Brain scientists offer insight into vision

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A team of neuroscientists report in the July 21 issue of the science journal Neuron their research about how neuron clusters in the brain overlap to communicate such combined visual information as a flower's color, shape,and distance. The team, including Dezhe Z. Jin, Penn State assistant professor of physics and an affiliate of the Penn State Neuroscience Institute, performed the research at the Picower Center for Learning and Memory at the Massachusetts Institute of Technology.

The team's research suggests that multitasking may be fundamental to the way the brain works. "Since every part of the cortex has neurons that are involved in multiple tasks, there is every reason to think that this is a deep principle of brain organization," said Mriganka Sur, the Sherman Fairchild professor of neuroscience and head of MIT's Department of Brain and Cognitive Sciences.

In the visual cortex, neighboring neurons detect objects in neighboring regions of space, creating an image or map of the visual scene. Neurons are clustered according to their ability to detect different properties -- such as the vertical or horizontal edge of an object or whether the object is being seen by the left eye or the right -- but they need to overlap so each combination of features can be represented by the cortex. If the clusters did not overlap with each other the correct way, then we would have "blind spots" for certain feature combinations. For example, in certain regions of the visual scene we might detect vertical edges with only the left eye, or horizontal edges with only the right eye.

This study by Sur, postdoctoral associate Hongbo Yu, graduate student

Brandon J. Farley and visiting scientist Dezhe Z. Jin from Penn State, tests the predictions of Finnish mathematician Teuvo Kohonen, who developed mathematical formulas in 1982 that showed how the neuron clusters could pull off this overlapping feat. The research team's approach was to factor in a quirky distortion of some species' cortical map.

In some species' brains, a square region of the visual image is represented by a square region of the cortex. But in other species, the visual cortex is distorted, causing a square region in the visual image to be represented by a rectangular region of cortex. "Our study shows that the distortion in the mapping of the visual scene onto the cortex has an influence on clustering that Teuvo Kohonen's formulas predicted," Jin said. "The shape of the clusters of neurons representing similar orientations, and also the species' eyes, are distorted in such a way that each feature combination still can be detected in each part of space."

The researchers comment that the visual cortex's solution to accommodating several parameters probably holds true for other brain regions, such as those involving hearing. "Hearing, like seeing, has multiple parameters: location of a sound in space, frequency and relative activation of the two ears," Farley said. "Maybe mapping multiple dimensions this way is a general strategy the brain uses when it faces this problem."

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Source: Penn State Neuroscience Institute