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Research Interests	Tong Lab	Publications	Biography	CV

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The Puzzle of How the Brain "Sees"

Most people intuitively think that human vision works like a camera. However, if pressed, they will quickly admit that a camera can't actually "see anything" or identify the objects in a scene; it simply replicates the projected image from the environment. Thus, the nature of human vision remains a mystery. How do we take the images projected onto our eyes and come to see color, depth, locations, shapes or objects? Somehow, the brain takes in all this information and interprets or imposes these perceptual attributes.

Research Interests

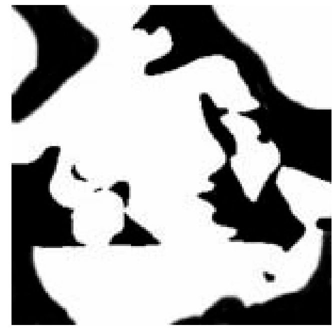
- Our lab conducts fMRI and behavioral studies of visual perception, object recognition, attention, and visual awareness.
- Research areas include: face perception, object recognition, binocular rivalry, perceptual filling in, visual imagery, visual attention, and the neural mechanisms of human visual awareness.
- The goal of this research is to understand how visual representations in the human brain mediate various aspects of visual awareness; namely, our ability to perceive visual features and to recognize objects.

Neural Correlates of Face Perception

In some situations we can readily perceive or recognize a face while in other situations we cannot. Our research aims to elucidate the brain mechanisms that allow us to switch between these mental "viewpoints" or representations. What neural representations are activated when we become conscious of a face? Might such neural regions be responsible for the conscious experience of faces?

We have shown that a face-responsive region in ventral extrastriate cortex, called the Fusiform Face Area, responds more to upright Mooney faces than to upside down Mooney faces that are more difficult to perceive (see adjacent figure).

Currently, we are using such Mooney face stimuli to investigate what brain areas likely contribute to the formation of perceptual decisions for ambiguous stimuli ("Am I seeing a face or not?").



Can you see the face in this image? If not, click here

Response Properties of the Human Visual System

Our lab investigates the response properties of the human visual system to probe the structure of visual representations. For example, we have found that the Fusiform Face Area responds equally strongly to human, cat and cartoon faces, and much more weakly to objects, houses, back views of humans heads and pictures of human eyes (Tong et al., 2000). click to see relevant publications

More recently, we have investigated the rate of information processing (or the temporal frequency response tuning) of visual areas throughout the ventral visual pathway. Tom McKeeff, David Remus and I have found that early visual areas such as V1 respond best to rapidly presented stimuli (houses or facs presented at 16 items/second), V4 responds best to intermediate presentation rates (8 items/s), whereas the Fusiform Face Area and Parahippocampal Place Area can respond best to slow presentation rates (4 items/second). In other words, showing more faces or houses in a short period of time actually leads to a dimished response from these high-level category-selective areas. These processing limits of the Face and Place Areas may underlie our limited ability to process rapid visual information under conditions such as the Attentional Blink.

We are also beginning to investigate the relative roles of modular versus distributed representations in face and object perception (cf. Haxby et al., 2001).

A common theme in the lab is to compare the response properties of early (retinotopic) visual areas and high-level visual areas to study their differential roles in visual perception and object perception.

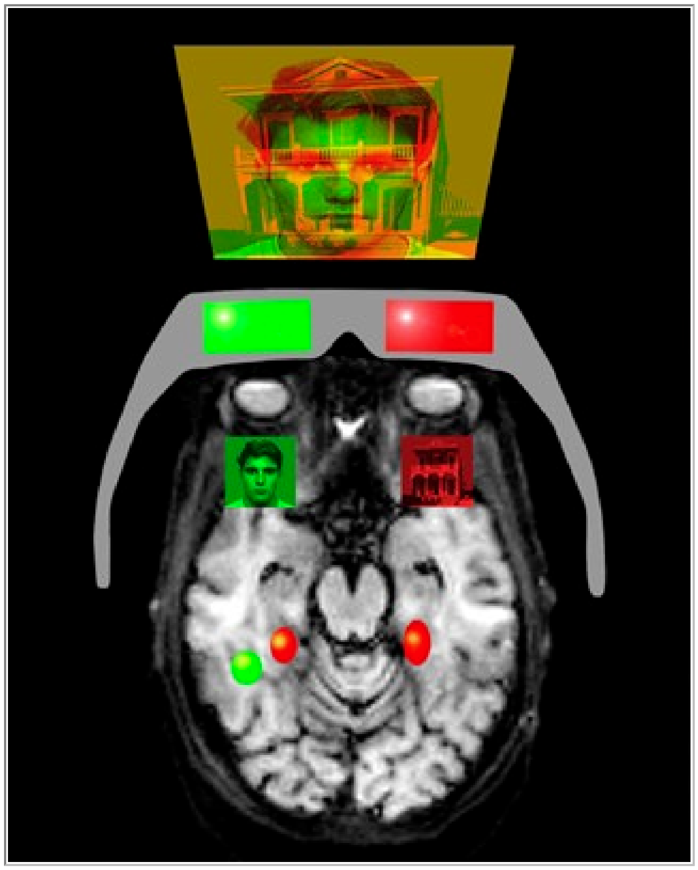
Binocular Rivalry - A Method to Probe the Neural Basis of Visual Awareness

Our lab studies the neural basis of visual awareness using a visual tecnhnique called binocular rivalry. When different images are simultaneous presented to the two eyes (see adjacent figure), one does not perceive a coherent blend of the two images. Instead, perception alternates between each monocular image every few seconds for as long as the observer continues to view the two rivalrous patterns. Because binocular rivalry dissociates the observer's conscious state (constantly alternating) from the physical stimulus (unchanging), this phenomenon provides a powerful tool for investigating the neural basis of visual awareness.

Binocular Rivalry in High-Level Extrastriate Areas

We found that during rivalry between a face versus a house, face- and house-selective extrastriate visual areas (respectively illustrated in green and red) tightly reflect the observer's conscious perception. These neural regions show the exact same fMRI responses for perceived alternations between a rivaling face versus house and for actual stimulus alternations between a face and house, suggesting that the neural competition in binocular rivalry has already been fully resolved by the time visual information reaches these high-level areas (Tong et al., Neuron, 1998).

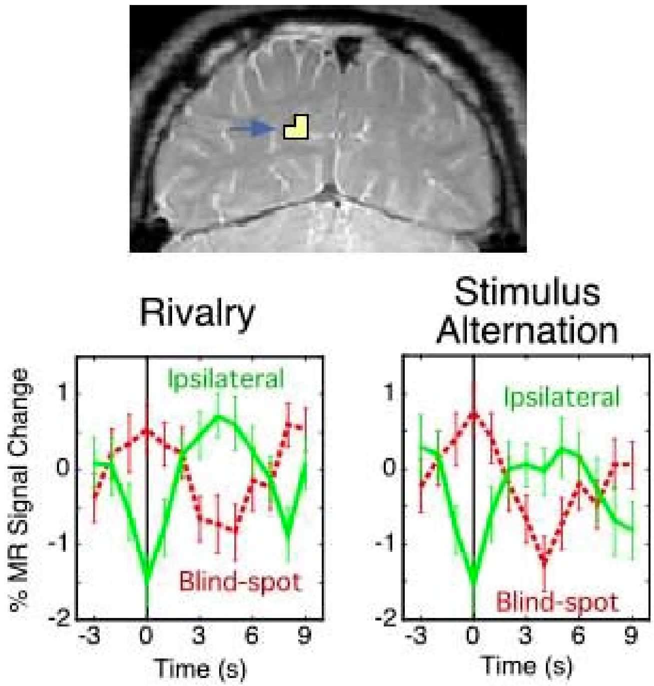
click to see relevant publications



Binocular Rivalry in the Monocular V1 Blind-Spot Representation

To probe the neural origins of binocular rivalry, we used fMRI to target a relatively large monocular region of human V1 corresponding to the blind spot. The V1 blind-spot representation can be identified based on its much stronger response to stimulation of the ipsilateral eye than of the contralateral blind-spot eye (see figure to right). During binocular rivalry scans, this monocular region showed increasing fMRI activity when subjects perceived the grating viewed by the ipsilateral eye and decreased when subjects perceived the grating shown to the contralateral blind-spot eye (gratings twice the size of blind spot). These awareness-related fMRI responses were as large as those evoked during stimulus alternation. Our findings suggest that this competition for awareness is fully resolved in monocular visual cortex and that binocular rivalry results from interocular competition (Tong & Engel, Nature, 2001).

click to see relevant publications



Retinotopic Mapping of Human Visual Cortex

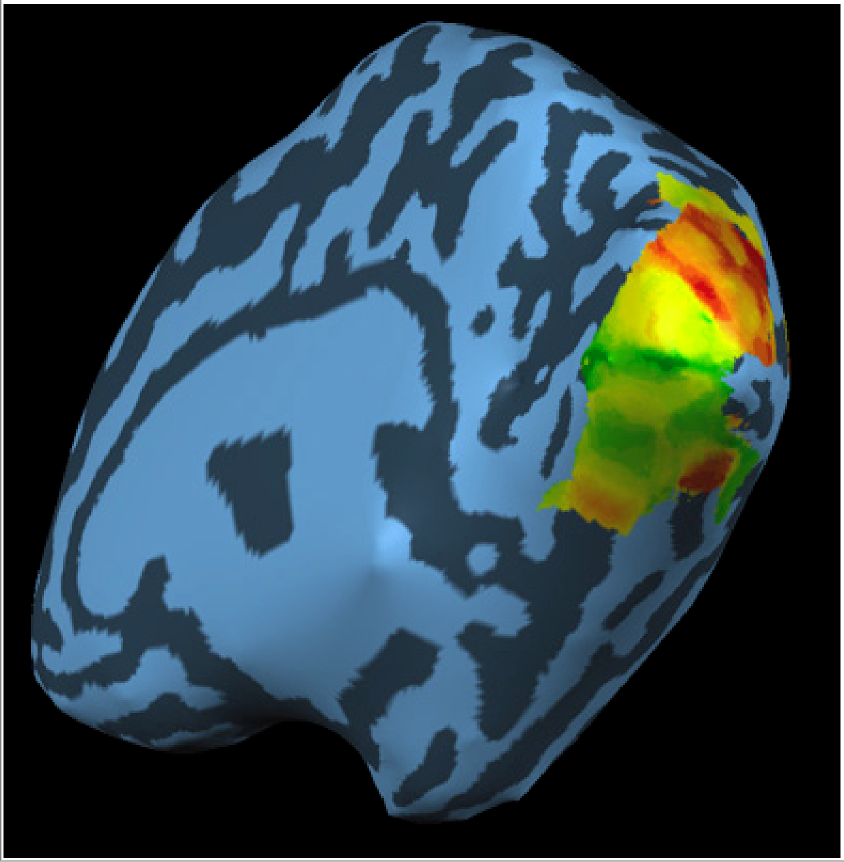
Our lab uses cortical segmentation and flattening techniques to create "flat-maps" of the retinotopic organization of early human visual areas. This allows us to investigate the role of each visual area in various aspects of human perception and awareness.

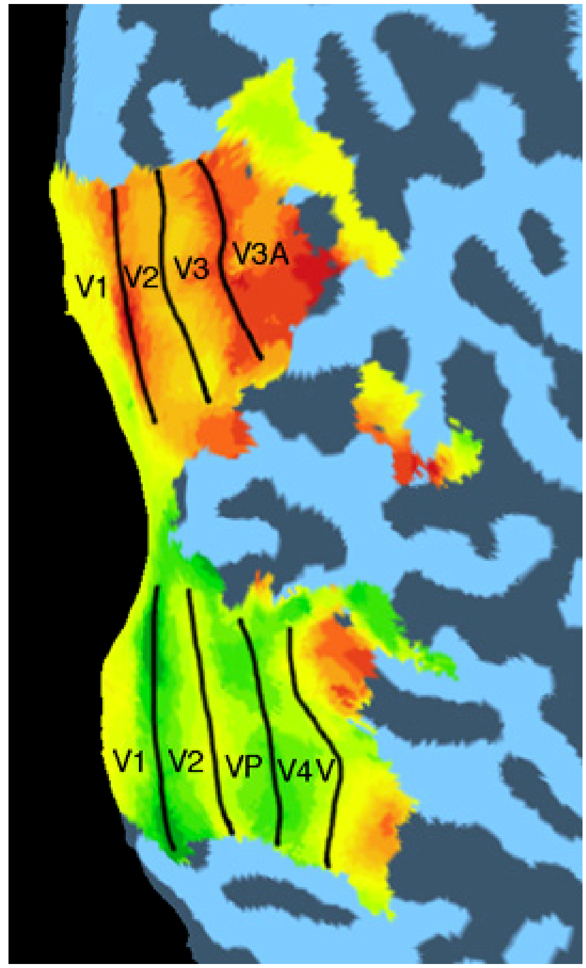
Figure below shows the phase-encoded pattern of fMRI activity evoked by a rotating wedge stimulus depicted on an inflated brain. Red = Lower visual-

Figure below shows the boundaries between retinotopic visual areas on a flattened cortical representation of the same subject's right occipital cortex. A cut was applied along the calcarine sulcus to separate the upper and lower bank of V1.

These MRI data were collected on the Princeton 3T Siemens Allegra Scanner.

field vertical meridian, yellow = horizontal meridian, green = upper vertical meridian. Meridians delineate the boundaries between visual areas.





The Constructive Nature of Vision - Filling-in and Imagery

In studies of perceptual filling-in, Ming Meng, a graduate student in the lab, has found evidence that perceptual completion of phantom gratings involves "neural filling-in" in human visual area V2. Area V2 shows evidence of perceptual filling-in of the phantom grating (i.e., the gap between to physical gratings) regardless of whether subjects are attending to the gratings or attending away to letters shown at central fixation, suggesting that this neural filling-in mechanism operates in an automatic fashion. Interestingly, V1 shows evidence of neural filling-in only when subjects are attending to and aware of the visual gratings.

In studies of visual imagery, we find that imagining seeing a peripheral object leads to activation in the exact same region of V1 as physical stimulation in that region. These results are consistent with the view that V1 may have an necessary and perhaps integral role in the conscious representation of real, illusory, and imagined stimuli (Tong, Nature Reviews Neuroscience, 2003).

Links

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Last updated on Nov 23, 2003