UA Part of Group That is Unraveling How the Brain Manages Memory

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A group of scientists, including two neuroscientists from The University of Arizona, may have resolved a long-standing controversy about the role of a part of the brain that is a key component of memory. The group is the Centre for the Biology of Memory at Norwegian University of Science and Technology in Trondheim, Norway. Their results are published in today's (July 22) issue of Science.

For the last two decades, researchers have been debating whether the hippocampus is essentially a cognitive mapping system or a general memory organizing system, said Bruce L. McNaughton, a professor of psychology at the UA.

His collaborator at the UA is Carol A. Barnes, also a professor of psychology and current president of the 30,000-member Society for Neuroscience. The technological expertise developed in McNaughton's laboratory helped make the study possible.

At issue is the hippocampus, a structure in the brain that is critical for the formation of long-term memory and is essential for storing and processing memories, as well as helping retrieve them.

One theory, said McNaughton, is that because the hippocampus sits atop the other cortical structures, it is positioned to link together patterns stored in lower-level modules that themselves are not strongly connected. What happens in memory consolidation is, eventually, the links become more direct as a result of the hippocampus' hierarchical position.

A second argument results from findings garnered from studies of individual hippocampus cells linked to specific points in space, and coupled with what researchers already know about damage to the hippocampus and how it effects long-term memories.

McNaughton said the results of the current study suggest that these two lines of theory are not mutually incompatible.

"What we've basically shown is that there are two codes simultaneously being expressed by these neurons," McNaughton said. "One is a code for 'where' things are happening. The other is the code for 'what' is happening."

Individual hippocampal cells fire in a particular place and a particular environment. By recording the activity of many cells simultaneously, McNaughton and other researchers have shown that the location of the animal can be determined just by looking at which cells are active at a given moment, suggesting that the hippocampus provides the rest of the brain with some sort of map.

However, data from the last 10 years also show that changing elements within an environment can very often change activity patterns, leading other researchers to say that the hippocampus is not creating a map, but just reporting on the different sensory inputs that occur in different places.

"What this paper shows is that if you analyze the data in the right way, when you change things about the (laboratory) animal's experience in the environment and the code seems to change, what is changing is not where the cells are firing, but how strongly - the number of impulses per second the cells emit when in the correct space - they're firing," McNaughton said.

"What that means is that the spatial component of the information is preserved by where the cells are firing. And the experiential - what we call the episodic information, the memory aspect of what was going on - is encoded in the relative firing rates over a huge population of cells," he said.

McNaughton and his colleagues at the UA developed the technology that made the research possible. It essentially allows researchers to monitor hundreds of brain cells at a time through computers that process the large amounts of data the experiments generate.

This particular experiment itself was fairly simple. Animals were recorded while they foraged for food in a box. The experiment had two components, called "constant place - variable cue" and "variable place - constant cue."

Constant place - variable cue meant changing the color or shape of the box the animal ran around in. The animal always knew it was in the same place because the box was put in the middle of the same room. The animal would be placed in a corner of the room and allowed to see where it was, and then placed in the box to forage. Then the animal was taken out of the box and placed inside another box with a different shape or color, but at exactly the same place in the room. In other words, the animal had different experiences in the same place.

In variable place - constant cue, animals were brought into distinctly different rooms and allowed to run around in the identical box.

"What we saw was that, in the variable place - constant cue condition, the entire spatial pattern of firing rearranged," McNaughton said. "Different cells were active and in different combinations. But in the constant place - variable cue condition, it was the same cells that were active, but their firing rates had changed, a lot, some increasing, some decreasing."

McNaughton said the results support an idea he has been pushing for several years, that there is a fundamentally spatial code being generated in the brain, a map-like organization that is intrinsically wired to the brain. And the information about what is going on is superimposed on that spatial, map-like pattern.

"We still don't fully understand how that map-like pattern arises," he said, but noted that additional work from this research group recently led to important new insights which he and the others intend to follow up on.

Source: The University of Arizona

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