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Brain maps help guide you through large-scale space, researchers find

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Lost? Not sure how to get home? Trying to find your way through the mall or an airport? Help is on the way, thanks to a stack of cells, or neurons, in your head. They're mostly on the left side of the brain in males, on the right in females.

Scientists have long known that a small, seahorse-shaped region in the brain, the hippocampus, contains neurons called "place cells" that specialize in geography.

In recent years, working mostly with laboratory rats, they have discovered additional types of neurons in or near the hippocampus known as "grid cells," "head-direction cells" and "border cells."

Taken together, "these cells form a map of the environment," said Edvard Moser, a leading expert on brain mapping at the Norwegian University of Science and Technology in Trondheim, Norway.

The brain maps tell animals, including humans, where they are, how they got there and how to navigate to their next destinations, neuroscientists say.

"The ability to find one's way through a large-scale space such as an airport, college campus or city neighborhood is essential for successful functioning in the modern world," said Russell Epstein, a neuroscientist at the University of Pennsylvania in Philadelphia. "When we are lost and need to re-establish our general location, scene recognition mechanisms

... are likely to be crucial, potentially enabling the correct 'map' to be selected in the hippocampus."

Matthew Wilson, a neurobiologist at the Massachusetts Institute of Technology in Cambridge, compared the hippocampus to a computer hard drive. Instead of electronic bits and bytes, it contains millions of neurons that store memories of places, people, things and events.

Neuroscientists say that brain mapping cells "fire" -- that is, release tiny electric charges -- when they sense they're in specific locations or headed in certain directions.

Border cells, for example, light up when they're close to walls or other boundaries. Moser called them "the brain's border patrol."

In a report last December in the journal *Science*, Trygve Solstad, a researcher in Moser's lab, outlined how the various cell groups work: "Place cells fire when we pass through fixed locations, letting us know where we are; head-direction cells fire when we face particular directions, acting as a compass, and grid cells fire when we're at specific points on a hexagonal grid that the brain superimposes on our surroundings."

Moser likened the stack of mapping neurons to a deck of cards.

"The maps are stored as extremely thin cards in a deck in the hippocampus, the area that is regarded as the brain's memory focal point," he said. "The deck is sorted by rank, so that the fine-grained detail maps are located at the top, with the biggest, most coarsely drawn maps further down in the deck."

It's much easier for researchers to experiment with laboratory mice and rats than with people. They make the little animals run along tracks, navigate mazes or swim pools to find rewards. As they run or swim, brain cells fire as they pass over each place in their internal maps. The order of the firings shows the creatures' paths.

The firing pattern "reflects both the animals' present spatial position in the environment and the specific trajectory taken to reach that position," Douglas Nitz, a cognitive scientist at the University of California at San Diego, wrote in the Oct. 15 issue of Nature.

"Cells care about the sequence, the path of motion," MIT's Wilson said.

"There is also evidence for such maps in humans, although much less," Moser said. In all mammals, "the wiring diagram is so similar that there are all kinds of reasons to believe that the same neural firing patterns are generated."

Researchers on humans used to have to rely on sticking sensors in the brains of epileptic patients or studying the effects of brain injuries in the hippocampal area.

Now they're increasingly using "virtual reality" environments, like those found in computer games.

For example, Eleanor Maguire, an expert on the hippocampus at the Wellcome Trust for Brain Imaging in London, put people in a functional magnetic resonance imaging machine to observe which neurons fired as they navigated through a simplified virtual-reality maze.

"Remarkably, we could accurately predict the position of an individual within this environment solely from the pattern of activity in his hippocampus," Maguire reported in the April 14 edition of *Current Biology*.

Researchers have identified gender differences in the ways that brain maps work in males and females.

"Female animals use landmarks as external cues," Wilson said. "Male animals use internal, spatial maps."

According to Georg Groen, a psychiatrist at the University of Ulm, Germany, men and women who are searching for a way out of a complex, three-dimensional virtual reality maze use different parts of their brains. Males activate the left hippocampus, while females use other regions on the right side, Groen said.

Incidentally, Maguire acknowledged, "men were significantly faster than women at finding a way out of the maze."

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