors: Z. Li, C. Coles, M. E. Lynch, G. Desphande, S. Hamann, & X. Hu

Prenatal cocaine exposure (PCE) is a major insult to brain development during gestation. Since arousal dysregulation is one of the major findings of previous work on neurodevelopmental effects of prenatal cocaine exposure, our initial neuroimaging studies of PCE focused on alterations in the associated neural networks and their effects on cognitive function. Using a working memory task with emotional distractions, our first study revealed that the suppression of amygdala activation with increased memory load in normal subjects was diminished in the PCE adolescents. The unsuppressed emotional arousal in turn affected cognitive prefrontal activation. To further our understanding along this line, we expanded our investigation to examine the PCE effect on the “default mode” network both in terms of deactivation and functional connectivity derived from resting state data. The exposed adolescents were found to exhibit a reduced deactivation and increased functional connectivity in this network. These results suggested an increased baseline arousal and altered excitatory/inhibitory balancing in the exposed adolescents. Because arousal regulation and inhibitory control are key functions of prefrontal cortices, we next focused on the ventral prefrontal region using fMRI, resting-state fMRI, and DTI. We observed a reduced inhibitory effect of this region over bilateral amygdala in the PCEs. In addition, causal influence from ventral prefrontal cortex to amygdala and structural connectivity between them were found to be diminished in the exposed adolescents. This study complemented our findings of PCE impact on amygdala and suggested possible structure-function association underlying the arousal dysregulation. While all of these studies focused on PCE effect in specific brain regions/networks, these regions do not play in isolation in brain function. In a more recent study, we examined effective connectivity between all regions affected by PCE and using Granger causality analysis and support vector machine classification and demonstrated that changes of effective connectivity allow us to predict, with 98%

accuracy, whether any given subject was prenatally exposed to cocaine, even in the absence of behavioral abnormality. This last study may lead to the development of imaging based diagnostic biomarker.

David Huber
University of California, San Diego

Adaptation to the Temporal Statistics of Spatial Cueing
Authors: C. A. Rieth & D. E. Huber

Spatial cueing produces facilitation for short (< 150 ms) cue-target SOAs but deficits for long (> 300 ms) SOAs. These deficits are termed inhibition of return (IOR). We tested whether this reflects environmental regularity by training participants that the SOA determines target location. Following training that targets appear on the cued side only for long SOAs, the IOR was reversed. In contrast, the IOR was enhanced after training that targets appear on the uncued side only for long SOAs. However, no training effects were observed for short SOAs. A subsequent experiment used only short SOA training to avoid the ambiguities of training with both short and long SOAs. With this change, training modulated spatial cueing even at short SOAs. These results are compatible with the claim that spatial cueing is a learned behavior that incorporates not only expectation of location but also expectations of time.

Holly Jimison
Oregon Health & Science University

Evaluating Approaches to Cognitive Health Interventions
Authors: H. Jimison & M. Pavel

Maintaining cognitive health is a key concern of older adults and an important factor in being able to age in place. Several studies have shown evidence for neural plasticity at older ages, leading to a recent surge in both commercial and research-based cognitive interventions. In this talk I will review the evidence on the effectiveness of various approaches to cognitive training, both in the healthy elderly as well as those with various forms of dementia. Research-based has training typically targeted speed of processing, attention, working memory, and executive function more generally. Concerns regarding the evaluations of cognitive training so far have been that the focused interventions do not seem to generalize to everyday life and that the effects may not last over time. Additionally, most of the research approaches have been found to be quite onerous by the participants leading to poor adherence outside of a study environment. Commercial systems have typically used computer games to provide cognitive exercise within an enjoyable activity. However, most of these have not been well tested. To address these issues, we have created a Cognitive Health Coaching platform designed to deliver modular cognitive interventions with tailored coaching messages based on home monitoring data. This system is being used to compare the effects of game technologies and lifestyle interventions such as physical exercise, sleep management, mood management, and socialization on cognitive performance. The modular design allows us to deliver interventions within a similar coaching framework that encourages optimal use and adherence over time.

Kerry Jordan
Utah State University

Numerical Cognition in Children and Coyotes

My lab investigates numerical cognition in human children and non-human animals. Redundant, multisensory stimuli can facilitate animal and human behavior in areas as diverse as rhythm discrimination, signal detection, orienting responses, maternal call learning, and associative learning. I have recently found that multisensory stimuli also boost numerical performance during childhood. The first experiment I will present tested preschool children who performed more accurately in a numerical matching task when given multisensory rather than unisensory information about number. Intersensory redundancy boosted performance especially for more difficult numerical comparisons, supporting a

mechanism of improved precision of numerical representation. I speculate that this mechanism may potentially include a switch in representational format from approximate, nonverbal analog magnitude representation of number over unisensory input to a more precise, linear verbal representation of number over multisensory input. I will next present an experiment designed to test quantitative abilities in coyotes. In particular, I tested the ability of coyotes to discriminate between large and small quantities of food items. I show that coyotes can reliably discriminate between large versus small quantities of food, and these quantitative discrimination abilities are mediated by the numerical ratio between the large and small quantities of food. This trend is indicative of an analog magnitude system of quantity representation. Taken together, data from this series of studies suggests that humans and nonhuman animals may share a system of approximate nonverbal number representation; this system may be enhanced when receiving multisensory rather than unisensory information about number.

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Shaw Ketels
University of Colorado at Boulder

The Anchoring Heuristic in Intelligence Integration: A Bias in Need of De-biasing
Authors: S. L. Ketels, C. D. Wickens, A. F. Healy, C. J. Buck-Gengler, & L. E. Bourne, Jr.

In information integration tasks, anchoring is a prominent heuristic, such that the first few arriving information sources (cues) tend to be given greater weight on the final integration product than those cues following. Such a bias may be particularly problematic when the situation is dynamic, such that earlier arriving cues are more likely to have changed, and hence are less reliable for the final integration judgment. Such is often the case in military intelligence, when enemy intentions are inferred from multiple sources. We describe results of a simulation of such intelligence gathering in which anchoring is prominently manifest, in the processing of seven sequentially delivered cues bearing on enemy threat. In Experiment 1 an anchoring bias was present. In Experiment 2 a simple “debiasing” wording, inserted in the instructions and emphasizing the age of intelligence information, induced more optimal weighting of the most recent cues, but did not eliminate anchoring.

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Michael Lee
University of California, Irvine

Combining Knowledge Through Competition
Authors: M. Lee, J. Shi, E. Grothe, & S. Zhang

We present two real-world case studies exploring the idea that competition is an effective way to combine knowledge distributed across people. The first case study involves the Intrade prediction market, where people's estimates of propositions like "Obama to win presidency" are aggregated through the competitive trading of stock. We show that the group aggregate probabilities rarely, if ever, show the sorts of logical fallacies usually found in individual people's estimation of probabilities. The second case study involves the game show "Price is Right," where players have to estimate the price of a prize in a competitive setting. We show how, using models of decision-making, their individual estimates can be combined to give a more accurate group estimate or the true price. We argue competition provides a way of exposing people to the opinions of others in a way that calibrates, rather than anchors, their estimates, and forces people to contribute their knowledge in a way that improves group estimates. These properties make competitions well suited to knowledge aggregation in many real-world settings.

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Del Lindsey
Ohio State University

Color-Naming Motifs in English and the World Color Survey
Authors: D. T. Lindsey & A. M. Brown

To understand the relationship between color naming and color appearance, investigators have traditionally studied color naming across languages, and have emphasized the language-to-language variability in the number of color terms in the lexicon and how they are assigned to colored stimuli. Our analyses of the World Color Survey (WCS) and English suggest that greater emphasis should be placed on the color-naming behavior of the individual informant.

The WCS is a data set of color terms of 2,616 monolingual individuals, each living in a pre-industrial society and speaking one of 110 unwritten languages. We have used clustering techniques to study the structures of the color-naming systems represented in these languages. The color-naming data from individual WCS informants clusters into about 4-6 universal “motifs,” or characteristic combinations of color terms used to name a standard set of color samples. These motifs occur worldwide, with minor variation across individuals, across and, strikingly, within languages: most WCS languages included multiple motifs among their speakers.

Here, we report new work where we used the same clustering techniques to study individual variation in the color categorization of 57 American English informants living in Columbus, OH. Although our subjects used 100 different color names among them, these represented only about eighteen distinct color categories: the eleven Basic Color Terms of Berlin and Kay (1969), and seven supernumerary “non-basic” colors. These categories were organized into at least two distinct American English motifs: one that included only the eleven basic terms, and one that included the seven additional terms from our glossary. Although women used more color terms than men, once the synonymous color terms were glossed to the eighteen categories, equal numbers of men and women fell into each of the two motif groups.

Our results lead to three conclusions that apply equally well to English informants living in a modern industrialized society, and informants in other parts of the world living in preindustrial societies: (1) diversity of color categorization within the language is the rule rather than the exception, (2) individual differences in color categorization behavior are not idiosyncratic, but are well characterized by a few motifs, and (3) these features of color categorization are revealed only by examination of color naming at the level of the individual rather than at the level of the language as a whole.

Zhong-Lin Lu
University of Southern California

Mechanisms of Perceptual Learning of Adults with Amblyopia

Amblyopia is a developmental visual disorder characterized by reduced vision in the absence of any detectable structural or pathological abnormalities that cannot improve with refractive correction. In traditional clinical practice, only young child amblyopes (8 yr old) are treated, because of “conventional wisdom”: that spatial vision, fully developed by that age, is no longer subject to therapeutic modifications. However, we found significant improvements in contrast sensitivity and visual acuity by training adults with anisometric amblyopia to detect sinewave gratings at their cutoff spatial frequencies. The improvements reflect a mixed mechanism of internal noise reduction and external noise exclusion. We further demonstrated that the bandwidth of perceptual learning in the amblyopic visual system is much broader than that of the normal visual system. The broader bandwidth, suggesting more plasticity and wider generalization in the amblyopic visual system, provides a strong empirical and theoretical basis for perceptual learning as a potential treatment for amblyopia.

Anna Manelis
Carnegie Mellon University

Combining fMRI and Eye-Tracking to Understand Contextual Cueing in Visual Search Authors: A. Manelis & L. M. Reder

Contextual cueing is characterized by facilitation of visual search when a target appears within learned spatial configurations (Chun and Jiang, 1998). We recorded eye movements while subjects performed an abbreviated contextual cueing task in a scanner. Both response time and number of eye fixations to locate the target in a display decreased with practice but this decrease was greater for repeated than novel displays. While improvement for novel displays may reflect procedural learning, improvement for repeated displays may reflect a mixture of both task learning and learning of the contextual cues. If contributions from procedural learning and contextual cueing are independent, the patterns of neural activity in the procedural learning regions should not depend on whether spatial configurations are novel or repeated. The analysis of repeated display trials (contrasting early and late trials) revealed a strong correlation between repetition-related

changes in BOLD signal and the number of fixations in right hippocampus, right inferior temporal gyrus, bilateral frontal and parietal regions. The same (early vs. late) analysis of novel displays revealed a strong correlation between these measures in right superior parietal lobule, bilateral occipital fusiform and prefrontal regions, a network distinct from that for repeated displays. Given that the neural regions associated with practice for novel displays were not replicated for repeated displays, there is little support for the position that procedural learning and contextual cuing are independent. The strong correlation for repeated trials between increases in hippocampal activation and decreases in the number of fixations leads us to believe that the contextual cueing effect results from successful binding of a specific target location to its repeated spatial context.

Gail McKoon
Ohio State University

Reading and the Diffusion Model: How Do We Measure Inferences?
Authors: G. McKoon & R. Ratcliff

Older adults suffer significant deficits in some forms of memory, but do related deficits occur in reading comprehension? With studies of inferences (e.g., McKoon & Ratcliff, 1986), we compare older to younger adults. The two groups differ in baseline error rates and response times, so their performance cannot be directly compared. We show how Ratcliff's diffusion model solves this problem.

Danielle S. McNamara
University of Memphis

Capturing Coherence in Writing
Authors: D. S. McNamara & S. Crossley

This talk reviews studies in which human judgments of essay quality and coherence are assessed using Coh-Metrix, an automated text analysis tool (see cohmetrix.memphis.edu). The goal of these studies is to better understand the relationship between human judgments of writing quality and linguistic features of essay quality related to coreference, connectives, syntactic complexity, lexical diversity, spatiality, temporality, and lexical characteristics. These studies have analyzed essays written by both first language and second language writers. The results support the notion that human judgments of essay quality are best predicted by linguistic indices that correlate with measures of language sophistication such as lexical diversity, word frequency, and syntactic complexity. In contrast, human judgments of essay quality and coherence are not strongly predicted by linguistic indices related to cohesion. Further studies have explored other means of providing automated measures of essay coherence, with some limited success. These recent studies will also be described.

Jeff Mulligan
NASA Ames Research Center

Assessing Visual Delays Using Pupil Oscillations

Stark (1962) demonstrated vigorous pupil oscillations by illuminating the retina with a beam of light focused to a small spot near the edge of the pupil. Small constrictions of the pupil then are sufficient to completely block the beam, amplifying the normal relationship between pupil area and retinal illuminance. In addition to this simple and elegant method, Stark also investigated more complex feedback systems using an electronic "clamping box" which provided arbitrary gain and phase delay between a measurement of pupil area and an electronically controlled light source.

We have replicated Stark's results using a video-based pupillometer to control the luminance of a display monitor. Pupil oscillations were induced by imposing a linear relationship between pupil area and display luminance, with a variable delay. Slopes of the period-vs-delay function for 3 subjects are close to the predicted value of 2 (1.96-2.39), and the implied delays range from 254 to 376 milliseconds. Our setup allows us to extend Stark's work by investigating a broader

class of stimuli, including stimulation targeting the recently-discovered intrinsically photosensitive retinal ganglion cells.

Erica Okada
University of Hawaii

The Individual and Social Benefits of Green Products
Authors: E. M. Okada & E. L. Mais

Ecologically sustainable or "green" products are typically offered at a higher price point than comparable non-green products, and many consumers are willing to pay the price premium. Our own experimental work has shown that consumers were willing to pay on average about 20% more for various types of green products, from cotton apparel to lights to coffee. For the price premium, consumers receive a combination of both individual benefits to themselves, as well as indirect social benefits. For example, consumers pay more for organic foods and directly receive the added benefits of minimized exposure to pesticides and hormones. Clothes made of organic cotton cost more than conventional cotton, but they feel no different to the wearer and are no more durable. But cotton is one of the most chemical-intensive agricultural products, and buying organic cotton promotes environmental sustainability, which benefits the society as a whole, which of course includes the consumers themselves. We contrast between the individual and social benefits of green products, and demonstrate that consumers (1) are more (less) price sensitive when they perceive the benefits to be more individual (social), and (2) respond relatively more favorably to price reductions when they perceive the benefits to be more individual, and relatively more favorably to quality enhancements when they perceive the benefits to be more social. We explore the theory and choice patterns through a series of experimental work and field surveys.

Wolfgang Pauli
University of Colorado at Boulder

Separable Contributions to Calculating Outcome Expectancies – A Biologically Plausible Neural Network Model
Authors: W. M. Pauli, T. E. Hazy, & R. C. O'Reilly

Goal-directed actions are performed because they are expected to result in valued outcomes. Which brain areas participate in calculating outcome expectancies in a given context? Based on currently available behavioral and physiological data, we developed a biologically plausible neural network model that highlights the division of labor among three different systems contributing to outcome expectancies. In this trichotomy, the lateral orbitofrontal cortex maintains recent outcomes in working memory and provides a teaching signal to the basolateral complex of amygdala which slowly acquires the conditioned stimulus – outcome associations. The striatum of the basal ganglia learns through reinforcement to update orbitofrontal working memory for recent outcomes. The model accurately simulates Pavlovian reversal deficits found in patients with orbitofrontal lesions, and also simulates the abolition of these reversal deficits produced by simultaneously lesioning the basolateral complex of the amygdala. The model further predicts that working memory for recent outcomes is activation-based and does not depend on synaptic plasticity in orbitofrontal cortex.

Misha Pavel
Oregon Health and Science University

Smart Health and Well-Being and the importance of Utility in the Detection of Rare Events
Authors: M. Pavel & H. Jimison

Curing the nation's ailing healthcare system will require solutions of a myriad of political, social medical and technological problems. In response to this challenge, NSF established a new "crosscutting" program called "Smart Health and Well Being" (SHB) that is aimed at researching fundamental problems in computation, engineering, behavioral and biological sciences to ultimately improve healthcare and quality of life. In this talk I will first briefly describe the program and some of the challenges. In the second part of this talk I will discuss an example of a "crosscutting" problem: detection

of novel or incongruent events. Because of the low prevalence of the rare events, even detectors with high sensitivity and specificity generate too many false alarms to make them practical. In contrast, human observers generally handle this problem by responding to important rare events and ignoring unimportant ones. To approximate this aspect of human performance we explore the use of utilities of different outcomes and objective function that maximizes the expected utility of the outcome. The key idea is that utilities depend on the context and the classification task. We will show that the context-dependent utilities can be learned in a similar manner as the original pattern classification.

Nicholas Port
Indiana University

Fixation, Saccade, and Pursuit Ocular-Motor Performance of Junior Olympic and Indiana University Athletes
Authors: N. Port, S. Hitzeman, T. Hoffa, K. Monroe, M. Elrod, & J. Gray

Little is known about the ocular-motor performance of elite athletes. The principle hypothesis of this series of experiments is that competitive athletes (Division-I Indiana University or Junior Olympic) have exceptional ocular-motor performance in comparison to age-matched controls. Two additional hypotheses are being tested: A) ocular motor performance predicts athletic performance, and B) ocular-motor performance changes with age.

Four tasks were used to test these hypotheses. Task 1 is a fixation task in which subjects fixate a small spot of light for 30 seconds on a computer with and without a whole-field moving background distractor. Task 2 is a simple saccade task in which subjects saccade back-and-forth for 30 seconds between two static stimuli that are 12 deg apart on a computer monitor. Task 3 is a 10 second sinusoidal pursuit task at 4 different frequencies. Task 4 is a classical step-ramp Rashbass pursuit task with 6 different step-sizes and ramp-velocities. Each task yields multiple measures of ocular-motor control. All of our experiments were embedded in a clinical vision screening and were collected in the field using a portable laboratory consisting of a table-mounted Eyelink 2K eye tracker (SR Research), computer monitor, and 2 portable computers. Data collection is ongoing, with a current sample size of 285 Indiana University athletes, 96 Junior Olympic athletes and 32 age-matched controls.

All four tasks showed significant (ANOVA $p < 0.01$) differences with the control group and across sports for various measures of ocular-motor control including, for example, saccade frequency and pursuit gain. In addition, there were clear gender differences both within our control group and between various sports, e.g. men's soccer vs. women's soccer (post-hoc test, $p < 0.01$). For Junior Olympic athletes, there were clear age trends. For example, the frequency of saccade increased and fixation control was more accurate among older rather than younger athletes.

Janos Posfai
New England Biolabs, Inc.

Autism Hypothesis

The human brain emerged from millions of years of evolution. In its immature state, this brain undergoes self-organization. Self-wiring of the brain is analogous to unsupervised learning in artificial neural nets, where repeated presentations of structured inputs makes the system learn how to recognize the given structure in further inputs. In the case of the immature human brain, stimuli from sensory organs is the input that drives learning and leads to the formation of neural circuits that will recognize the elementary features in those inputs (e.g. edges, surfaces, depth, color on retinal projections). Over evolutionary times, generation after generation, essentially the same structures were present in sensory samplings of the natural environment, and selection led to a brain that is adapted to self-organizing on those stimuli. With technological advances, suddenly, sensory stimuli come embedded with new structures. For example, illumination with mixtures of monochromatic lights, flat imagery and simulated motion on TV screens, moving light sources, fast-moving observer positions, and movement of very large objects add to the complexity of visual input. Self-organization on these inputs results in brain circuitry that differs from the one that evolution selected, and this atypical wiring manifests in atypical psychology. Perhaps, as a consequence of training on the more complex visual input, additional bundles of neurons get seized for vision that would otherwise be devoted to sound processing, to language, or to social interactions, and autism develops. The acquisition of fundamental skills (sensory processing, integration of senses) requires not just a healthy brain, but also training on inputs that are compatible with the brain. Even healthy brains will fail if trained on bad,

incompatible input. This theory can be viewed as a substantial extension, generalization of the Hubel-Wiesel theory of binocular rivalry in amblyopia.

Roger Ratcliff
Ohio State University

Modeling Confidence and Response Time

I describe a model for confidence judgments in perception and memory that deals with response confidence and response time distributions. The model assumes a distributed representation of memory strength and the areas between confidence criteria drive diffusion processes, one process for each confidence category. The new model updates an earlier model (Ratcliff & Starns, 2009, Psychological Review) with a new decision mechanism. The model is fit to recognition memory data including quantiles of RT distributions and ROC functions. The model fits data from individual subjects and accounts for puzzling nonlinear z-ROC functions. The model is also fit to perceptual brightness discrimination data using confidence judgments. This experiment adds external noise to stimuli, which provides an estimate of how much internal noise is added in stimulus processing.

Paul Sajda
Columbia University

Cortically-Coupled Computer Vision: A Closed-Loop BCI for Image Search *

We describe a closed-loop brain computer interface (BCI) system that re-ranks an image database by iterating between user generated 'interest' scores and computer vision generated visual similarity measures. The 'interest' scores are based on decoding the electroencephalographic (EEG) correlates of the attentional orienting response, resulting when images are shown as a rapid serial visual presentation (RSVP). These scores are passed as noisy labels to a semi-supervised computer vision system that uses a graph-based representation to capture the visual similarity of images in the database. Transductive inference is used to propagate the interest scores and reorganize/re-rank the database. Using a metric on the graph, the system either adaptively resamples the database, querying the user via another RSVP sequence having an increased prevalence of the 'suspected' image category, or converges to the 'done' state. The done state includes a final ranking of the image database and also a "guess" of the category of interest. We show results for 12 subjects, with analysis of performance for re-ranking done using the Caltech image database. We find that the closed-loop adaptive resampling of the image database improves the final database re-ranking, increasing prevalence of images that were of interest to the user.

*joint work with E. Pohlmeier, J. Wang, D. Jangraw, B. Lou, & S.-F. Chang

Matthias Scheutz
Indiana University

Human Eye Gaze Patterns and Visual Spatial Attention in Human-Human and Human-Robot Interaction

We will describe results from a series of human-human and human-robot interaction experiments where a human teacher is supposed to teach a human or robot the meaning of new objects. In particular, we compare tightly controlled interactions between a real robot and a "human robot" (impersonated by a confederate), which demonstrate subtle modulations of human attention processes based on the robot's appearance. We briefly discuss the importance of these findings for HRI and conclude with an outlook for the kind of modeling work enabled by this study.

Richard Shiffrin
Indiana University

A Guided Search Model for Visual Search
Authors: C. Donkin, D. Cousineau, & R. Shiffrin

Cousineau and Shiffrin (2004) presented a model for the control conditions of a visual search study. Multiple modes were observed for target present trials and the model posited serial terminating comparisons, partially and probabilistically guided to the target location by a separate parallel automatic process. We expand and extend the Cousineau and Shiffrin model to fit the distributions of response times for their control conditions and also for their experimental conditions in some of which the visual display objects are presented successively, at speeds fast enough that the displays appear simultaneous. In our model, 'guiding' is probabilistically determined by several (often competing) factors: 1) endogenous observer decisions to compare in some preferred order; 2) automatic attraction of attention to the target that is learned due to consistent mapping of targets and foils across training; 3) perceptual differences between targets and foils large enough to attract attention without training; 4) onset of some display object. Guidance can occur whenever the current comparison ends. We also obtained strong evidence that on some trials O's terminate search early with a negative response, and included this process in the model. The model was additionally fit successfully to a set of web-published but not analyzed distributions of visual search data by Jeremy Wolfe (and another such set by Gilden and Thornton, not discussed in this talk). The relatively simple guided search model accounts for accuracy and response time distributions in extraordinary detail. The model and the data are inconsistent with the models of Gilden and Thornton. We believe the model should be thought of as a simplification of, and improvement upon, the related model of Jeremy Wolfe.

George Sperling
University of California, Irvine

Deriving a Perceptual Motion-Processing Algorithm From the Perceived Motion of Plaids

As with most biological processes, the more the visual computation of the perceived direction of a moving visual stimulus has been studied, the more complex it has turned out to be. Studies of the motion of simple sine-wave gratings revealed three concurrent motion-analysis systems (first-, second- and third-order motion systems). Combinations of two moving sine waves (called plaids) have led to hundreds of publications but not to any defensible theory of plaid motion perception. The three-systems theory of motion-direction perception will be reviewed (with demonstrations). It is shown that, when plaid stimuli are directed exclusively to the first-order motion system (by using only stimuli with very high temporal frequencies), the plaid combination rule is remarkably simple and robust: the vector addition of component motion strengths. A priori predictions of the perceived direction of new plaid stimuli account for 97% of the variance of the data once the experiments are actually performed. The perceived motion direction of slower (lower temporal frequency plaids) is shown to consist of two components, first-order plus third-order, with zero contribution from the second-order system. The methods described herein ultimately can yield complete descriptions of the first- and third-order motion systems.

*The plaid experiments were carried out by Dantian T. Liu as part of her Ph.D. thesis; the data were recovered and analyzed by Ling Lin.

Bosco Tjan
University of Southern California

Isoeccentric Organization of Spontaneous Activity in the Human Visual Cortex Exists in Normal But Not in Blind Subjects
Authors: P. Bao & B. S. Tjan

Spontaneous or resting state activity measured with fMRI refers to the variability in BOLD signal when subjects are not performing any task or being deliberately stimulated. This activity exhibits systematic and bilateral correlations across brain regions in a manner that is indicative of multiple large-scale cortical networks (Fox et al., 2005). The cause of such correlations is unknown. We studied fine-scale spontaneous activity in the human visual cortex (V1-V3) with fMRI,

capitalizing on the detailed retinotopic maps that we can obtain for visual areas. We found that the strongest correlations in spontaneous activity are between voxels with functional receptive fields at the same visual eccentricity, irrespective to whether the receptive fields are in the same visual quadrant or across a meridian. Such long-distance isoeccentric organization of correlations in spontaneous activity is robust both within and between visual areas. The organization can be observed either when the subject is resting with eyes closed or performing a fixation task (identifying the color of a fixation dot). When we presented a stimulus (an arc-shaped flickering checkerboard at different eccentricities) in one quadrant of the visual space, we observed weak modulation in the other three nonstimulated quadrants. These weak modulations were not statistically significant with respect to a general linear model; however, when we sorted these modulations by the visual eccentricity of the nonstimulated regions, we found that the weak modulations were not random ($p < 0.02$) but were strongly correlated with the evoked activity at the same eccentricity in the stimulated quadrant.

To determine whether this isoeccentric organization of the spontaneous activity in the visual cortex correlated with visual functions, we measured the spontaneous activity in two subjects with retinitis pigmentosa (RP) who were resting with eyes closed. Because retinotopic mapping of the visual cortex is not possible with RP subjects, landmark-based cortical coregistration (Pantazis, et al, 2010, Neuroimage) was used to align the cortices of the RP and control subjects to a reference subject who has been retinotopically mapped. For the RP subject with only light sensation and no residual form vision, the correlations of spontaneous activity across cortical hemispheres and between early visual areas (V1, V2, V3) in the same hemisphere were greatly reduced, as compared to the control subjects with normal vision. For the RP subject with preserved tunnel vision within the central 3° , these correlations were comparable to those measured for normal controls. Most interestingly, the isoeccentric organization of spontaneous activity, which was presented in all control subjects (N=6) even when computed with a foreign retinotopic map, was absent from the RP subject with only light sensation and very weak for the RP subject with tunnel vision. Our findings show that the isoeccentric organization of spontaneous activity in the visual cortex depends on visual experience and is correlated with normal form vision. A simple model of temporally varying and spatially diffused feedbacks from at least two higher cortical areas with different amount of coverage of the peripheral visual field provides a quantitative account of these findings.

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Marcus Watson
University of British Columbia

Similar Letters, Similar Colours: Analogical Mapping in Grapheme-Colour Synaesthesia
Authors: M. R. Watson, K. A. Akins, & J. T. Enns

It is well established that a large number of individuals (approximately 1% of the general population) are grapheme-colour synaesthetes, individuals who associate specific colors with otherwise achromatic letters and numerals. Recent research has shown that these associations are not entirely idiosyncratic, but it remains unclear whether they are influenced by analogical mappings from one domain (color) onto another (letters). We report a study of 54 synaesthetes that looked for relations among synaesthetic color choices and the various similarity structures of letters. The main finding was that similarly shaped letters have a tendency to be assigned similar hues. Interestingly, letter shape similarity did not influence the luminance of the selected colors, making this a pure "shape-hue effect." A secondary finding was the observation that a previously-reported relationship between alphabetic letter order and colour is also confined to hue, such that letters early in the alphabet tend to have more distinct hues than letters later in the alphabet. Another secondary and previously-reported finding was that letters appearing with similar frequency in print are assigned luminance values of similar strength. The entire pattern of results is presented in support of a theory of synaesthesia in which the associations between letters and colours are made at a relatively "high" categorical level; the results are less supportive of accounts for these associations in terms of low-level neuronal mechanisms.