26th Symposium of the Center for Visual Science
University of Rochester
Rochester, NY 14627

Blurring the Borders Between Vision, Cognition, & Action

May 29 - 31, 2008

Symposium sponsored by the Office of Naval Research, the National Science Foundation, and the Center for Visual Science
**GENERAL INFORMATION**

- Free round-trip shuttle transportation will be provided from the hotel to the Rochester International Airport and to the University of Rochester River Campus (Wednesday) and Medical Center (Thursday-Saturday).

- Meal tickets for the lunches and dinners are in your registration packet if requested on your registration form. A separate lunch line will be provided for vegetarians. Please take one serving per person when going through the food line to ensure that everyone receives his or her meal. After everyone has been served, the remainder of the food will be available for general consumption.

- On Thursday, an announcement will be made during the final session to orchestrate transportation to the dinner. Carpooling will be organized outside the registration area at the medical center. Parking will be available at the Colgate Divinity School. The dinner will be held directly after the final sessions, so dress is casual.

- There will be a public wireless network in the Medical Center Atrium called "UR_MCguest". No username/password should be necessary to connect. If you have difficulties, contact the registration desk.

- Please remember to turn off all cell phones, PDAs, and pagers during the talks.

**Organizing Committee**

Tatiana Pasternak, Neurobiology & Anatomy, Brain & Cognitive Sciences, Center for Visual Science  
Duje Tadin, Brain & Cognitive Sciences, Center for Visual Science  
Debbie Shannon, Administrator  
University of Rochester  
Center for Visual Science  
(585) 275-2459 Voice  
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*Symposium sponsored by the Office of Naval Research, the National Science Foundation, and the Center for Visual Science*
POSTER PRESENTATION INSTRUCTIONS

- The posters should be put up early Thursday morning, May 29. The poster session will be held in the Flaum Atrium, which is adjacent to the meeting room. You are asked to stay with your poster from 6:00 - 7:00 pm on Thursday and Friday evenings. You should take down your poster after the meeting has concluded.

- The posters should be prepared to fit on an approximately 5 ft W x 3.5 ft H foam core poster board that has a white background.

- All boards will be numbered. Attach your poster to the board that corresponds to your number on the "Poster Presentations" list in the program booklet.

- We will have a supply of pushpins available at the registration desk should you be unable to bring your own. Do not use tape.

- Do not try to mount heavy materials, as they will have difficulty staying attached to the foam core poster board.

- Please see the administrative staff at the registration desk if you have any difficulties.
PROGRAM SCHEDULE

May 29 - 31, 2008

*All talks and discussion sessions will be held in the Class of '62 Auditorium, University of Rochester Medical Center

Wednesday, May 28

7:00 pm - 10:00 pm  Registration and Welcome Reception, 269 Meliora Hall, River Campus

Thursday, May 29

8:00 am  Registration & Breakfast, Medical Center Atrium
8:45 am  Welcome, Tatiana Pasternak & Duje Tadin

VISUAL AND COGNITIVE CIRCUITS

Liz Romanski, Session Chair

9:00 am - 9:45 am  Simon Thorpe  From vision to action in 100 ms - is there time for cognition? (T1)
CNRS, France

9:45 am - 10:30 am  Emilio Salinas  How behavioral constraints influence sensory tuning curves (T2)
Wake Forest University

10:30 am - 11:00 am  Break (Refreshments will be served), Medical Center Atrium

11:00 am - 11:45 am  Helen Barbas  How the frontal lobe controls the mind's eye (T3)
Boston University

11:45 am - 12:30 pm  Leslie Ungerleider  The primate prefrontal cortex and the executive control of attention (T4)
NIMH

12:30 pm - 1:00 pm  Discussion Session

1:00 pm - 2:00 pm  Lunch, Medical Center Atrium

VISUAL SIGNALS IN COGNITIVE CIRCUITS

Greg DeAngelis, Session Chair

2:00 pm - 2:45 pm  Tatiana Pasternak  Representation of visual motion during motion discrimination tasks in primate prefrontal cortex (T5)
University of Rochester

2:45 pm - 3:30 pm  Andreas Nieder  Representation of number in the primate brain (T6)
University of Tuebingen

3:30 pm - 4:00 pm  Break (Refreshments will be served), Medical Center Atrium

4:00 pm - 4:45 pm  John Assad  Encoding behavioral relevance in parietal cortex (T7)
Harvard Medical School

4:45 pm - 5:30 pm  Wendy Suzuki  Associative learning signals in the monkey medial temporal lobe (T8)
New York University
5:30 pm - 6:00 pm Discussion Session
6:00 pm - 7:00 pm Posters
7:30 pm - 9:30 pm Dinner, Colgate Divinity School

Friday, May 30

8:00 am Breakfast, Medical Center Atrium

**COGNITIVE INFLUENCES ON VISUAL PROCESSING I**
*Charles Duffy, Session Chair*

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<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>9:00 am - 9:45 am</td>
<td>Marisa Carrasco</td>
<td>Spatial and feature-based attention: psychophysics and neuroimaging studies (T9)</td>
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<td>New York University</td>
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<td>9:45 am - 10:30 am</td>
<td>Frank Tong</td>
<td>Decoding the contents of perception and attention from human brain activity (T10)</td>
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<td>Vanderbilt University</td>
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<td>10:30 am - 11:00 am</td>
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<tr>
<td>11:00 am - 11:45 am</td>
<td>David Heeger</td>
<td>The normalization model of attention (T11)</td>
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<td>New York University</td>
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<td>11:45 pm - 12:30 pm</td>
<td>Stefan Treue</td>
<td>Attentional influences on motion processing in area MT: of space, features and objects (T12)</td>
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<td>University of Göttingen</td>
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<td>12:30 pm - 1:00 pm</td>
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<td>1:00 pm - 2:00 pm</td>
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**COGNITIVE INFLUENCES ON VISUAL PROCESSING II**
*Duje Tadin, Session Chair*

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<tr>
<th>Time</th>
<th>Speaker</th>
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<tr>
<td>2:00 pm - 2:45 pm</td>
<td>Patrick Cavanagh</td>
<td>Attention and nonretinotopic processing in vision (T13)</td>
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<td>University of Paris</td>
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<td>2:45 pm - 3:30 pm</td>
<td>Charles Gilbert</td>
<td>Brain states (T14)</td>
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<td>Rockefeller University</td>
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<td>3:30 pm - 4:00 pm</td>
<td>Break (Refreshments will be served), Medical Center Atrium</td>
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<td>4:00 pm - 4:45 pm</td>
<td>Carl Olson</td>
<td>Selectivity for features, conjunctions and configurations in ventral stream cortex (T15)</td>
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<td>Carnegie Mellon University</td>
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<td>4:45 pm - 5:30 pm</td>
<td>Shinsuke Shimojo</td>
<td>Behavioral and neural correlates of visual preference decision making (T16)</td>
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<td>California Inst. of Technology</td>
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<td>5:30 pm - 6:00 pm</td>
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<td>6:00 pm - 7:00 pm</td>
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<td>7:30 pm - 9:30 pm</td>
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<td>9:00 am - 9:45 am</td>
<td><strong>David Burr</strong></td>
<td><em>Keeping vision stable</em> (T17)</td>
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<td>9:45 am - 10:30 am</td>
<td><strong>Carol Colby</strong></td>
<td><em>Attention and active vision</em> (T18)</td>
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<td>10:30 am - 11:00 am</td>
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<td>11:00 am - 11:45 pm</td>
<td><strong>Tirin Moore</strong></td>
<td><em>Mechanisms of saccadic suppression in ventral visual cortex</em> (T19)</td>
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<td>11:45 am - 12:30 pm</td>
<td><strong>Randolph Blake</strong></td>
<td><em>Actions can arbitrate visual conflict</em> (T20)</td>
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<td>12:30 pm - 1:00 pm</td>
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<td>1:00 pm - 2:00 pm</td>
<td>Lunch, Medical Center Atrium</td>
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*End of Meeting*
POSTER PRESENTATIONS

(P1) Bartlett, A: Modular second-order processing in the human visual system

(P2) Bouamama, S: Does fixation prime letters and non letters recognition?

(P3) Canto-Pereira, L: The influence of odor on perception of emotional stimuli

(P4) Diehl, M: Neuronal activity during discrimination of faces and vocalizations in the primate ventrolateral prefrontal cortex

(P5) Lin, Z: Specificity of masked priming of face: evidence for early dissociation of identity and expression recognition

(P6) MacKenzie, K: Sensitivity of implicity visual rule-learning to the complexity of context

(P7) Maier, A: What happens in primary visual cortex when a stimulus becomes visible? Insights from fMRI and layer-specific neurophysiology in non-human primates

(P8) Massot, C: 3D shape perception from texture: psychophysical experiments and computational modeling

(P9) Murray, R: The light-from-above prior overrides contextual lighting cues

(P10) Navalpakkam, V: A neural Bayesian theory of visual search and its behavioral predictions

(P11) Page, W: Cortical neurons reveal perceptual strategies for the active control of steering

(P12) Pearson, J: The functional impact of mental imagery on conscious perception

(P13) Rao, V: Prior probabilities and decision formation in area LIP

(P14) Sims, C: Bayesian adaptation to the dynamics of uncertainty

(P15) Sun, H: Contextual influences on rapid object categorization in natural scenes

(P16) Teichert, T: A physiological account of perisaccadic shift based on the reafference model
TALKS
**From vision to action in 100 ms – is there time for cognition?**

**Simon Thorpe**, CNRS, France

When two natural scenes are displayed left and right of fixation, human subjects can initiate saccades towards the side containing an animal target in just 120-30 ms (Kirchner & Thorpe, 2006, Vision Research, 46, 1762), but processing time is even faster when the target is a human face. Accuracy can be around 90% even when the mean saccadic reaction time is only 140 ms, and the fastest saccades can start 100-110 ms after image onset. If we allow 20 ms for response initiation, it would appear that the underlying visual processing can be done in as little as 80 ms. What sorts of visual representations could be involved? How might the brain produce anything that is selective for faces at such short latencies? Recent modeling work using feed-forward networks coupled with Spike-Time Dependent Plasticity has shown how unsupervised learning schemes can lead to the development of selectivity to frequently encounter visual patterns (Masquelier & Thorpe, 2007, PLoS Comput Biol, 3, e31). Could the fact that faces often dominate the visual environment of newborn babies allow neurons in relatively early visual areas such as V4 to become selective for facial features? If so, this might help explain how such rapid behavioral responses can be generated, but it leaves open the question of whether this involves cognition.
How behavioral constraints influence sensory tuning curves

Emilio Salinas, Wake Forest University

Many types of neurons respond to sensory stimuli such that their response profiles have a single peak at a 'preferred' point, and population codes are often thought of as arrays of such units. However, many neurons show monotonic dependencies on sensory parameters. Such monotonic responses are both widespread and difficult to reconcile with current ideas about sensory coding, which are based on two fundamental ingredients: stimulus statistics and efficiency criteria (redundancy reduction, decorrelation, sparseness, etc.). I will discuss a complementary point of view in which the responses of a neuronal population are evaluated in terms of the range of outputs that they are capable of generating. The idea is that optimal sensory representations should take into account not only the statistics of the sensory world, but also the statistics of the downstream motor activity that generates behavior. When the downstream responses are non-monotonic, in general the sensory responses that are optimal for driving them will have peaks. However, if the downstream responses are monotonic, then the optimal sensory tuning curves will be predominantly monotonic. Biological examples that are consistent with these results include the encoding of binocular disparity and of heading direction in the visual cortex, as well as the encoding of echo delay in bats. These results suggest that knowledge about the downstream impact of sensory representations is crucial for understanding some of their basic properties.
How the frontal lobe controls the mind's eye

Helen Barbas, Boston University

Successful completion of everyday tasks requires focusing on relevant information and ignoring irrelevant stimuli. The prefrontal cortex in primates has a key role in these processes through mechanisms that are not well understood. Recent findings indicate that the prefrontal cortex may select or ignore stimuli through pathways that form synapses with laminar-specific excitatory and inhibitory neurons in sensory and high-order association cortices. In addition, prefrontal pathways target extensively the frontal and sensory sectors of the inhibitory thalamic reticular nucleus, and the inhibitory intercalated masses of the amygdala. Circuit-based models suggest that these prefrontal pathways may select relevant sensory stimuli and suppress distracters at an early stage of processing. The interface of the prefrontal cortex with subcortical and cortical inhibitory and excitatory systems provides the structural basis for suppressing irrelevant stimuli, allowing behaviorally significant signals to gain access to the cortex.
The primate prefrontal cortex and the executive control of attention

Leslie Ungerleider, NIMH

The prefrontal cortex is thought to play a prominent role in the cognitive control of sensory information. To examine its contribution to the allocation of visual attention, we removed the prefrontal cortex unilaterally in combination with transection of the forebrain commissures in two adult rhesus monkeys. As a result, visual processing in only one hemisphere could be modulated by feedback inputs from the prefrontal cortex. Monkeys were trained to fixate a central spot and their performance in the affected and unaffected visual hemifields was compared on a variety of attention-demanding tasks. The results showed that the prefrontal cortex is critically involved in the top-down selection of the behaviorally relevant target from surrounding irrelevant distracters for processing resources and in updating this information from moment to moment. The prefrontal cortex does not appear to play a crucial role, however, when target selection from surrounding distracters is based on bottom-up mechanisms. Parallel neuroimaging studies in humans reveal the focus within human prefrontal cortex for the top-down attentional effects.
**Representation of visual motion during motion discrimination tasks in primate prefrontal cortex**

**Tatiana Pasternak, University of Rochester**

I will show that during motion discrimination tasks, prefrontal cortex (PFC) neurons carry faithful representation of visual motion stimuli being discriminated. During a task requiring the monkeys to discriminate and remember stimulus direction, many neurons show direction selectivity and represent motion coherence in a way that is reminiscent of neurons in area MT. During a task requiring the discrimination of stimulus speed and ignoring its direction, the same neurons show tuning for stimulus speed resembling speed selectivity in MT. The nature and the temporal dynamics of these motion selective responses support their bottom-up origins. This response selectivity strongly depends on task demands. Thus, during speed discrimination, direction selectivity is reduced and delayed but not completely eliminated, suggesting a link between speed and direction signals expected from signals arriving from motion processing cortical neurons. In some neurons, the reduction in direction selectivity results from a decrease in the response to the preferred direction and in other neurons from an increase in the response to the anti-preferred direction, suggesting that PFC neurons possess or have access to the relatively low-level motion mechanisms. Finally, when the animals are not required to use motion stimuli to get a reward, responses to these stimuli become weak and stimulus selectivity nearly disappears. These observations demonstrate that PFC neurons, in addition to carrying signals about the rules governing the use of sensory stimuli, carry bottom-up signals that could allow active participation in sensory processing of behaviorally relevant stimuli.
Representation of number in the primate brain

Andreas Nieder, University of Tuebingen, Germany

The verbal number concept allows humans to develop the superior mathematical skills that are a hallmark of technologically advanced cultures. Recent findings in animal cognition, developmental psychology and anthropology, however, indicate that numerical skills are rooted in non-verbal biological primitives. We investigated the neural foundations of quantitative categories and concepts in behaving macaque monkeys in combined psychophysical/neurophysiological studies. Monkeys were trained to discriminate different types of quantitative information in delayed match-to-sample tasks. Many neurons in the prefrontal and posterior parietal cortices encoded stimulus magnitude during sample presentation, or maintained this quantitative information ‘on line’ during a memory period. The tuning characteristics of such neurons can explain basic psychophysical effects in dealing with quantities (such as distance and size effects). Tuning to the preferred quantity was deteriorated whenever the monkeys made judgment errors, indicating the behavioral relevance of quantity-selective neurons. The current data shed light on the question of how the primate brain processes quantity information at an evolutionary early stage.
Encoding behavioral relevance in parietal cortex

John Assad, Harvard Medical School

Flexible control of behavior requires the selective processing of task-relevant sensory information. A great deal of evidence suggests a central role for the parietal cortex in these functions. I will discuss the role of parietal cortex in the selective representation of visual information in behaviors for stimulus categorization, selective spatial attention and movement initiation. I will also show evidence for a hierarchy in processing from lower to higher parietal cortical areas, with lower parietal areas providing a more veridical representation of the retinal stimulus (particularly with respect to motion), and higher parietal areas showing a more plastic representation that can be adapted according to the demands of the task at hand.
Associative learning signals in the monkey medial temporal lobe

Wendy Suzuki, New York University

A critical function of the medial temporal lobe is the ability to successfully acquire new declarative information about facts and events that includes new associations between initially unrelated items (associative learning). A major goal of my lab is to understand the brain basis of new associative learning. I will first summarize the studies we have done characterizing the patterns of neural activity seen as monkeys learn new associations on-line. These studies have shown that neurons throughout the medial temporal lobe signal new learning with changes in their stimulus-selective response properties. More recent studies have revealed that these changes in stimulus-selective responses reflect the animal's behavioral learning strategy. A surprising new finding shows that hippocampal neurons also provide a powerful signal of trial outcome, differentiating between trials that are correct or wrong. I will discuss the possible role of these signals in a feedback process by which information about behavioral outcome can be used to strengthen correct performance and modify error performance.
Spatial and feature-based attention: psychophysics and neuroimaging studies

Marisa Carrasco, New York University

We select relevant information by attending to particular locations and features in the environment. First, I will present psychophysical studies comparing spatial and feature-based attention. In one study, we address the temporal dynamics of spatial and feature-based attention with identical stimuli and task. We show that spatial attention is deployed faster than feature-based attention, but that at longer delays they both exert the same effect on the detection of a speed increment task. In another study, we compare the effects of spatial and feature-based attention on motion selective channels, using equivalent noise functions and deriving population responses. The finding that spatial attention reduces the threshold for direction of motion only at low levels of external noise (high motion coherence) suggests that this type of attention is mediated by a gain change in the population response. The finding that feature-based attention reduces the threshold across all levels of external noise (encompassing high and low motion coherence) suggests that it is mediated by both gain and tuning changes in the population response. Lastly, I will discuss two studies that relate psychophysical performance and fMRI activity. One study deals with the effects of covert spatial attention and contrast sensitivity. The other deals with feature-based attention and its effects on selective adaptation and the tilt aftereffect. Together these studies advance our understanding of the behavioral consequences and the neural correlates of spatial and feature-based attention.
Decoding the contents of perception and attention from human brain activity

Frank Tong, Vanderbilt University

Is it possible to determine what a person is seeing, experiencing, or paying attention to, using noninvasive measures of brain activity? My lab has developed a novel decoding approach to extract information about orientation and motion direction from fMRI activity patterns obtained from the human visual cortex. Random variability in the distribution of feature-selective columns or neurons can lead to weak biases in individual fMRI voxels; by pooling the information available from many voxels we can obtain robust ensemble feature selectivity. Our studies indicate that we can reliably decode which of several orientations or motion directions a person is seeing from activity patterns in early visual areas. These feature-selective responses are strongly stimulus-driven. They depend on the strength and quality of the incoming visual signal, and can be observed even when the subjects must attend to irrelevant letter stimuli rapidly presented at fixation. Nonetheless, these orientation and direction-selective responses are also strongly biased by feature-based attention. We can reliably predict which of two overlapping orientations or motion directions a subject is paying attention to based on activity in early visual areas. Bias effects can even be found in V1, indicating that attention modulates feature-selective responses at the earliest possible stage of processing. Finally, when spatial attention is directed to one of two lateralized gratings, we find stronger feature-selective responses at the attended location. Our studies of population-level activity indicate that top-down effects of spatial and feature-based attention can dynamically alter the gain of feature-selective responses in early visual areas.
The normalization model of attention

David Heeger, New York University

Attention has been reported to have a wide variety of effects on the responses of neurons on visual cortex. There is evidence that attention increases contrast sensitivity (described as a change in contrast gain), that it scales neuronal responses by a fixed gain factor (response gain), that it causes intermediate effects that appear consistent with neither contrast gain nor response gain, that it sharpens neuronal turning curves, and that it can, with multiple stimuli in the receptive field, reduce neuronal responses. These different effects of attentional modulation have not previously been explained within the framework of a single computational model. We describe a model of attention that exhibits each of these different forms of attentional modulation, depending on the stimulus conditions and the spread (or selectivity) of the attention field in the model. The model consists of three basic components: 1) the stimulus-evoked excitatory field, 2) divisive suppression that is pooled over a larger region of spatial locations and features (orientations) than the excitatory field, and 3) an attention field which is multiplied by the excitatory field (and inherited by the suppressive field), the gain of which is specified in terms of its spatial and featural extents. In addition to unifying a range of experimental data within a common computational framework, the proposed model helps reconcile proposals that have been taken to represent alternative models of attention. We argue that the ostensible variety and complexity of the results reported in the literature emerge from the variety of empirical protocols that were used, such that the results observed in any one experiment depended on the stimulus conditions and the attentional strategy, a notion that we define precisely in terms of the attention field in the model, but that has not typically been completely under experimental control.
Attentional influences on motion processing in area MT: of space, features and objects

Stefan Treue, University of Göttingen, Germany

Attentional modulation is a powerful influence on the processing of visual information in primate cortex. I will present experimental findings focusing on the influence of attention on area MT in macaque visual cortex. Here electrophysiological recordings have demonstrated the influence not only of spatial attention but also the neural correlates of attention to stimulus features and of object-based attention. The attentional modulation appears to have a multiplicative influence on neural responses but it is still able to create non-multiplicative changes in receptive field profiles and population responses.
Attention and nonretinotopic processing in vision

Patrick Cavanagh, University of Paris, France

Attention allows a desired target to be selected from a cluttered field of distracters. We examine the limits of selection in both space and time. In space, we estimate the central selection area of attention from measures of "crowding" whereas we use attentive tracking tasks to examine the suppressive area surrounding selection. We attribute capacity limits of visual attention to this mutual interference between suppressive surrounds of targets. We find the interference to be hemifield and quadrant limited suggesting an early quadrantic locus for the inter-target interference. Using moving attention, we study the integration of information across space when the target object moves but the eyes do not and find this object-based integration to have similar properties to transsaccadic integration when the eyes move and the object does not. Specifically, surface features like color and motion can be integrated across long distances but shape features like letter identity cannot. This result suggests that non-retinotopic integration (whether for moving objects or moving eyes) relies on crude summation by cells with large receptive fields, a process that cannot align information in object-centered coordinates and so only works for information that needs no alignment. The summation depends on attention to limit summation to properties of only the target object.
Brain states

Charles Gilbert, The Rockefeller University

Vision is active. It is a dynamic process, resulting from an interaction between context, perceptual learning and top-down influences. All cortical and thalamic levels of sensory processing are subject to powerful top-down influences, the shaping of lower level processes by higher order, more complex information and cognitive states. There is an expanding view of the kind of information that is conveyed in a top-down fashion, including attention, expectation, and perceptual task. As a consequence every cortical area acts as an adaptive processor, undergoing continuing cycles of state change and functional switching, with earlier states influencing the way in which the bottom up sensory information is interpreted in subsequent states. Recording from primary visual cortex (V1) while animals perform shape detection and discrimination tasks, we find that neurons adapt different stimulus selectivities as animals learn these tasks. Moreover, neurons alter their functional properties along with the task requirements. The output from V1 therefore reflects both sensory and behavioral context, which may reflect an interaction between feedback pathways to V1 and local circuits within V1. We propose that during perceptual learning, both the encoding and recall of learned information involves a selection of the appropriate inputs that convey information about the stimulus being discriminated.
Selectivity for features, conjunctions and configurations in ventral stream cortex

Carl Olson, Carnegie Mellon University

Neurons in monkey inferotemporal cortex (IT), when tested with digitized images from any arbitrary library, seem like snowflakes, all alike at one scale (in that they exhibit pattern selectivity), each unique at another scale (in that each responds to a distinctive subset of images). What accounts for this remarkable degree of pattern selectivity? By what properties are images that elicit a strong response from a given neuron set apart from other images that do not? I will describe experiments testing three hypotheses: that IT neurons are selective for

1. specific features
2. specific conjunctions of features
3. specific global arrangements of features

The results cast light on the computational underpinnings of pattern selectivity in IT. In so doing, they help to explain human performance in tasks requiring visual search and the perceptual discrimination of hierarchical figures.
Behavioral and neural correlates of visual preference decision making

Shinsuke Shimojo, California Institute of Technology

Even a newborn Infant preferential looks at an object over others, which may be interpreted either as just an orienting response or a preference decision making (or both). It also raises an intriguing question as to how orienting behavior and cognitive preference decision are related in adults. We found that the observer's gaze is biased towards the to-be-chosen face as more attractive, long before (s)he is consciously aware of the decision ("gaze cascade effect"). Moreover, (a) we could manipulate the observer's preference decision by manipulating gaze (and it could not be attributed to the mere exposure effect), (b) when the observer was allowed only local visual sampling through a small window which moved along with gaze direction, the gaze bias started surprisingly early, during the local sampling, and (c) the qualitatively similar gaze cascade effect was found in stimuli other than faces (geometric figures, jewelry, watches, etc.). These all strongly argue that orienting response is involved critically in the process of preference decision making.

Our fMRI study employing a similar face preference task indicated the nucleus accumbens, the orbito-frontal cortex, and the operculum/insula activation in this dynamic time sequence. Moreover, the initial activity in the nucleus accumbens were independent of the explicit task, reflecting task-irrelevant "first impression." Yet another issue about preference is how memory modulates preference. The literature was split into the novelty principle vs. the familiarity principle, with very little indication as to how there are reconciled or segregated. I will show some behavioral data suggesting dominance of familiarity in face stimuli, and that of novelty in natural scenes.
Keeping vision stable

David Burr, University of Florence

One of the more intriguing mysteries of visual perception is how in the face of continual saccadic eye movements do we construct a stable representation of the world based in external rather than retinal coordinates. This question is far from solved, but progress is being made. I will report a series of studies from our group, describing the transient changes in perception that occur at the time of saccades and speculating on how these may contribute to stability. Studies show that the magno-cellular system is selectively suppressed; that visual space undergoes a transient but drastic distortion at the time of saccades, selectively for verbal reports, not for blind pointing; and that there is a dramatic compression, and even an inversion, of perceived time. I will also discuss recent evidence from fMRI studies showing that a motion selective area in the human brain, MT complex, is spatially selective in spatiotopic rather than retinotopic coordinates.
Attention and active vision

Carol Colby, University of Pittsburgh

Vision is an active process. Attention interacts with incoming sensory signals and information about intended actions to construct a stable spatial representation of salient objects and locations. At the single neuron level, memory traces of attended stimuli are remapped when a saccade occurs. Responses to remapped stimulus traces are found in parietal, frontal and extrastriate cortex. In functional imaging studies in humans, remapping is evident throughout visual and parietal cortex. Remapping of salient stimuli ensures that the contents of visual memory are aligned with the new eye position at the end of the saccade and may contribute to spatial stability.

What is the brain circuit that produces remapping? Is it a purely cortical phenomenon? We tested split brain monkeys in an eye movement task that required remapping of a memory trace from one hemifield to the other. Their performance was initially profoundly impaired but recovered quickly. This recovery of function tells us that subcortical as well as cortical pathways can contribute to the transfer of memory traces from one side of the brain to the other. In single neuron studies of split brain monkeys, remapped memory traces were still observed in parietal cortex. These findings indicate that a unified and stable representation of visual space is constructed by a redundant circuit with a remarkable capacity for reorganization.
Mechanisms of saccadic suppression in ventral visual cortex

Tirin Moore, Stanford University

Saccadic eye movements rapidly displace the image of the world on the retina several times per second. Our failure to notice these displacements, and instead to perceive the world as stable, is largely due to saccadic suppression, in which visual sensitivity is momentarily disrupted shortly before, during, and after each movement. Because saccadic suppression primarily affects motion and luminance contrast sensitivity, it is typically attributed to a disruption of the magnocellular pathway and of dorsal visual areas. Using a procedure based on psychophysical experiments, we have measured the dynamics of contrast sensitivity of neurons in ventral visual area V4 just prior to saccades. We find that the sensitivity of V4 neurons to luminance contrast is profoundly suppressed at the time of saccades. However, as with psychophysically measured suppression, the sensitivity of V4 neurons to chromatic contrast remains largely intact. Thus the luminance-selective feature of saccadic suppression is exhibited by individual neurons in this area. The results demonstrate that although the perceptual phenomenon of saccadic suppression is confined to particular stimulus parameters its underlying neural mechanism is not be confined to a particular visual pathway.
POSTERS
Modular second-order processing in the human visual system

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Motoyoshi and Kingdom (2007; Motoyoshi & Nishida, 2004) have recently proposed a model of second-order visual processing where contrast and orientation modulations are detected by different mechanisms. One prediction of this model is differential sensitivity to skew within the filter output histograms (sub-band or wavelet histograms) of orientation or spatial frequency channels. Here we explicitly test this prediction with a novel psychophysical experiment. We generated 1/f noise with varying levels of skew within an orientation or spatial frequency sub-band, using modified texture synthesis algorithms (Heeger & Bergen, 1995; Portilla & Simoncelli, 2000). Using a spatial 4AFC paradigm, we derived thresholds for detecting a texture patch of opposite skew polarity for both orientation and spatial frequency sub-bands. We found thresholds for detecting skew within an orientation sub-band were half a log unit higher than for spatial frequency sub-bands, as predicted by the dual-stream model. Our results do not support the existence a single contrast polarity and orientation selective mechanism, and provide further empirical support for the dual-stream model.

References:

Does fixation prime letters and non letters recognition?

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Our ease to recognise a printed or handwritten character seems to depend on its fixation point; especially when the presentation time is very short. For instance, clear priming for the right visual field (RVF) and in some case for the upper right visual field is reported in the literature. This effect holds also for words but it disappears when non words are used. These effects are usually attributed to reading habits, and yet some preliminary data suggest that for recognizing characters also the writing habits may play some role. The present study is aimed to disentangle if the priming in recognising characters is yielded either by an attention asymmetry, or by reading habits, or by writing habits. We investigated whether short presentations of four rotations of the character “U” (u, n, c, z) presented in four positions of the fixation point (1. upper right, 2. upper left, 3. lower left, and 4. lower right visual field) provide additional information about visual field advantage. In a first condition (reading task) participants were asked to recognise as quick as possible the character, given in the four rotations, as “u”, “c”, “mirror u” (n), or “mirror c” (z). In the second condition (non reading task) the rotated character had to be interpreted as a symbol indicating a specific direction (“n” as up, “u” as “down”, “z” as “right” and “c” as “left”). Preliminary results show a priming effect for RVF in the reading task and for LVF in the non reading task.

References:
The influence of odor on perception of emotional stimuli

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Emotion can play a major role on how we allocate our attention to relevant stimuli. Pereira et al. (2006) have shown longer reaction times, in a target detection task, when participants were exposed previously to unpleasant images; on the other hand, faster reactions times occurred when pleasant images were presented, suggesting an activation of appetitive motivational systems. The present study was aimed to investigate how odor affects performance in a 2-AFC paradigm proposed by Erthal et al. (2005). A central picture, taken from the International Affective Picture System (Lang, 1999), was presented briefly (200ms) flanked by two peripheral bars. The bars were located 10° to the right and left of the center of the screen with five possible orientations (0°, 6°, 11°, 22° and 45°). Participants (n=6) were asked to respond (key presses) whether or not the bars had the same orientation. The experiment consisted of three blocks; in each block a single type of picture (neutral, pleasant or unpleasant) was presented. There were two experimental sessions, control and appetitive odor (lemon oil). Experimental sessions were carried out in a counterbalanced way. Replicating Pereira et al. (2006), participants showed longer reactions times to trials in the unpleasant block in both sessions. However, participants were overall faster to respond during the appetitive odor session. This suggests that attentional resources are modulated both by positive pictures and appetitive odor resulting in an increased performance for this condition.

References:

Neuronal activity during discrimination of faces and vocalizations in the primate ventrolateral prefrontal cortex

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Integration of appropriate face and voice information is especially important in human and non-human primate communication. We have begun to investigate the integration of face and vocalization information in the ventrolateral prefrontal cortex (VLPFC) of non-human primates. In previous studies we have shown that VLPFC cells are multisensory and demonstrate enhanced or suppressed responses to combined audio-visual vocalizations when compared to unimodal stimuli (Sugihara et al., 2006). To further investigate the role of the VLPFC in sensory integration, we have recorded prefrontal neuronal activity while animals performed a discrimination task using face-vocalization stimuli as the memoranda and found changes in single-cell activity of the previously identified multisensory regions during this non-match to sample task. During the task, a face-vocalization movie was presented as the sample and a variation of the sample stimulus was presented as the non-match stimulus in which the animal had to detect with a button press and received a juice reward for a correct response. We altered either the auditory or visual track of the vocalization movie as the non-match stimulus. Electrophysiological recordings in VLPFC revealed both task related and stimulus related changes in neuronal firing compared to baseline firing. Single units showed changes during presentation of the sample, presentation of the non-match stimulus, the delay period, the response period, or the reward period. Analyses also revealed stimulus specific responses. Continued analysis and recordings are aimed at determining the role of the VLPFC in the integration of communication information.

References:

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Specificity of masked priming of face: evidence for early dissociation of identity and expression recognition

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Background: Recognition of facial identity and facial expression involves distinct functional and neural routes (Bruce & Young, 1986; Haxby, Hoffman, & Gobbini, 2000). But at what level of analysis does the identity route bifurcate from the expression route? Both models propose an early dissociation occurring immediately after the structural encoding stage with distinct visual representations for identity and expression afterwards. This view has been challenged by image-based analysis techniques such as principal components analysis (PCA, reviewed in Calder & Young, 2005), which proposes a late dissociation after a common representation of both identity and expression. In the present study, we used masked priming to address whether there is a common representation of identity and expression at an early stage.

Methods: In each trial, observers were shown a forward mask (150 ms), followed by a prime face (50 ms) and then a probe face (300 ms) at fixation. They performed a classification task according to either gender (male/female) or expression (positive/negative). There were 4 categories of faces specified by gender (male and female) and expression (happy and angry), with 4 individual photos in each combination. Photos were adapted from Ekman and Friesen (1976) with hairstyle and contour trimmed and contrast/brightness adjusted.

Results: Significant priming effect was observed in both gender and expression tasks, but such priming effect was not modulated by the congruency of the second dimension (i.e. expression congruency in gender task or gender congruency in expression task). These findings suggest an early dissociation of facial identity and expression representation.

References:


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Sensitivity of implicit visual rule-learning to the complexity of context

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Human infants have been shown to implicitly learn abstract rules, such as the repetition of ABB or ABA patterns, regardless of the identity of the items used. However, it is unknown how such rules are extracted in more complex situations, where the rule is defined in one feature dimension within a multi-dimensional feature space rather than by item identity. In a series of experiments, we examined the performance of adults presented with an implicit rule-learning task, where both the size and color of items followed some underlying rule. Subjects were first exposed to a series of triplet scenes shown in random order: complexity was manipulated in each experiment by the number of shapes and scenes used. Patterns within each triplet varied in both size and color, following AAB and ABA rules. The test phase consisted of triplets made of elements not seen during learning, which varied only in size. In each trial subjects saw two triplets, an AAB and an ABA pattern, and judged which seemed more familiar. In tasks of higher complexity (five learning triplets) subjects did not find the AAB size pattern to be more familiar than the alternative, even when the size difference was 500 percent. Not until complexity was drastically reduced, by decreasing both the number of triplets and the number of elements used, did learning take place to a significant degree. These results suggest that the complexity of the context can interfere with implicit learning, so much so that highly salient global features are ignored.
What happens in primary visual cortex when a stimulus becomes visible? Insights from fMRI and layer-specific neurophysiology in non-human primates

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The contribution of the primary visual cortex (V1) to perception is a long-standing, controversial topic. Neuroimaging studies in humans have suggested that neural activity in V1 is strongly reduced during perceptual suppression, suggesting that V1 may play a direct role in visibility itself. In sharp contrast, microelectrode recordings in monkeys have reached nearly the opposite conclusion, emphasizing instead the maintained firing of neurons to visual patterns, even when they are not perceived. To investigate the basis of this discrepancy, we evaluated both fMRI and electrophysiological signals in area V1 of behaving monkeys, and correlated responses there with both the physical presence and perceived visibility of a salient stimulus. We show that these signals, while generally in good agreement, become uncoupled during perceptual suppression. Surveying diverse aspects of the electrophysiological profile, we report that the strongest correlates of perceptual suppression were observed in decreased currents in the upper layers of V1. This diminished supragranular activity related to perception may reflect a disruption of synaptic input corresponding to feedback from the extrastriate cortex or a modulatory signal of subcortical origin.

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3D shape perception from texture: psychophysical experiments and computational modeling

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Texture is a major monocular cue to retrieve 3D shape from static visual information. However it is still not clear how texture is represented by the visual system. Recently Li and Zaidi (Journal of Vision, 2004, 4) have argued that texture information could be divided into two separate cues corresponding to frequency and orientation information. In order to further explore this hypothesis, we conducted psychophysical experiments to evaluate the contribution of frequency and orientation gradients for the estimation of surface orientation from texture based on a new stimulus consisted of a homogeneous texture made of Gabor patches. Such a stimulus is proved to be very well suited to independently manipulate the frequency and orientation gradients in order to study each cue in isolation or in combination.

We then developed a biologically plausible model for frequency and orientation analysis applied to the shape from texture problem. First, specific log-normal filters are designed to model complex cells in visual area V1. Two methods to estimate the local frequency and the local orientation in the image, which discard the need to choose the best local scale, are designed. The estimations of the local frequency and orientation gradients are used to recover the shape parameters from the texture under perspective projection. The accuracy of the method is evaluated and discussed on different kind of textures, both regular and irregular, with planar and curved surfaces and also on natural scenes and psychophysical stimuli. It compares favorably to the best existing methods. Importantly this model would account for simple neuronal connections in the primary visual areas.

References:
The light-from-above prior overrides contextual lighting cues

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How does the human visual system's assumption that light comes from above interact with visual cues indicating that light does not come from above in a particular scene? Following Sun and Perona (1998), we used visual search for a bump among dents to infer observers' implicit beliefs about direction of illumination. Our search stimuli were embedded in realistically rendered 3D scenes, with different simulated lighting directions in different conditions. Regardless of lighting direction, search performance indicated that observers always assumed that illumination came from above. That is, the light-from-above prior completely overrode contextual information about direction of illumination.

References:


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A neural Bayesian theory of visual search and its behavioral predictions

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While signal detection theory can successfully account for several visual search phenomena, its neural implementation remains elusive. A common neural interpretation of the theory has been that decisions on whether the target is present in a field of distractors depend on the response of a single neuron best tuned to the target; however, this has been shown to be suboptimal for searches when the target is similar to the distractors. We propose a neural Bayesian theory of visual search using probabilistic population codes, of which signal detection theory is a special case. We provide a two layer neural network implementation of the Bayesian theory, that uses quadratic non-linear operations and divisive normalization. Our theory makes a unique prediction, that on a single trial, observers can estimate uncertainty in stimulus representation at each location in the display and combine it optimally across locations to decide whether the target is present or not. Do humans behave in such a Bayes-optimal manner? To test this, we asked human subjects to search for a more tilted target among less tilted distractors in different experimental conditions: 1) where all stimuli have the same contrast (hence constant uncertainty in stimulus representation) that is either LOW or HIGH; 2) a MIXED contrast condition where the contrast (or uncertainty) of each stimulus is randomly set to LOW or HIGH, and the set size varies randomly between 4, 6, or 8 items in the display. Results from 3 subjects show that the theory can quantitatively predict subject's ROC curves for different set sizes in the MIXED contrast condition. This shows that on a single trial, humans combine uncertainty across locations in a Bayes-optimal manner.
Cortical neurons reveal perceptual strategies for the active control of steering

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Optic flow indicates heading direction during self-movement and can be used to control autonomous navigation. Neurons in monkey medial superior temporal cortex (MST) respond selectively to heading direction in optic flow.

We trained monkeys to manipulate a joystick to control its simulated heading direction in an optic flow display. The optic flow stimulus first appeared with the simulated heading at 20° eccentricity in one of eight directions around the fixation point. The monkey's task was to use the joystick to center its heading on the screen. In interleaved passive trials, the monkey released the joystick and watched a video re-play of a previous heading stimulus sequence.

We recorded the optic flow responses of 90 MST neurons. Initially, we found that active steering evoked smaller responses than those evoked during the passive viewing of the same stimuli. Behavioral testing showed that the monkeys had learned to steer using local motion at the center of the display. Re-training the monkeys to use the global pattern of optic flow reversed the effect of active steering: active steering evoked larger responses than passive viewing.

In a second experiment, we interleaved two types of trials: active steering using local motion at the center, and active steering using patterned motion in the surround. We recorded the responses of 59 MST neurons with full-field and center or peripherally masked stimuli. This revealed two types of neuronal responses: neurons suppressed by peripheral stimulation were more active during local motion steering, and neurons suppressed by central stimulation were more active during surround pattern steering.

We conclude that the monkey's perceptual strategy during active steering alters MST neuronal responses to optic flow. This effect may depend on interactions between the monkey's perceptual strategy and the receptive field properties of individual neurons: a local motion strategy enhances the responses of neurons with inhibitory surrounds and a global motion strategy enhances the responses of neurons with excitatory surrounds.

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The functional impact of mental imagery on conscious perception

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It is debated whether mental imagery relies on the same sensory representations as perception, and if so, what functional consequences such an overlap might have on perception itself. Here, we utilized binocular rivalry as a tool to reveal the perceptual and mnemonic contents of mental imagery. Observers were either shown or instructed to imagine one of two oriented patterns, several seconds prior to the presentation of an ambiguous rivalry display. The presentation of low luminance patterns strongly biased the perception of subsequent rivalry displays, in favor of the previously seen pattern. Remarkably, mental imagery of a specific pattern led to equally potent bias effects. The effects of both imagery and perception were highly orientation-specific, with bias effects showing peak tuning for matching orientations. Longer periods of imagery led to progressively stronger bias effects, mimicking the effects of prolonged viewing of a physical pattern. In addition the top-down effects of imagery could be distinguished from manipulations of visual attention. These results demonstrate that imagery leads to the formation of a short-term sensory trace that can bias future perception, suggesting the means by which high level processes such as memory and cognition could shape low-level sensory representations.

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Prior probabilities and decision formation in area LIP

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Prior expectations can alter decisions about a stimulus. This prior may modify sensory encoding of the stimulus, or how the decision emerges from sensory evidence. Since area LIP has been proposed to accumulate evidence in a direction discrimination task [1], we examined how prior knowledge modifies activity in LIP. In our task, an arrow-shaped cue, pointing in one of two opposite directions, is presented for 200ms at the fovea. Following a delay, a foveal random-dot motion stimulus is displayed. The stimulus contained variable-coherence motion either along or opposite to the cued direction [2]. Cue direction matched that of the motion on 67% of trials. Behavioral data show that the monkey integrates its prior expectation with the motion information to improve performance. Stimuli were configured so that one saccade target (T1) lay within the neuron’s response field (RF).

LIP responses were elevated when the monkey expected motion toward the RF. Following the cue, the response increased on trials with cues towards the RF, and decreased for cues pointing away from the RF. This shift in activity persisted during the motion stimulus and into the period where LIP activity ramps up before a T1-choice. The slope of the ramping activity before T1 choices was not increased by a valid cue, consistent with our previous finding [3] that the cue had essentially no effect on responses in area MT. Together, these findings suggest that prior knowledge acts on the computation of decision variables rather than on the sensory representation of motion.

References:


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Bayesian adaptation to the dynamics of uncertainty

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In recent years researchers have increasingly explored the remarkable adaptivity of even routine interactive behavior—the extent to which humans adapt to and exploit the low-level dynamics of cognitive processes, perception, and motor control without conscious deliberation. We developed an experimental paradigm known as Bayes' Ball, in which subjects must estimate short time intervals (< 1000 ms) in order to maximize a point score in a simple ball tracking task. Optimal performance in this task requires that subjects possess intricate knowledge of the dynamics of uncertainty in their estimates of elapsed time. According to the Weber law of timing, the uncertainty in an estimate of a short time interval scales linearly with the duration of the interval. In our experiment, subjects must anticipate and compensate for this property to maximize their score in the task. The results of our experiment show human performance that approaches, but does not fully match the predictions of an ideal performer. On average, humans differed from the ideal performer by less than 40 ms in their response timing.

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Contextual influences on rapid object categorization in natural scenes

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Event-related potential studies have shown that the underlying processing required to decide whether a briefly flashed natural scene contains an animal can be achieved in 150 ms (Thorpe et al., 1996). Moreover, participants can reliably indicate the side containing an animal when two images are simultaneously flashed in the left and right hemi-fields, demonstrating that rapid object detection can be accomplished in parallel (Rousselet et al., 2002). An interesting question is what makes rapid object categorization possible. One potential factor comes from the scene context because previous studies have shown that contextual knowledge facilitates object recognition (Bar, 2007). Here we tested whether the contextual information provided by the scene contributes to rapid object categorization. In the current study, two natural scenes were simultaneously flashed left and right of fixation, and participants had to indicate the side on which an animal appeared. We examined the influence of contextual information either by retaining or deleting the original scene background. The results showed no differences in the accuracy of animal detection. However, the reaction times were significantly faster for animals appearing with a scene background, demonstrating that scene context bolsters rapid object categorization.

References


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A physiological account of perisaccadic shift based on the reafference model

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The *Reafference Model*, as proposed by von Holst and Mittelstaedt (1950), provides a powerful framework in which to pose and explain problems of perceptual stability during active sensor movements. A copy of each efferent signal to an effector is conveyed to the so called *forward model* whose output comprises an estimate of the changes in afferent flow which are to be expected following the given motor command. We present a physiologically plausible model of shift-like perisaccadic mislocalization of flashed stimuli (e.g., Honda, 1998) relative to a continuously present reference, in the framework of the *Reafference Model*. It explains perisaccadic mislocalization of flashed relative to continuously present stimuli as a byproduct of the main goal of the system which is to guarantee perceptual stability for continuously present stimuli under the assumption of neuronal persistence (Pola, 2004).

In our approach the *forward model* provides a time-resolved transfer function from retinal to world-centered position estimates during saccades. This transfer function is optimized such that continuously present stimuli are perceptually stable during saccades. Neuronal persistence leads to different time-resolved retinal position estimates of the flashed and the continuously present stimuli. Thus, applying the transfer function optimized for continuously present stimuli to flashed stimuli leads to the observed effect of perisaccadic shift.

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