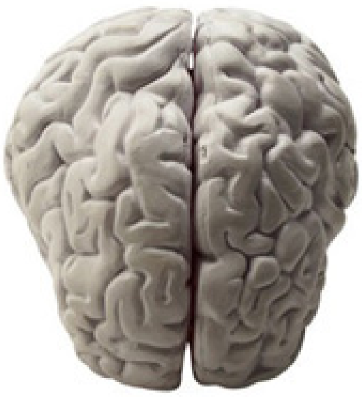
How the brain finds what it's looking for

September 4 2014



Despite the barrage of visual information the brain receives, it retains a remarkable ability to focus on important and relevant items. This fall, for example, NFL quarterbacks will be rewarded handsomely for how well they can focus their attention on color and motion – being able to quickly judge the jersey colors of teammates and opponents and where they're headed is a valuable skill. How the brain accomplishes this feat, however, has been poorly understood.

Now, University of Chicago scientists have identified a brain region that appears central to perceiving the combination of color and motion. They discovered a unique population of neurons that shift in sensitivity toward different colors and directions depending on what is being attended – the red jersey of a receiver headed toward an end zone, for example. The study, published Sept. 4 in the journal *Neuron*, sheds light on a fundamental neurological process that is a key step in the biology of attention.

"Most of the objects in any given visual scene are not that important, so how does the brain select or attend to important ones?" said study senior author David Freedman, PhD, associate professor of neurobiology at the University of Chicago. "We've zeroed in on an area of the brain that appears central to this process. It does this in a very flexible way, changing moment by moment depending on what is being looked for."

The visual cortex of the brain possesses multiple, interconnected regions that are responsible for processing different aspects of the raw visual signal gathered by the eyes. Basic information on motion and color are known to route through two such regions, but how the brain combines these streams into something usable for decision-making or other higher-order processes remained unclear.

To investigate this process, Freedman and postdoctoral fellow Guilhem Ibos, PhD, studied the response of individual neurons during a simple task. Monkeys were shown a rapid series of visual images. An initial image showed either a group of red dots moving upwards or yellow dots moving downwards, which served as an instruction for which specific colors and directions were relevant during that trial. The subjects were rewarded when they released a lever when this image later reappeared. Subsequent images were composed of different colors of dots moving in different directions, among which was the initial image.

Dynamic Neurons

Freedman and Ibos looked at neurons in the lateral intraparietal area (LIP), a region highly interconnected with brain areas involved in vision, motor control and cognitive functions. As subjects performed the task and looked for a specific combination of color and motion, LIP neurons became highly active. They did not respond, however, when the subjects passively viewed the same images without an accompanying task.

When the team further investigated the responses of LIP neurons, they discovered that the neurons possessed a unique characteristic. Individual neurons shifted their sensitivity to color and direction toward the relevant color and motion features for that trial. When the subject looked for red dots moving upwards, for example, a neuron would respond strongly to directions close to upward motion and to colors close to red. If the task was switched to another color and direction seconds later, that same neuron would be more responsive to the new combination.

"Shifts in feature tuning had been postulated a long time ago by theoretical studies," Ibos said. "This is the first time that neurons in the brain have been shown to shift their selectivity depending on which features are relevant to solve a task."

Freedman and Ibos developed a model for how the LIP brings together both basic color and motion information. Attention likely affects that process through signals from higher-order areas of the brain that affect LIP neuron selectivity. The team believes that this region plays an important role in making sense of basic sensory information, and they are trying to better understand the brain-wide neuronal circuitry involved in this process.

"Our study suggests that this area of the brain brings together information from multiple areas throughout the brain," Freedman said. "It integrates inputs – visual, motor, cognitive inputs related to memory and decision making – and represents them in a way that helps solve the task at hand."

More information: "Dynamic Integration of Task-Relevant Visual Features in Posterior Parietal Cortex," *Neuron*, 2014.

Provided by University of Chicago Medical Center