Medical Xpress

Encountering a wall corrects 'GPS' in mouse brains, study finds

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By analyzing the activity of "GPS" neurons in mice, researchers at the Stanford University School of Medicine have discovered that the mental maps created by these cells accumulate errors, which are corrected when the animal encounters a wall.

The findings support the theory that these cells, called grid cells, use an animal's perceived speed and direction to help it navigate familiar places.

Thus, as you stumble through your pitch-black kitchen in the middle of the night for a glass of water, your body knows how many steps to take and when to turn to get to the sink. Scientists believe grid cells are responsible for constructing the internal, GPS-like map that keeps you from colliding with the refrigerator.

But grid cells can make small errors, the Stanford researchers assert, taking you to the dishwasher instead of the sink, at which point other nearby neurons, called border cells, assist in reorienting the grid cells to correctly map your current position.

How the brain integrates this sensory and motion data is one of the big open questions of spatial navigation. A paper that helps to answer that question will be published April 16 in *Neuron*. Lisa Giocomo, PhD, assistant professor of neurobiology at Stanford, is the senior author; the lead author is graduate student Kiah Hardcastle. This work was done in close collaboration with the theory lab of Surya Ganguli, PhD, assistant professor of applied physics at Stanford, who is the other co-author on the study.

Learning from Nobel laureates

A decade ago, grid cells were identified in the entorhinal cortex of the brain by Norwegian scientists May-Britt Moser, PhD, and Edvard Moser, PhD, who were among the winners of last year's Nobel Prize for the discovery of the neurons involved in self-location and navigation. They found individual cells that fired consistently when a mouse wandered past certain places in both light and dark enclosures. At each of these places, a unique set of grid cells activated, presumably signaling to cells in the hippocampus the mouse's location.

"You can think of them as a neurological longitude and latitude system," said Giocomo, who did postdoctoral work with the Mosers at the Kavli Institute of Systems Neuroscience/Centre for Neural Computation at the Norwegian University of Science and Technology.

It was there that she collected data from 11 mice, each outfitted with a microdrive. The device, surgically implanted in the mice's brains, contained numerous microelectrodes, each with the ability to record from several neurons, including grid cells, so researchers could monitor the firing of several cells simultaneously. During the 40- to 50-minute session that each mouse spent exploring a dark, 1-square-meter space, a particular set of grid cells would activate in its brain when it arrived at certain place within the enclosure.

But when Hardcastle, a graduate student in Giocomo's lab, analyzed specific paths where the mouse spent a long time far away from the border, she found that the grid cells began firing when the animal was not quite in the place where the cells usually fired. Over time, the cells would lose accuracy and begin to fire when the mouse was at an increasing distance from that place. But encountering a wall corrected this discrepancy. Giocomo suspects border cells are responsible for this correction.

Rapid rate of errors

The speed at which the grid cells acquired errors surprised her. "Within two minutes, the maps started to drift," she said. "We thought it would take 30 to 40 minutes."

However, a particular set of grid cells wouldn't fire when the mouse was a long way from the place where those cells were supposed to fire. This supports the theory that grid cells use speed and direction to calculate the animal's location; errors could creep in if the mouse misestimated its speed or turned too much, or not enough. These small mistakes would accumulate the more it traveled, explained Hardcastle, and lead to larger errors.

The research "represents an important step forward in understanding how spatial cues from the outside world influence spatial representations inside the brain," said neuroscientist Ila Fiete, PhD, of the University of Texas at Austin, who was not involved in the study.

Giocomo and her students have gathered an even larger data set from mouse studies in her Stanford lab and are planning to study grid cells in rats, as well. Giocomo is interested in investigating how more complex visual information, as well as touch and smell, is used to correct grid cells, and for that, they need to be able to sample more neurons. Rats also have the advantage of being more curious and less inclined to stick to the walls of the enclosure, Hardcastle said.

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