Medical Xpress

Deconstructing brain systems involved in memory and spatial skills

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(Left to right) Image shown to study participants; image drawn by memory by a control subject; and image drawn by patient with hippocampal damage. Credit: *PNAS*

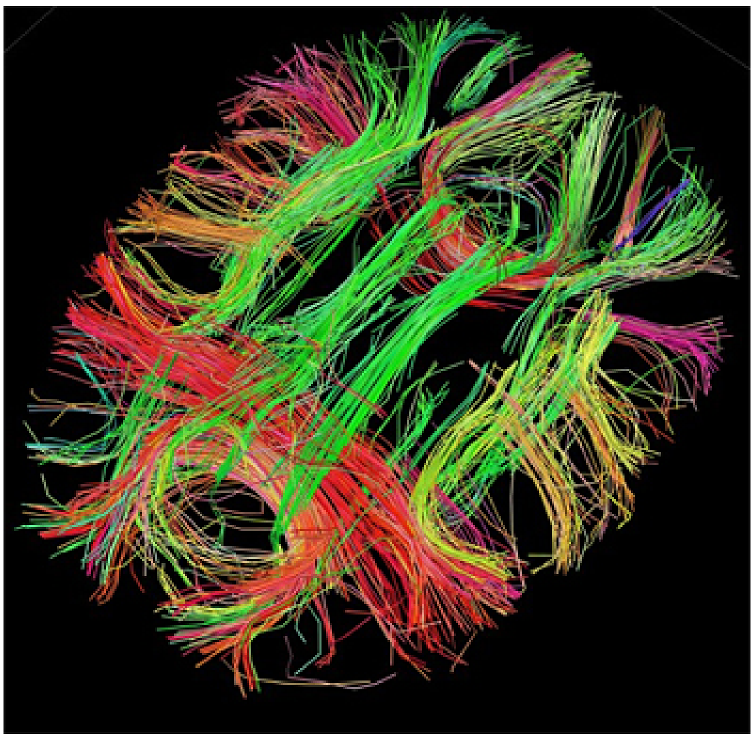
In work that reconciles two competing views of brain structures involved in memory and spatial perception, researchers at University of California, San Diego School of Medicine have conducted experiments that suggest the hippocampus - a small region in the brain's limbic system - is dedicated largely to memory formation and not to spatial skills, such as navigation. The study is published in this week's issue of the *Proceedings of the National Academy of Sciences*.

"The role of the hippocampus in spatial cognition versus memory formation is a major debating point in our understanding of how the human brain processes its exterior environment," said senior author Larry Squire, PhD, Distinguished Professor of Psychiatry, Neurosciences, and Psychology. "This study shows that the hippocampus is primarily associated with memory. It's an adjudication on two perspectives that span more than 60 years of research."

In one of these perspectives, developed in the 1950s, the hippocampus is viewed as being the critical structure enabling the formation of declarative, long-term memories, such as the ability to remember one's high-school prom. That view shifted in the 1970s when experiments conducted largely with rats showed that the hippocampus plays a major role in spatial skills, such as those needed to navigate through a maze. The experiments led some researchers to speculate that the human hippocampus might also be active in spatial cognition and mapmaking skills.

"We have not found evidence that this is the case," said Squire, who is also a research career scientist at the Veterans Affairs San Diego Healthcare System. "Patients with hippocampal lesions can perform spatial tasks as long as these tasks don't depend on long-term memory. We think they can do these spatial tasks because these tasks can be managed within short-term memory functions, supported by the frontal lobe of the neocortex. The discrepancy we see with rats may reflect the fact that rodents don't have a well-developed frontal cortex or the associated short-term memory processing skills. The spatial tasks that we can do with our neocortex using short-term memory must be performed by the hippocampus in rats."

The results are based on experiments with six adults with hippocampal lesions, one adult with damage to the medial temporal lobe, which includes the hippocampus, and 12 control subjects. For the experiments, participants were asked to study a simple scene, such as a pair of boots, and to draw the scene from memory. The drawings were scored for detail and accuracy on a 1-5 scale. Participants were also evaluated for a normal tendency, known as boundary extension, in which people tend to recall an image as having a larger background and smaller foreground than is present in reality. In the boot example, this means people tend to draw the boots smaller than they were in the original photograph. The background consequently takes up a larger fraction of the image, hence the term boundary extension.



White matter fiber architecture of the brain. Credit: Human Connectome Project.

In a second set of experiments, participants were asked to look at a scene, such as a slide in a park, and describe what might come into view if the image were enlarged. The participants' narratives were scored for details, spatial references, thoughts and emotions.

All participants with hippocampal damage demonstrated an impaired ability to accurately recall details about the boots. Their average score was 2, compared with 3 for the control group. However, the patients displayed normal boundary extension. Both patients and control subjects shrunk the size of the boots relative to the background by about 60 percent. Both groups were also equally skilled in imagining and constructing detailed narratives about what might come into view if the scenes were expanded.

"The value of this type of research is that we are building an understanding of how the brain works," Squire said. "We know Alzheimer's disease usually begins in the medial temporal lobe and this study reminds us that it's not the patients' spatial skills that are immediately at risk, it is their memory. This is consistent with clinical experiences. Patients don't complain about loss of spatial skills, they complain about memory loss."

More information: Memory, scene construction, and the human hippocampus, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1503863112

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