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Organizer: George Sperling, University of California, Irvine

ABSTRACTS

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Ben Backus
SUNY College of Optometry

A Bayesian Model of Cue Combination for Perceptually Dichotomous Behavior, and its Use in Characterizing the Effects of a Newly Recruited Cue

Dosher, Sperling & Wurst (1986) used probit analysis to quantify the relative effectiveness of three visual cues—binocular disparity, perspective, and proximity luminance—that biased the apparent direction of a rotating Necker cube. When the "strength of evidence" from each cue was described as a z-score, effects were additive. Here I build on this result. First, probit analysis can be motivated by interpreting the z-scores as belief terms that correspond either to log likelihoods for the respective cues or to likelihoods for the probability parameter in a binomial decision model. The second model may be preferred insofar as it collects the decision noise into in a single, separate term. In either case, additive effects are equivalent to an assumption of conditional independence within a Bayesian statistical framework. Second, new data show that a newly recruited cue (stimulus position) and a long-trusted cue (disparity) also have additive effects and the use of both monocular and binocular test stimuli allow us to test the proposition that the visual system's trust in the new cue is the same whether binocular disparity is present or not. These results show that perceptually dichotomous stimuli can be understood, and therefore used to study cue combination, within an established framework that is already used to study continuously valued perceptual attributes. They also suggest that by default the visual system assumes a newly discovered visual cue to be conditionally independent of the long-trusted cues from which the new cue's meaning was inferred.

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Tom Busey
Indiana University

Temporal Processing in Hearing, Vision and Touch: Effects of Aging
Authors: T. Busey, L. Humes, J. Craig, & D. Kewley-Port

In this presentation we report results from an ongoing study of temporal processing in older adults. Multiple measures of temporal processing are obtained from three modalities using parallel psychophysical procedures and analogous stimuli across modalities. Modalities examined include hearing, vision, and touch. Psychophysical measures reported in this presentation include threshold sensitivity at several frequencies, temporal gap detection, and temporal-order identification for 2-item and 4-item sequences. By project completion, data will be available from 50 young adults and 200 older adults. In this presentation, we review results for 137 participants (32 young and 105 older adults) who have completed the measures of threshold sensitivity and gap detection, and 44 participants (15 young and 40 older adults) who have completed these measures plus the temporal-order identification tasks. Group data reveal significant differences for nearly all the measurements obtained, with older adults consistently exhibiting poorer performance than young adults as a group. There are sizable differences among the elderly, with some performing like the younger adults. At this stage of the project, factor analyses of the individual differences are more in line with modality-specific temporal processing mechanisms underlying performance rather than common amodal processing mechanisms.

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Patricia Cheng
University of California, Los Angeles

Causal Reasoning

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Barbara Dosher
University of California, Irvine

Iconic Memory

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James Elder
York University

A Bayesian Multi-Scale Model of Perceptual Organization
Authors: J. Elder & F. Estrada

Humans have a remarkable ability to rapidly group and organize image data into coherent representations reflecting the structure of the visual scene. However current computer vision algorithms are by comparison relatively primitive in their performance. Key issues include the combinatorial complexity of the problem and difficulties capturing and combining global constraints with local cues. In this work we develop a coarse-to-fine Bayesian algorithm that addresses these issues.

In our approach, candidate contours are extracted at a coarse scale and then used to generate spatial priors on the location of possible contours at finer scales. In this way, a rough estimate of the shape of an object is progressively refined. The coarse estimate provides robustness to texture and clutter while the refinement process allows for the extraction of detailed shape information. The grouping algorithm is probabilistic and uses multiple grouping cues derived from natural scene statistics. We present a quantitative evaluation of grouping performance on natural images and show that the multi-scale approach outperforms single-scale contour extraction algorithms. We suggest that the substantial feedback connections known to exist in ventral stream of the visual cortex may support an analogous refinement of perceptual representations in the human brain.

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Mounya Elhilali
Johns Hopkins University

Foreground & Background at the Cocktail Party – Interaction Between Attention & Auditory Pop-Out

Attention is the cognitive process underlying our ability to focus on specific components of the environment while ignoring all others. By its very definition, attention plays a key role in defining what foreground is (i.e. object of attention), and differentiating it from irrelevant unattended clutter or background. In order to tackle aspects of these questions, we engage listeners in two complimentary tasks involving the perception of a repeating target tone amidst a background of non-regular notes. The novelty of this experimental paradigm is: (i) to use a more realistic yet controlled stimulus design that builds on previous work in stream segregation using simpler stimuli; (ii) to combine behavioral measures of human perception with neural recordings using Magnetoencephalography (MEG); (iii) most importantly, to maintain the physical parameters of the stimulus fixed while manipulating one free parameter: the attentional state of the listeners. The experimental findings reveal that auditory attention strongly modulates the relative neural representation of the target-to-masker signals in the direction of boosting foreground perception, much like known effects of visual attention. We also find that, together with the behavioral demands of the task, the bottom-up saliency of a target shapes both the signal neural representation and the subject performance. Furthermore, the perceptual detectability of the target improves over time following a pattern that is highly correlated with the neural buildup of the signal representation.

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Bill Geisler
University of Texas, Austin

Uncertainty Minimization: A Principled Approach for Analyzing Natural Tasks and Scene Statistics

Normative models (ideal observers) play an important role in the study of perceptual and cognitive systems because they generally provide (i) deep insight into the information processing demands of the perceptual or cognitive task, (ii) a benchmark against which to evaluate performance of the organism, (iii) a starting point for formulating hypotheses about the underlying brain mechanisms, and (iv) a benchmark against which to evaluate the efficiency of hypothesized brain mechanisms. Typically, these normative models are based on the principles of Bayesian statistical decision theory. Unfortunately, in many cases it is impractical to either implement or evaluate the optimal Bayesian decision rule. For a number of these cases, however, the optimal decision rule reduces approximately to minimizing the expected entropy (uncertainty) of the posterior probability distribution across possible stimuli, thus making it possible to implement a wider range of normative models. The principle of minimizing expected entropy is illustrated for tasks that involve scanning natural (and naturalistic) images with saccadic eye movements, and for tasks that involve classification of local properties in natural images.

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Xiaoping Hu
Georgia Tech and Emory University

Assessing Brain Connectivity with fMRI
Authors: G. Gopikrishna & X. Hu

This talk will provide an overview of assessing functional connectivity and effective connectivity of the brain using fMRI data, highlight some representative techniques and demonstrate them with exemplar applications. Specifically, we will discuss measuring local coherence in fMRI data based on the integration of correlation function and its neurobiological relevance and application to studying the effect of anesthesia. In addition, analysis of effective connectivity using Granger causality analysis will be described, with an emphasis on a multivariate approach and its application to examine group differences in tactile perception and to examine dynamic changes in the motor network during fatigue.

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Bart Krekelberg
Rutgers University

Neural Mechanisms of Speed Perception

While the mechanisms and neural code for the perception of the direction of visual motion have been established quite firmly, much less is known about the neural representation of the perceived speed of motion. From behavioral data it is known that speed perception is much less robust than direction perception; even small changes in the visual stimulus can alter perceived speed considerably. While this may not appeal from an engineering standpoint, it actually provides an opportunity to learn more about the neural code. Our behavioral experiments with humans and monkeys, single-cell recordings in the middle temporal area (MT), and computational modeling of motion detection are aimed at finding a neural code that can link speed perception and neural responses to moving stimuli.

I will discuss how adaptation in MT can be linked to a reduction in perceived speed, as well as an improvement of speed discrimination. Interestingly, the same short-term adaptation process also leads to the encoding of temporal context in the neural response. This allows area MT to represent acceleration signals without any explicit acceleration dependence. While these findings show that we are beginning to understand the neural code for speed, other findings -- such as the relationship between stimulus contrast, MT responses, and perceived speed -- show that neurons in MT are not simple labeled lines for speed.

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Ulman Lindenberger
Max Planck Institute for Human Development

Between- and Within-Person Differences in Evidence Accumulation: Effects of Age, Practice, Intelligence, and the Val/Met COMT Polymorphism

Authors: U. Lindenberger, S.-C. Li, R. Ratcliff, L. Backman, C. Chicherio, H. Heekeren, M. Lovden, I. Nagel, A. Villringer, & F. Schmiedek

Adult age differences in simple two-choice decision-making were investigated with the diffusion model (Ratcliff, 1978). In a first study, 102 younger adults aged 20-31 years and 103 older adults aged 65-80 years participated in over 100 practice sessions in three perceptual choice tasks involving figural, verbal, and numerical materials, respectively. Preliminary analyses show that drift rates: (a) were lower in older adults than in younger adults; (b) increased with practice in both age groups; and (c) were correlated across tasks, forming a common factor of evidence accumulation that correlated positively with standard measures of working memory, episodic memory, and perceptual speed. In a second study, which included genetic assessment, 163 younger adults aged 20-30 years and 167 older adults aged 60-70 years performed a figural two-choice reaction time task in two consecutive sessions separated by one week. Again, drift rates were lower in older adults than in younger adults. In addition, and in line with the computational theory of deficient neuromodulation of cognitive aging proposed by Li and colleagues (e.g., Li, Lindenberger, & Sikström, 2001), drift rates were reliably related to a common val/met polymorphism affecting the Catechol-O-Methyltransferase (COMT) enzyme degrading dopamine in prefrontal cortex. Individuals with the val/val allele had slower drift rates than individuals with the met/met allele, suggesting a link between available dopamine in prefrontal cortex and evidence accumulation. Taken together, we find robust associations of evidence accumulation as estimated by the drift rate of the diffusion model to adult age, intelligence, practice, and the COMT genotype. Results for other parameters of the diffusion model will be reported as well.

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Del Lindsey
Ohio State University

Diversity in Color Naming in the World Color Survey
Authors: D. Lindsey & A. Brown

English and other languages spoken in industrialized societies include eleven basic color terms. In contrast, there is great diversity in color terminology across languages spoken in pre-industrialized cultures, with some languages using as few as two or three color terms, and other languages using more. We performed a novel analysis on the usage of color terms in the World Color Survey (WCS), a large color-naming database obtained from informants of mostly unwritten languages spoken in pre-industrialized cultures that have limited contact with modern, industrialized society. We find that the remarkable diversity in the color-naming idiolects of WCS informants can be classified according to a small number of universal "motifs," where each motif is comprised of a different subset of a universal glossary of about eleven color terms. These motifs are distinguished principally by the ways informants lexically partition the "cool" region of color space. Strikingly, these few motifs are distributed across the WCS languages in such a way that multiple motifs occur in most languages. Our results indicate that the culture a speaker comes from does not completely determine how he/she will use color terms. Our results further suggest that color lexicons do not generally evolve by adding single new color terms in response to a specific cultural or other environmental need. Rather, color lexicons evolve by changing the relative prevalence of motifs that are already in use.

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Zhong-Lin Lu
University of Southern California

TBA

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Dennis McFadden
University of Texas

Group and Individual Differences in the Inner Ear

The human cochlea not only processes incoming sounds, it also MAKES sounds that can be detected with small microphone systems located in the external ear canal. These sounds, known as otoacoustic emissions or OAEs, take several forms, some requiring acoustic stimulation and some not. OAEs exhibit large individual differences and substantial differences across groups. For example, females have stronger OAEs than males; monozygotic female twins have stronger OAEs than non-twins; females with male co-twins have weaker OAEs than other females; boys with attention-deficit/hyperactivity disorder (ADHD) have weaker OAEs than control boys; and homosexual and bisexual females have weaker OAEs than heterosexual females. Various facts suggest that these group differences in human OAEs are not simply attributable to differential hearing loss or drug use (including oral contraceptives), or to differences in other obvious lifestyle factors. Because OAEs exist at birth and appear to be quite constant through life, the basis for the group and individual differences in OAEs appears to reside in mechanisms operating during prenatal development. Under reasonable assumptions, our results suggest that those mechanisms include exposure to androgens (such as testosterone). Specifically, exposure to high levels of androgens prenatally appears to permanently weaken the so-called cochlear amplifiers and thereby push OAEs in the male direction. Our OAE measurements on spotted hyenas, rhesus monkeys, and sheep have confirmed this speculation. Unknown is exactly which cochlear elements are affected by this prenatal androgen exposure, but if the audience asks the right question, suggestions will be offered.

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Tim McNamara
Vanderbilt University

Human Spatial Memory and Navigation

There is a large body of evidence showing that many organisms rely heavily on the shape of the surrounding environment to reorient, even in situations in which non-geometric cues, such as unique landmarks, are more informative. In this presentation, I will discuss the results of experiments that have examined whether the shapes of rooms and the locations of objects in the rooms are mentally represented using similar spatial reference systems and the extent to which one's orientation in a room affects one's ability to remember the locations of objects in a different room of similar geometry. Our findings indicate that locations of objects and room shape are mentally represented in similar ways and that room geometry can produce orientation specific interference in the retrieval of object locations from memory.

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Jeff Mulligan
NASA Ames Research Center

Current Trends in Operator State Assessment

In many systems, the most unreliable component is the human operator. For example, far more automobile accidents are caused by driver fatigue or intoxication than by mechanical failures. There is therefore considerable interest in the development of technologies which might allow a system to monitor the fitness of its operator, and to take some remediating action if necessary. Methods for operator state assessment can be separated into two broad groups: active methods, in which the subject must voluntarily engage in a test of some sort; and passive, in which the subject simply performs his normal behavior, which is observed and analyzed. This talk will review approaches to passive operator state assessment, with particular attention to oculometric measures.

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Erica Okada & Eric Mais
University of Hawaii

Prospective Reflection Versus Memory of Time Expenditures

People typically spend a combination of both time and money to acquire products, and time and money are often traded off in product acquisition. Consumers generally pay a premium for convenience, and go the distance for a bargain. As

such, time, like money, is a medium of exchange. This research contrasts consumers' relative valuation of time and money expenditures in prospective versus past exchanges.

In economics, the value of time is expressed in monetary terms, generally one's wage rate. But due to intrinsic differences between time and money as resources, consumers are unlikely to value the two currencies in the same way.

If time were like money as in the economics view, a unit of time in the future would be less valuable than the same unit of time now. In fact, I demonstrate just the opposite: that future time is perceived to be more valuable than time now. My first experimental study shows how people perceive the opportunity cost of their time to be higher in the future than in the present. I further demonstrate actual behavioral patterns that are consistent with a relatively higher valuation of future versus present time.

In prospective reflection, time may be relatively more valuable than money. However, extant literature suggests that people's memory of past time expenditures may not be as good as for past monetary expenditures. In economics, sunk costs are historical costs that are irrecoverable and should be ignored in prospective decision-making. When decision makers consider economically irrelevant sunk costs, and become more likely to continue an endeavor because the expenditure is made, they exhibit a behavior called the sunk cost effect. The sunk cost effect is shown to a greater extent after people incur monetary costs than time costs, and presumably because they have a better memory of past monetary expenditures than of time expenditures. My second experimental study shows how people have more detailed recollections of the money that they spent in the past, than time. Furthermore, they rate their past monetary expenditures as being more negative.

An implication of this set of findings is that on the one hand, in a prospective purchase evaluation consumers may choose an alternative that they expect will be time-saving over one that is lower priced. In a post-purchase evaluation, however, they may also be more likely to forgive and repurchase a good after experiencing a cost overrun in time than in money. My last experimental study showed that in a choice between two banking services, there was a relative preference for a bank that they anticipated would have shorter service delays over another one that they anticipated would have lower total service fees. However, they were more likely to return to a bank after experiencing longer service delays than higher service fees. What is important in prospective reflection may also become easier to forget once in the past.

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Tatiana Pasternak
University of Rochester

Speed of Visual Motion is Represented in Prefrontal Cortex During Processing & Retention of Stimulus Speed
Authors: T. Pasternak, C. Hussar, & L. Lui

We have recently shown that responses of neurons in the prefrontal cortex (PFC) faithfully represent the direction of behaviorally relevant stimulus motion and often carry memory-specific directional signals (Zaksas & Pasternak, 2006). In this talk I will show that PFC neurons can also represent behaviorally relevant stimulus speed. We found that during a task in which the monkeys were asked to judge differences in speed of two stimuli, sample and test, separated by a delay, the majority of PFC neurons showed systematic variation in firing rate with stimulus speed, reminiscent of speed selectivity reported for area MT. Speed selectivity was also present throughout the memory delay and many neurons were modulated by the remembered speed during the comparison phase of the task. The presence of task-specific representation of stimulus speed throughout all phases of the memory for speed task supports the notion that the contribution of prefrontal neurons to the successful execution of such tasks may rely on their access to fundamental sensory signals.

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Misha Pavel
Oregon Health and Science University

TBA

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David Peterzell
UC San Diego

Identifying Sensory Processes Using Individual Differences in Color Vision

In the 1940s and 1950s, RW Pickford used individual differences in data to discover sensory, cognitive, neural and genetic mechanisms of vision. First, he measured the color vision of thousands of normal and color-deficient individuals using his anomaloscope, and then he used correlations and factor analyses to test models of color vision. Later, until the 1970s, he used chromatic individual differences to investigate aesthetics, personality, language, and culture. Pickford's remarkable insight was that individual differences in color perception are meaningful and not due to error; individual differences provide information about the structures underlying color vision. I have borrowed and modified his basic computational approach and have, since the '80s, attempted to develop a general framework for extracting neural structure from data. I will review my work on color vision using Pickford's general paradigm. (Collaborators included J Werner, D Teller, J Kelly, M Crognale, K Gunther, K Dobkins, J Wilmer, D MacLeod and others.) I have used a variety of archival and original data sets to determine statistical factors underlying normal human individual differences in:

A) Rayleigh matches (Oicherman & Eliasson, 2006);
B) isoluminance (Gunther et al. 2000);
C) chromatic adaptation (Werner & Steele, 1988);
D) visibility curves (Coblenz & Emerson, 1918; Gibson & Tyndall, 1923);
E) chromatic contrast sensitivity (Peterzell et al. 2000, others); and
F) the expression of functional human longwave-sensitive (L) photopigment (Shaaban et al. 1998; in the transgenic mouse retina, not in humans).

Each analysis provided identifiable visual components underlying visual functions, and estimates of the response characteristics of these components (e.g., photopigment, lens and macular pigment as a function of wavelength). Some analyses elucidated developmental changes, sex differences, and genetic differences in color vision. Past successes in studying individual differences in color vision seem to provide a roadmap for future discoveries.

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Alexander Petrov
Ohio State University

The Dynamics of Perceptual Learning in Non-Stationary Contexts: Data and Model
Authors: A. A. Petrov, B. A. Dosher, & Z.-L. Lu

The mechanisms of perceptual learning are analyzed theoretically, probed in an orientation-discrimination experiment involving a novel non-stationary context manipulation, and instantiated in a detailed computational model (Petrov, Dosher, & Lu, 2005, Psychological Review; 2006, Vision Research). Learning was evaluated for orientation discrimination of peripheral Gabor targets (+/-10 deg) in two filtered noise "contexts" with predominant orientations at either +/-15 deg. The training schedule alternated two-day blocks of each context. Three target contrast levels were tested. Thirteen observers received feedback and 18 didn't. Both groups improved both discriminability and speed within and across blocks. Performance dropped at each context switch, with approximately constant cost (about 0.3 d') over 5 switches (~10000 trials), indicating that a single set of connections is involved in both contexts. An incremental Hebbian reweighting network model accounts quantitatively for the recurring switch costs and several other data patterns. The model develops the multi-channel perceptual template model (PTM, Dosher & Lu, 1998, PNAS) and extends it with a fully functional representation subsystem and a biologically plausible learning rule. The stimulus images are processed by standard orientation- and frequency-tuned representational units, divisively normalized. Learning occurs only in the "read-out" connections to a decision unit; the stimulus representations never change. An incremental Hebbian rule tracks the task-dependent predictive value of each unit, thereby improving the signal-to-noise ratio of their weighted combination. Each abrupt change in the environmental statistics induces a switch cost in the learning curves as the system temporarily works with suboptimal weights. In this situation, self-generated feedback seems sufficient for learning.

Together, the empirical results and the model provide an existence proof that task-specific reweighting is sufficient to account naturally and quantitatively for a challenging set of perceptual learning phenomena. Reprints, data, and software are available at http://alexpetrov.com/proj/plearn/.

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Zygmunt Pizlo
Purdue University

3D Shape: Its Unique Place in Visual Perception

Prior approaches to 3D shape perception resembled approaches to other perceptual properties such as distance, size, lightness, and color. But 3D shape is very different from all other perceptual properties because it is characterized by (i) a high degree of complexity and (ii) regularity. These two properties of 3D shape make it unique: they allow the 3D shape to be recovered from the 2D retinal shape without the use of depth cues, context, invariant ratios or familiarity. For example, the 3D shape of a symmetrical object can be recovered much more reliably from skewed symmetry present in the 2D retinal image than from the 3D surfaces of the object. A new theory of shape constancy based on regularity constraints such as symmetry, maximal compactness and minimal surfaces will be presented and illustrated with examples.

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Lynne Reder
Carnegie Mellon University

How Synthetic Amnesia Can Help Us Understand Human Memory

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John Reynolds
Salk Institute

Mapping the Microcircuitry of Attention: Attentional Modulation Varies Across Cell Classes in Visual Area V4
Authors: J. F. Mitchell, K. A. Sundberg, & J. H. Reynolds

Cortical neurons differ from one another in important ways, including their neurochemical properties, patterns of connectivity, laminar distribution, gene expression patterns and developmental origin. Previous studies of attention have not sought to distinguish among different classes of neurons. We therefore know almost nothing about the complex circuitry that transforms attentional feedback signals into improved visual processing. Studies in the slice and in anesthetized animals find that parvalbumin expressing GABA-ergic interneurons with the morphologies of basket and chandelier cells have short duration action potentials, whereas most excitatory cell classes have longer duration action potentials, a difference that is due to expression of different classes of sodium and potassium channels. We thus examined differences in attentional modulation across visual area V4 neurons classified on the basis of action potential width. The distribution of action potential widths in our sample of neurons was clearly bimodal. Broad spiking neurons made up the majority of our sample and exhibited markedly lower levels of spontaneous activity and weaker stimulus-evoked responses than narrow spiking neurons. Narrow spiking neurons showed a median increase in firing rate that was substantially larger than the increase that was observed among broad spiking neurons. Attention also reduced response variability, as measured by the Fano factor. This reduction was significant in both types of neurons, but was significantly larger among narrow than broad spiking neurons. This is the first study of attention to distinguish among different neuron types, and our findings lead to the surprising conclusion that attention has a more pronounced influence on local inhibitory interneurons than on pyramidal neurons.

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Adina Roskies
Dartmouth College

Folk Intuitions About Freedom and Moral Responsibility

It is generally thought the people consider freedom and moral responsibility to be incompatible with determinism. A recent study has challenged that view. In this study we explore people's judgments about moral responsibility and freedom in cases set both in our own and other universes. The data suggest that the traditional philosophical ways of viewing intuitions about freedom and responsibility do not accurately reflect folk judgments. We offer several possible psychological explanations for the patterns of judgments we see.

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Paul Sajda
Columbia University

EEG-Informed fMRI Reveals Spatiotemporal Characteristics of Perceptual Decision Making
Authors: P. Sajda & M. G. Philiastides

Single and multiunit recordings in primates have already established that decision making involves at least two general stages of neural processing; representation of evidence from early sensory areas and accumulation of evidence to a decision threshold from decision-related regions. However, the relay of information from early sensory to decision areas, such that the accumulation process is instigated, is not well understood. Using a cued paradigm and single-trial analysis of EEG, we previously reported temporally specific components related to perceptual decision making. Here we use information derived from our previous EEG recordings to inform the analysis of fMRI data collected for the same behavioral task in order to ascertain the cortical origins of each of these EEG components. We demonstrate that a cascade of events associated with perceptual decision making takes place in a highly distributed neural network. Of particular importance is an activation in the lateral occipital complex implicating perceptual persistence as a mechanism by which object decision making in the human brain is instigated.

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Shihab Shamma
University of Maryland

Encoding Task Rules and Performance in Auditory and Frontal Cortex of the Ferret

This talk will review the role of behavior and attention in inducing plasticity in auditory cortical STRFs that reflect task performance and objectives as an animal learns to perform auditory detection and discrimination tasks. I shall also describe the dependence of responses in cortical frontal areas on behavioral task rules and stimulus meanings.

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Steve Shevell
University of Chicago

Lateral Inhibition Mediated by Object Segmentation, not Receptive-Field Organization
Authors: S. K. Shevell & A. D'Antona

The brightness of a fixed stimulus depends on the level of surrounding light. This is the well-known phenomenon of brightness contrast. Consider a surround with time varying rather than fixed luminance. At a slow temporal frequency (here 2 Hz), the perceived brightness of the center oscillates in counter-phase to the surround (center is brightest when surround is dimmest). If the center's luminance also varies in time at the same frequency and phase as the surround, with center and surround separated from each other by a dark gap, the result is *surround suppression*: the perceived modulation depth of the center is reduced compared to a steady surround because the peaks and troughs of induced brightness are, respectively, in sync with the troughs and peaks of the center's luminance. Physiological responses at the LGN show analogous surround suppression so retino-geniculate receptive-field organization is proposed to explain the perceived depth of temporal modulation (Kremers et al, *J Vision*, 2004). New results challenge this view, and instead support a cortical mechanism of surround suppression that depends on segmentation of center from surround. Surround suppression occurs when center and surround are separated by only an illusory counter rather than by a dark gap. Further, the surround suppression expected with a monocularly presented gap is reduced or abolished when the gap is perceived in a different depth plane than the center and surround. Neither result is consistent with LGN receptive-field organization. Instead, perceived temporal brightness modulation in context depends on a neural representation at an object level of visual processing.

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Richard Shiffrin
Indiana University

Modeling the Co-Evolution of Event Memory and Knowledge: Effects of Experience
Authors: A. Nelson & R. Shiffrin

Ss initially naive to Chinese characters used them in a visual search task for two weeks. Individual characters were encountered with different frequencies, in a geometric progression. Transfer tasks included episodic recognition, pseudo-lexical decision, and forced choice perceptual identification. High frequency characters were worse in episodic recognition and superior in the other tasks. Our model assumes that each presentation of a character forms an episodic trace and also adds information to a developing knowledge trace. In addition these traces gain features from characters encountered during training and test in nearby spatial and temporal contiguity. Conversely the encoding of each presented character is determined by the present state of its knowledge trace. Memory retrieval from either type of trace is determined by matches of a probe cue to the various traces in memory. This model of co-evolution of the two types of memory traces was fit to the data.

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Barbara Shinn-Cunningham
Boston University

Suppressing Irrelevant (and Relevant) Auditory Objects in Complex Auditory Scenes

In a typical setting, we cannot process the sound from every source that reaches our ears. Instead, we naturally group the mixture of sound into perceptual objects and then actively attend to one object at a time, suppressing the other objects in the scene. This talk will review results of a range of studies investigating how listeners process sound when there are multiple sources in a sound mixture, including studies requiring selective attention, divided attention, and switching of attention between perceptual objects. We find that perceptual segregation of the objects in the scene is helpful when listeners wish to actively attend to one object. However, perceptual segregation of the sources is costly when listeners must divide or switch attention between objects. Taken together, results suggest that whenever there are multiple objects in a auditory scene, there is an automatic competition between the objects that leads to an obligatory suppression of background objects, even though such suppression may hurt performance in many tasks. However, we find that the degree of perceptual segregation of the objects themselves is often partial or incomplete, and that suppression of the irrelevant (or relevant) background objects depends on the degree of perceptual segregation.

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George Sperling
University of California, Irvine

Deriving the Parameters of Attention Filters that Select and Reject Visual Inputs

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Duje Tadin
University of Rochester

Center-Surround Interactions in Vision: Description and Functional Roles

Neurophysiologists have amply documented the existence of center-surround interactions in motion processing. Proposed functional roles of this ubiquitous neural mechanism include figure-ground segregation and the analysis of object shape, but until recently those putative roles were untested conjectures. In a series of experiments, we investigated the properties of center-surround interactions: from a behavioral description and to a functional characterization.

Several years ago we demonstrated that increasing the size of a high-contrast moving object can make its motion substantially more difficult to perceive (Tadin et al., 2003). Based on converging lines of evidence, we attributed this counterintuitive finding to the involvement of motion-sensitive neurons with suppressive center-surround receptive fields,

such as those found in area MT. In subsequent studies, we explored center-surround interactions using a variety of psychophysical methods and phenomena, including reaction times, motion-aftereffect, binocular rivalry and modeling. Moreover, using a reverse correlation approach, we documented fine temporal delays associated with the interaction between center and surround signals.

What are functional roles of center-surround suppression in motion? Special population studies revealed that center-surround suppression is weaker in the elderly and in patients with schizophrenia - a result responsible for their paradoxically better-than-normal performance in some conditions. Moreover, these two subject groups exhibit deficits in figure-ground segregation, suggesting a possible functional connection. In a recent study, we directly addressed this possibility and report experimental evidence for a functional link between center-surround suppression and figure-ground segregation.

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Michael Webster
University of Nevada, Reno

Individual Differences and Perceptual Norms

We have used individual differences to explore the nature and basis for perceptual norms – stimuli that appear neutral and which may correspond to neutral and special response states in visual coding. Observers often differ in the stimuli they perceive as neutral, so that what appears gray to one person might appear reddish or greenish to another. We asked whether these differences can be tied to differences in the underlying visual response by measuring how an individual's color judgments are biased by adaptation. Adapting to red causes the hue of all stimuli to appear greener and vice versa, and thus an intermediate adapting level can be found that does not bias the observer's achromatic point. This level reflects the response norm of the mechanisms affected by the adaptation, and should correspond to the observer's subjective white point if the norm is established at the adaptation site. Consistent with this, differences in subjective judgments of white were significantly correlated with differences in the neutral adapting stimulus. Moreover, both white settings and the neutral adapting levels remained similar in the fovea and periphery despite the large differences in spectral sensitivity at the two locations. These results thus establish a strong link between perceptual norms and response norms in color vision, and we illustrate similar links for the perception of image blur or for face perception. Because norms can be strongly affected by adaptation, they may be defined by the observer's history of stimulation. This predicts that differences or similarities in perceptual norms may reflect individual differences in visual experience. Consistent with this, we also found that inter-observer differences in perceptual judgments are reduced when individuals are adapted to a common stimulus.

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Jeremy Wilmer
University of Pennsylvania

Isolating Mechanisms of Stereopsis, Motion Perception, & Oculomotor Control With Individual Differences

I present insights gained from individual differences in two domains of perception and oculomotor control. First, by assessing covariation across individuals, we have tied three distinct stages of smooth pursuit eye movements to different perceptual and motor mechanisms. We have tied early presaccadic pursuit to low-level (energy based) motion processing, early postsaccadic pursuit to high-level (position tracking based) motion processing, and have identified a sex difference in later postsaccadic pursuit that may reflect an efference copy mechanism. Second, we have conducted two classic twin studies of binocular visual function, assessing the relative influence of genes and environment on both stereopsis and dissociated phoria (aka vergence position with inputs to the eyes dissociated). Our results suggest that stereopsis and phoria are malleable due to environmental factors, raising the possibility that those factors may be harnessed for therapeutic intervention. As illustrated by these examples, individual differences provide a robust source of information about the functional organization, developmental bases, and utility of visual functions, while generating insights ripe for translation into applied and clinical contexts.

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Task-Dependent Suppression of Responses in Rat Auditory Cortex

Attention is a cognitive process in which a subset of sensory input relevant to behavior is subjected to further processing. Neural correlates of attention in both auditory and visual cortex typically take the form of an enhancement of neural activity to the attended stimulus. Here we have compared neural activity elicited by sounds while rats performed a two-alternative choice auditory task ("engaged" condition) with those elicited by identical stimuli while subjects were awake but not performing a task ("idle" condition). Surprisingly, we found that cortical responses were consistently suppressed rather than enhanced in the engaged condition. To probe the mechanisms underlying this cortical suppression, we recorded in the auditory thalamus, which provides input to the cortex. We found that although thalamic evoked responses were identical in the two conditions, spontaneous rates in the thalamus were higher in the engaged condition, consistent with a mechanism involving synaptic depression at the thalamocortical inputs. These results demonstrate that in the auditory cortex, engaging in an auditory task can induce a powerful and robust suppression distinct from, and with the opposite sign as, previously characterized forms of auditory attentional modulation, the function of which may be to reduce activity in neurons projecting to targets not involved in this task. Our results represent a first step toward understanding the synaptic and circuit mechanisms by which this suppression occurs.