A Role for the Superior Colliculus in Decision-Making and Decision Confidence

Michele A Basso

UCLA

Simple decisions arise from the evaluation of sensory evidence. But decisions are determined by more than just evidence. Individuals establish internal, decision criteria that influence how they choose. The criterion one uses to report a decision is also related to the sense of confidence in that decision. Indeed, recent models of decision confidence propose that our sense of confidence is based upon an optimal read out of decision signals from sensorimotor regions of the brain that participate in decision-making processes such as area LIP and SEF. I will describe results from our recent experiments in which we explore the relationship of neuronal activity in a sensorimotor area of the brain involved in decision-making, the superior colliculus of monkeys, to decision-making and decision confidence. Our experiments include correlational and causal manipulations and the results show that neurons in the superior colliculus express a signal that establishes the criterion that monkey use to inform their decisions in a simple Yes - No detection decision task. Moreover, using a novel stimulus display that de-correlates decision performance accuracy from decision confidence, we show that the decision-related signals of the SC predict performance accuracy but not decision confidence. The results suggest that other areas of the brain signal our subjective sense of confidence and also call into question optimal models of decision confidence.

Farran Briggs
Departments of Neuroscience and Brain and Cognitive Sciences
Ernest J. Del Monte Institute for Neuroscience
Center for Visual Science
University of Rochester

Title: Understanding attention at different neuronal scales

Abstract:
Visual attention enhances the signal to noise ratio of neuronal responses in the visual cortex, however the mechanisms by which these attentional modulations occur are not known. Visual attention is also studied at multiple scales from single neurons to larger neuronal populations, as measured with the local field potential (LFP). What can we learn from studying attentional modulation at these various neuronal scales? Here we compare attentional modulation across different scales within the early visual pathways that include reciprocal connections between the visual thalamus and primary visual cortex as well as local circuits within primary visual cortex.

When we examine attentional modulation of individual neurons, we see that attentional modulation of firing rate depends critically on the match between that individual neuron's feature selectivity and the features that are required for successful task completion. We see similar patterns when we examine local circuit connections between individual neurons in primary visual cortex. Given that the majority of neurons within a cortical column may not be tuned to the specific stimulus features relevant to a particular task, we predicted that multi-unit activity may show an average suppression of rate with attention. Preliminary data support this hypothesis.

When we examine attentional modulation at the level of the LFP, a slightly different picture emerges. We find that attentional modulation of LFPs is temporally dynamic. Specifically, there is more attentional modulation of LFP timing (i.e. phase) and communication across circuits than there is attentional modulation of LFP amplitude. We do not observe frequency-specific tagging of signals relayed in distinct early visual circuits, with the exception of attentional enhancement of gamma-band activity in the feedback corticogeniculate circuit linking visual cortex with the visual thalamus.

Together these results suggest that a holistic approach is probably required to fully understand the neuronal mechanisms of visual attention. While individual neurons provide important insight into links between spatial and feature attention within cortical columns, LFPs provide a clearer picture of the temporal dynamics of attention on short timescales.

The Reverse Pulfrich Effect

Johannes Burge[1.,2.,3.]
[1.] Department of Psychology, University of Pennsylvania
[2.] Neuroscience Graduate Group, University of Pennsylvania
[3.] Bioengineering Graduate Group, University of Pennsylvania

Monovision corrections have become a popular treatment for presbyopia. Each eye is fit with a lens that focuses light from a different distance, thereby causing differential blurring of the images in the two eyes. Little is known about how differential blur affects the perception of motion in depth. We investigated this by measuring the Pulfrich effect, a stereo-illusion that was first reported nearly 100 years ago… by Pulfrich. When a target oscillating in the frontoparallel plane is viewed with unequal retinal illuminance in the two eyes, the target appears to move along an elliptical trajectory in depth. More recent studies have shown that the Pulfrich effect occurs for stimuli with contrast differences between the two eyes. The effect is thought to occur because the image with lower illuminance or contrast is processed more slowly than the image in the other eye. The mismatch in the speed of processing causes a neural disparity, which in turn results in the illusory motion in depth. What happens when the images of the two eyes are differentially blurred? When the two eyes are differentially blurred, a reverse Pulfrich effect occurs, an apparent paradox. Blur is known to reduce contrast and should therefore cause that eye's image to be processed more slowly, but the reverse Pulfrich effect implies that the blurred eye's image is processed more quickly (rather than more slowly) than the sharp eye's image. The paradox is resolved by recognizing two facts. First, blur reduces the contrast of high-frequency image components more aggressively than low-frequency image components. Second, high spatial frequencies are processed more slowly than low spatial frequencies, all else equal. Thus, this new version of a 100-year-old illusion is readily explained by known properties of the early visual system. Implications will be discussed.

Lawrence Cormack

UT Austin

Attentional filters for object motion revealed by dynamic tracking responses

Recently, Sperling and colleagues (e.g. Sun et al. AP&P, 2016) introduced a clever technique for measuring attention filters – behavioral filters for segregating objects based on the value of some feature (e.g. contrast). In this technique, observers are asked to estimate the location of the centroid of multiple target objects, objects having a particular value of the feature of interest, while ignoring groups of distractor objects, objects having other values of this feature. One can then recover the weights that observers assigned to the different groups in determining their centroid estimates (a plot of weights vs. feature value showing the attention filter). Here, we introduce a continuous tracking version of this paradigm that offers two key enhancements. First, it allows us to efficiently examine characteristics of object motion as a feature for study. Second, it is quite powerful, yielding an enormous amount of data in a small amount of experimental time, while also being easy and fun for naïve observers. We have measured attention filters for average object speed, and have found that even undergraduates are able to segregate objects by their average speed well (and with minimal instruction). Observers were better at attending to a speed that was either the fastest or slowest in the display, controlling for actual speed. Further, objects with the slowest speed in the display were the hardest to ignore; they generally leaked into the filter for the next highest speed. Further extensions of this fun, powerful paradigm will also be discussed.

Peter Dixon
University of Alberta

Mind Wandering and Temporal Focus in Task Switching

When subjects switch tasks from trial to trial, there is generally switch cost: Responses are slower when performing a task that is different from the previous trial. Surprisingly, there is also residual switch cost that occurs even when subjects have ample opportunity to prepare for the new task. Here, I used a new type of task switching paradigm that allowed me two identify two components to residual switch cost: interference from the previous task and failure to completely prepare for the current task. I combined this paradigm with self reports of mind wandering: Subjects were periodically interrupted during the session and asked to rate the extent to which they were on task. Subjects who reported being on task showed little interference from the previous task; mind wandering subjects, on the other hand, showed substantial interference. I argue that when mind wandering, subjects have relatively poor temporal focus, so that they are inclined to make a response that was appropriate for a previous trial.

Modeling *n*-alternative judgments

Barbara Dosher
Department of Cognitive Sciences, University of California Irvine

Using *n*-alternative choice (*nAFC*) tasks to study visual perceptual learning (almost always studied in *2AFC*) provides a context for comparing different forms of supervision. This can contrast the rate of improvement in performance using fully supervised (response feedback), partially supervised (accuracy feedback), and unsupervised (no feedback) learning. We show how an elaborated extension of the Integrated Reweighting Theory of perceptual learning (Dosher et al., 2013) accounts for improvements in percent correct and/or contrast thresholds as well as confusion matrices and their corresponding measures of association between the stimulus and response categories. This model has been applied in 8-alternative forced choice orientation and spatial frequency categorization using both accuracy and threshold measures.

Collaborators: Jiajuan Liu and Zhong-Lin Lu
Supported by NEI # EY-17491

James Elder

York University, Canada

LS3D: Single-View Gestalt 3D Manhattan Surface Reconstruction

Recent deep learning algorithms for single-view 3D reconstruction recover rough 3D layout but fail to capture the crisp linear structures that grace our urban landscape. Here we show that for the particular problem of 3D Manhattan building reconstruction, the explicit application of linear perspective and Manhattan constraints within a classical constructive perceptual organization framework allows accurate and meaningful reconstructions to be computed. The proposed Line Segment to 3D (LS3D) algorithm computes a hierarchical representation through repeated application of the Gestalt principle of proximity. Edges are first organized into line segments, and the subset that conforms to a Manhattan frame is extracted. Optimal bipartite grouping of orthogonal line segments by proximity minimizes the total gap and generates a set of Manhattan spanning trees, each of which is then lifted to 3D. For each 3D Manhattan tree we identify the complete set of 3D 3-junctions and 3-paths, and show that each defines a unique minimal spanning cuboid. The cuboids generated by each Manhattan tree together define a solid model and the visible surface for that tree. The relative depths of these solid models are determined by an L1 minimization that is again rooted in a principle of proximity in both depth and image dimensions. The method has relatively fewer parameters and requires no training. For quantitative evaluation, we introduce a novel 3D Manhattan building dataset. We find that the proposed LS3D method generates 3D reconstructions that are both qualitatively and quantitatively superior to reconstructions produced by state-of-the-art deep learning approaches.

Re-understanding internal noise as internal confidence for time, space and number

Justin Halberda
Professor
The Department Of Psychological And Brain Sciences
The Johns Hopkins University

In this presentation, I invite a re-understanding of the contents of our analog magnitude representations (e.g., approximate duration, distance, number). As my main example, I consider the Approximate Number System (ANS), which supports numerical representations that are widely described as fuzzy, noisy, and limited in their representational power. I contend that these characterizations are largely based on misunderstandings of psychophysical theory. Specifically, I propose that what has been called "noise" and "fuzziness" in these representations (e.g., *approximately 7*) is actually an important epistemic signal of *confidence in my estimate of the value* (e.g., think *7, with confidence intervals*). Rather than the ANS having noisy or fuzzy numerical content, I suggest that the ANS has exquisitely precise numerical content that is subject to epistemic limitations.

Retinal Center-Surround Processing: Spatiotemporal Dynamics and Influence on Perception

Jihyun Yeonan-Kim
National Eye Institute

Center-surround processing is a biological system architecture that normalizes the information coded at a certain spatial coordinate (e.g. responses of a cell) given the information at its vicinity (e.g. average responses of neighboring cell) on a neural plane. This process improves the efficiency of neural signaling by reducing the redundancy of information that the signals represent. On the retinal plane, this architecture is known to produce lateral inhibition that contributes to perceptual phenomena such as spatial induction and contrast sensitivity. However, the precise mechanisms of retinal center-surround processing and their full impact on perception are mostly understudied. Here, I provide a brief review on neurophysiological details by which complicated spatiotemporal dynamics emerge in the retinal ganglion cell responses as consequence of the process and explain how this contributes to perceptual phenomena of visual persistence and afterimages both of which are modulated by temporal (stimulus duration) and spatial (stimulus spatial-frequency) of stimulus. Several psychophysical experiments on the phenomena were simulated in an existing retinal model by Wilson (1997), which previously has successfully predicted light-adaptation dependent human contrast sensitivity as well as the afterimage phenomena under study. Utilizing Wilson's model, I avoid adding yet another model to the overflowing list of retinal or vision models, simulate perceptual experiments in a purely neurophysiology-based model (as opposed to a model to fit psychophysical data), identify which temporal and spatial cellular properties are critical for the phenomena, and demonstrate the commonality of neural architecture (center-surround processing) underlying visual persistence, afterimages, light adaptation, contrast sensitivity, and spatial induction.

Assessing the detailed time course of perceptual sensitivity change in perceptual learning

Zhong-Lin Lu

Ohio State U.

Perceptual learning improves perceptual sensitivity through training. The learning curve is typically sampled in blocks of trials because of the number of trials required for estimating human performance. The procedure could result in imprecise and possibly biased estimates, especially when learning is rapid. Recently, Zhao et al (2017) developed a Bayesian adaptive quick Change Detection (qCD) method to accurately, precisely, and efficiently assess the time course of perceptual sensitivity change. The method selects the optimal test stimulus, and updates, trial by trial, a joint probability distribution of the parameters of a model of perceptual sensitivity and its change over time. In this study, we implemented and tested the qCD method in assessing the learning curve during perceptual learning. Both computer simulations and a psychophysical experiment showed that the accuracy (bias) and precision (standard deviation or confidence bounds) of the estimated learning curves from the qCD were much better than those obtained by the staircase method. Our results suggest that the qCD method can be used to precisely and accurately assess the trial-by-trial time course of perceptual learning.

Bayesian Decision Theory and Navigation

Timothy P. McNamara

Effective spatial navigation depends on the ability to combine information from multiple sources or cues to estimate properties of the environment, such as the location of a goal. Spatial cues include landmarks, and other visible features of the environment, and body-based cues generated by self-motion (e.g., vestibular, proprioceptive, & efferent information). A number of recent experiments have investigated the extent to which visual cues and body-based cues are combined optimally according to statistical principles (maximum-likelihood estimation). Although several of these studies have documented optimal or near-optimal cue combination, other studies have shown that navigators sometimes fail to combine cues optimally or even at all. A potential limitation of all of these investigations is that they have assumed uniform priors and have not tested fully-specified decision models. In this presentation, I will examine whether apparent violations of optimal cue combination can be explained by incorporating non-uniform priors or appropriate loss functions in Bayesian decision-theoretic models.

Who is Where? Representing Social Space in the Primate Brain

Cory Miller
UCSD

Primates are distinguished from other animals by the sophistication and breadth of their (Our) understanding of - and capacity to effectively navigate - the complexities of the social landscape. A cornerstone of this cognitive faculty is integrating knowledge of where all conspecfiics are in physical space and their relative relationships in the social network. Here we will present new neurophysiological studies examining each of these processes in the hippocampus of common marmosets. I will discuss recent evidence from my lab on the discovery of 'place cells' as well as neurons that encode the individual identity of conspecifics. Finally, I will discuss ongoing work investigating how these disparate social and spatial processes conjoin to represent social space in this neural structure.

The Optoretinogram at 38.5

Jeffrey B. Mulligan, NASA Ames Research Center

As early as 1980, Donald MacLeod coined the term "optoretinogram" to describe a change in the near-infrared reflectance of the retina following visual stimulation. The hope that such signals might exist was stimulated by an observation of a change in the infrared transmission of isolated toad retinae (Harary, Brown & Pinto, 1978). This signal showed a time course of several seconds, much slower than the electroretinogram, and was thought to be related to some chemical step in the phototransduction cascade. During the early 1980's, we made several attempts to observe such signals *in vivo* in humans, without success. In the intervening decades, however, researchers have succeeded in observing what are now known as "intrinsic optical signals" or IOSs. Responses from single photoreceptors (obtained using adaptive optics) are surprisingly heterogenous, with some cells increasing their reflectance in response to visual stimulation, while others decrease (Cooper et al., 2017). This talk will review our early work, survey recent findings, and consider various theories for the origin of the effect.

Selection for attention: Neural circuits and computations in owls and mice

Shreesh P. Mysore, PhD
Assistant Professor
Psychological & Brain Sciences, and Neuroscience
Johns Hopkins University

Attention, the ability to selectively process the most important subset of information in the environment (at the expense of all others) is a fundamental component of adaptive behavior. Much is known about the consequences of attention to behavior and neural representations, about the shaping of attention by neuromodulators, and about genetic factors associated with attentional dysfunction. However, the neural basis of the *control* of attention has remained largely elusive. Specifically, how do neural circuits select the next target of (spatial) attention, and what canonical neural computations underlie this function? I will share recent findings from our work in barn owls that addresses one such computation underlying stimulus selection for spatial attention, namely, location-invariance. We discovered that specialized inhibitory neurons in the barn owl midbrain, which are conserved across all vertebrates, employ a novel form of population coding, namely, combinatorially-optimized coding, through the use of unusual representations of space. We showed that this results in a combinatorial strategy for solving selection at all possible pairs of stimulus locations, a strategy that also minimizes the net costs of building and operating the neural circuitry. I will then switch gears and share briefly our recent work in developing primate-like behavioral paradigms for visuospatial attention in freely behaving mice. These paradigms are designed to allow the (ongoing) dissection of mammalian neural circuitry underlying spatial attention control. We anticipate that such efforts will help not only to advance our understanding of attention control at a circuit-level, but also to lay a foundation for the ‘neurotype’ of attentional impairments.

Modeling Dual Task Interference using Information-Theoretic Approach

Misha Pavel and Holly Jimison, Northeastern University

Leveraging recent advances in sensor and mobile technology, it is now possible to monitor behaviors in real life with the potential to assess perceptual, cognitive and motor characteristics of people in the wild. Since humans typically perform more than one task at the time the observed performance of either or both tasks is usually degraded. This multiple-task interference could potentially be used to assess aspects of cognitive capabilities (especially for populations at risk), but it would require quantitative models of the interference that would infer the underlying cognitive capacity limitation captured empirically by the Performance Operating Characteristics (POC). For binary tasks, we developed an information-theoretic model of channel capacity that enables us to describe the overall capacity limitation as well as the POC tradeoffs. To make this useful in practice, we had to extend the models to incorporate tradeoffs between overt behaviors and cognitive processes. We investigated combinations of information-theoretic and control-theoretic approaches to quantify sensory-motor behaviors such as walking in terms of information capacity. In this presentation we discuss our theoretical framework and simulations.

A Public Cloud Platform for Large-Scale Data Analysis, Visualization and Sharing of Reproducible Neuroscience Research.

Franco Pestilli, Indiana University

Neuroscience is at the forefront of science by reaching across disciplinary boundaries and promoting transdisciplinary research. This is a process that, in principle, can facilitate discovery by convergent efforts from theoretical, experimental and cognitive neuroscience, as well as computer science and engineering. To ensure the success of this process mechanisms to guarantee reproducibility of scientific results must be established. Open software development and data sharing are therefore paramount in the quest to achieve reproducibility.

We present brainlife.io, a platform which addresses challenges of neuroscience reproducibility by providing integrative mechanisms for publishing data, and algorithms while embedding them with computing resources to impact multiple scientific communities.

We present three main technological results with broad impacts on neuroscience research and discovery. First, we demonstrate that platform can process brain data, publish algorithms as reproducible applications, and perform data-intensive computing on clouds. Second, we present novel algorithms for mapping brain networks using clouds. These algorithms will enhance discovery by leveraging the online platform for data-intensive processing of large datasets. Third, we publish test-retest brain datasets and derived data (processed), such as connectome matrices, multi-parameters tractography models, cortical segmentation and functional maps. These datasets can be used as a reference or to develop algorithms for functional mapping, anatomical computing, and optimization.

The platform represents a unique method and technology for publishing the full set of scientific research assets in a study comprising data and analyses code as well as all provenance information, embedded in a series of reproducible, open cloud platform web-services that allow collaborative tracking of the scientific process. We demonstrate that the core platform can integrate previously published data, and analyses to reproduce major published results in neuroscience. To promote open neuroscience, brainlife.io allows scientists to publish data and reproducible analyses with seamless access to national supercomputers.

In sum, the brainlife.io platform provides access to algorithms, data, and computing resources to trainees and faculty nationwide. The entire platform and all technologies developed with it are freely available and open-source in order to contribute to the wide community of users and researchers in the neurosciences.

Symmetry is the *sine qua non* of 3D vision

Zygmunt Pizlo
UC Irvine

Symmetry refers to: (i) the *invariance* of objects under transformations, and to: (ii) the *redundancy* (self-similarity) within objects. The invariance aspect of symmetry, which has been studied for over a century in Mathematics and Physics, allows the identification of permanent characteristics of objects, such as their shapes and sizes. It is widely accepted that the main task for human vision is to provide the observer with veridical information about these permanent characteristics. This task is difficult because the mapping from a 3D object to its 2D retinal image is “infinity-to-one.” This mapping violates all 4 axioms of a *group*, which means that the invariants that exist in the 3D world are lost in its 2D retinal image. These invariants can be recovered, however, by using the redundancy aspect of the symmetry of objects. The redundancy aspect of symmetry has been discussed in vision science at least since the seminal book published by Ernst Mach in 1886, but its importance has traditionally been underestimated. We now know that it is *this* redundancy that restores the one-to-one mapping between a 3D object and its single 2D retinal image, making 3D vision possible. The talk will conclude by suggesting that all cases of reconstructing a “shape from X” actually refer, explicitly or implicitly, to the use of symmetry.

Nicholas Port

Title: The Clinical Utility of Using Involuntary Eye Movements to Assess Concussion

PURPOSE: Critical decisions are made daily about whether to bench athletes who might have suffered a concussion or mild traumatic brain injury (mTBI). The low-level damage underlying mTBI has been difficult to measure, especially during competition when assessments are made quickly utilizing primarily subjective symptoms. The ideal instrument would be a) sensitive to low-level diffuse damage, b) easily and rapidly administered on the sidelines, and c) unaffected by human bias or sandbagged baselines. Based on a body of research documenting the sensitivity of oculomotor movements (e.g., saccades and smooth pursuits) to mTBI damage, we have constructed 5 Sideline Eye Trackers and are evaluating their clinical use for quick, objective and accurate assessment of mTBI.

METHODS: Current enrollment of athletes is over 1200, including the entire IU athletic department and several local schools. All enrollees complete a six-minute, pre-season, baseline oculomotor exam consisting of two saccade, two pursuit, and one ocular following task. Balance is simultaneously measured using a portable balance board. Anyone suspected by the team physician of having a concussion during the season repeats this exam 3 additional times: 1) immediately post-injury (minutes to an hour), 2) at the time of being cleared for return-to-play, and 3) as far post-injury as possible (~4-9 months). To provide two separate measures of test-retest variability, two control groups are also being studied: 1) within-sport non-concussed matched control group, and 2) non-concussion prone cross-country athletes.

RESULTS: Athletes with mTBI show significant deficits in both saccadic and pursuit function compared to their baseline (ANOVA $p < 0.0001$). Drift in the center of pressure measure (balance) is also significantly affected in many subjects. Signal detection theory yields a specificity and sensitivity of greater than 85% with our current data set of 69 concussed athletes.

CONCLUSIONS: Measuring ocularmotor dysfunction in athletes with a 6-minute task via a Sideline Eye Tracker may be a promising tool for the diagnosis and management of mTBI.

C1QL-mediated complexes, a novel molecular logic in synapse adhesion

Susanne Ressl
Indiana University

Proper brain function is based on neuronal networks, which are based on synapses, the fundamental structural unit of neuronal communication. Synaptic adhesion proteins bind across the synaptic cleft forming membrane tethered complexes, and have important functions in synapse homeostasis. Dysfunction of synaptic adhesion proteins are linked to complex brain disorders, 'synaptopathies'. Members of the family of complement component 1, q subcomponent-like proteins (C1QL1-3) act as synapse organizers. C1QLs are secreted into the synaptic cleft and bind to a post-synaptically localized adhesion GPCR B3 (ADGRB3). We hypothesize that C1QLs bidirectionally coordinate a trans-synaptic complex by interacting with ADGRB3 and a yet unknown pre-synaptic partner. Building on our *in-vivo* interactome data that identified such pre-synaptic binding partner, our research focusses on X-ray crystallography and electron microscopy studies to elucidate the stoichiometry and identify binding surfaces of this new C1QL-mediated complex. Additionally, C1QL proteins can form distinct higher oligomer species, which together with calcium specificity, dictate the nature of binding and stoichiometry, resulting in a novel mechanism of how trans-synaptic adhesion is achieved. Our discovery of a novel trans-synaptic complex will reveal an entirely new biochemical pathway that achieves synapse formation and maintenance in a unique way with an unusually complex stoichiometry.

Title: Spontaneous Traveling Cortical Waves Gate Perception

Zac Davis, Lyle Muller, Terry Sejnowski, Julio Martinez-Trujillo, John Reynolds
The Salk Institute for Biological Studies

Abstract: A stimulus presented near perceptual threshold may or may not be detected, depending on brain state. Neocortical neurons emit variable spike patterns to repetitions of the same stimulus. It is critical to understand the nature of neural variability and its effect on perception. Using electrode recording arrays in Area MT of the common marmoset (Callithrix jacchus), we find that spontaneous network fluctuations travel as waves across the cortical surface. The position and timing of waves predict the magnitude of spiking activity evoked by visual stimuli presented near perceptual threshold, and predict the animals' perceptual sensitivity. These electrophysiological results reveal for the first time that spontaneous traveling waves are a ubiquitous cortical phenomenon that gates perception.

Using simultaneous multi-area neuronal recordings to investigate how attention improves behavioral performance

Douglas A. Ruff and Marlene Cohen
University of Pittsburgh

Visual attention dramatically improves subjects' ability to see and also modulates the responses of neurons in every known visual and oculomotor area, but whether those modulations can account for perceptual improvements remains unclear. We measured the relationship between the activity of populations of visual neurons (area MT), oculomotor neurons (the Superior Colliculus), and behavior, which we found to be inconsistent with all published hypotheses about how attention improves perception. Instead, our results suggest a novel hypothesis: that the well-known effects of attention on firing rates and shared response variability in visual cortex reshape the representation of attended stimuli such that they more effectively drive downstream neurons and guide decisions without explicitly changing the weights relating sensory responses to downstream neurons or behavior. More generally, this study shows that leveraging the ability to record simultaneously from neurons at different stages of neural processing and constraining analyses by the subjects' behavior can greatly clarify the relationship between many sensory, cognitive, and motor processes, neuronal responses and behavior.

Spatial attention, visual perception, and slow fluctuations in endogenous brain activity

Michael Silver
Helen Wills Neuroscience Institute and School of Optometry
University of California, Berkeley

Spatial attention improves performance on visual tasks, increases neural responses to attended stimuli, and reduces correlated noise in visual cortical neurons. In addition to being visually responsive, many retinotopic visual cortical areas exhibit very slow (<0.1 Hz) endogenous fluctuations in functional magnetic resonance (fMRI) signals. To test whether these fluctuations degrade stimulus representations in the brain, thereby impairing visual detection, we recorded fMRI responses while human subjects performed a visual target detection task that required them to allocate spatial attention to either a rotating wedge stimulus or to a central fixation point. We then measured the effects of spatial attention on response amplitude at the frequency of wedge rotation and on the amplitude of endogenous fluctuations at non-stimulus frequencies.

We found that in addition to enhancing stimulus-evoked responses, attending to the wedge also resulted in suppression of endogenous fluctuations that were unrelated to the visual stimulus in several topographic occipital and parietal cortical areas. In addition, attentional enhancement of response amplitude and suppression of endogenous fluctuations are dissociable. First, individual cortical areas vary in the relative amounts of attentional enhancement and suppression. Second, across multiple 5-minute runs, the amplitude of enhancement of visual responses was uncorrelated with the amount of suppression of endogenous activity. Finally, we found that subjects' ability to detect visual targets within the wedge was inversely correlated with the amplitude of endogenous fluctuations but was unrelated to the stimulus-evoked response amplitude.

These results suggest that endogenous fluctuations in brain activity are modulated by spatial attention and that successful suppression of this endogenous activity facilitates visual perception.

The Perceptual Experience of Variability

Jessica K. Witt

Colorado State University

Abstract. What is the perceptual experience of variability? Unconscious perceptual processes are well-calibrated to variability, as are unconscious motor processes, whereas cognitive processes are not well-calibrated and tend to underestimate variability. Regarding the perceptual experience of variability, perceivers are sensitive to differences in the variability of ensembles of objects, but any potential biases have not yet been explored. In the current experiments, participants viewed a set of lines at various orientations that were presented one at a time in a random order. Participants judged whether the orientations within each set were more similar to each other or more disperse. Although participants were sensitive to differences in spread, participants overestimated the variability of the set by 50%. The results have implications for mechanisms underlying ensemble perception, which is the extraction of summary statistics from a set of objects. In particular, there are both shared and unique processes related to perceiving similarities across objects (such as the mean orientation) and perceiving differences (such as their spread). Both visual abilities were thorough and used the full set of lines, rather than efficient by using only a subset, but the perception of spread relied more heavily on differences presented at the beginning whereas perception of the mean relied more heavily on features of the lines at the end of the animation. The results also have implications for visualizations of uncertainty, such as hurricane forecasts. A perceptual bias to overestimate variability could help counteract cognitive biases to underestimate variability.

The Effects of Acute Stress on Episodic Memory

Grant S. Shields, Matthew A. Sazma, Andrew M. McCullough, and Andrew P. Yonelinas
University of California, Davis

A growing body of research has indicated that acute stress can critically impact memory. However, there are a number of inconsistencies in the literature, and important questions remain regarding the conditions under which stress effects emerge as well as basic questions about how stress impacts different phases of memory. We conducted a meta-analysis that examined 113 independent studies in humans with 6,216 participants that explored effects of stress on encoding, postencoding and retrieval phases of episodic memory. These analyses indicate that stress disrupts some episodic memory processes while enhancing others, and that the effects of stress are modulated by a number of critical factors. These results provide important constraints on current theories of stress and memory, and point to new questions for future research.