Don't I know that guy? Neuroscientists pinpoint part of the brain that deciphers memory from new experience

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Research assistant Jeremy Johnson feeds a rat on the behavioral track used to determine where the brain decides what is new and what is familiar. Credit: Johns Hopkins University

You see a man at the grocery store. Is that the fellow you went to college with or just a guy who looks like him?

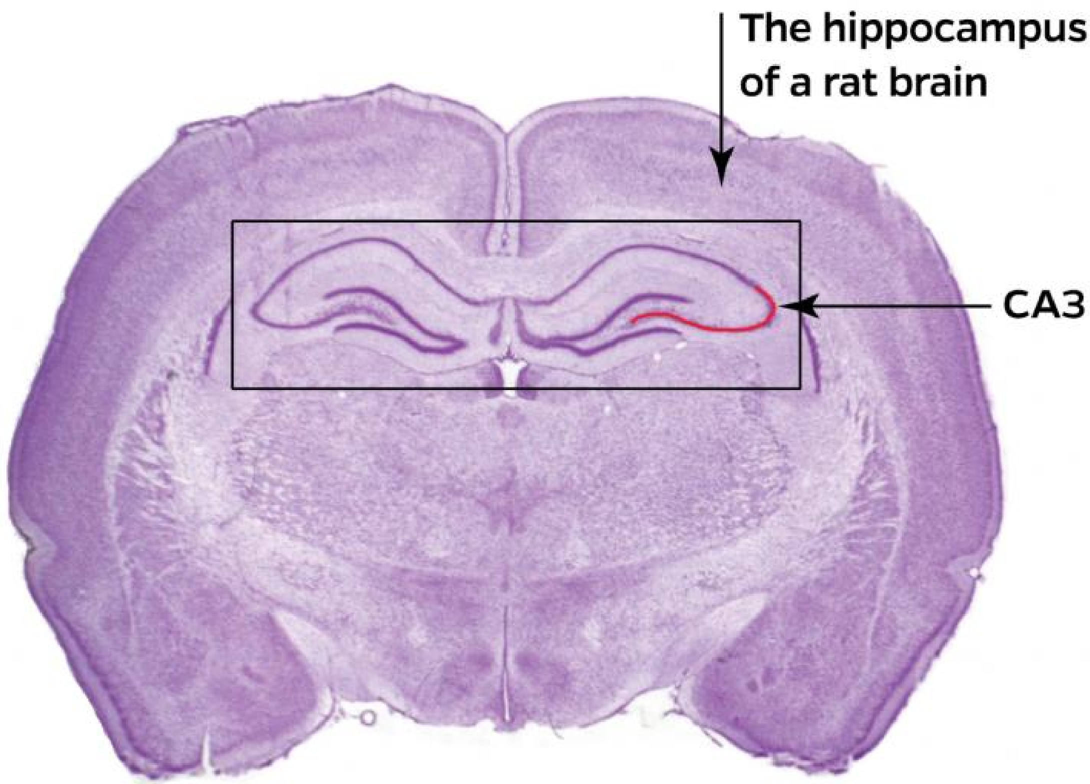
One tiny spot in the brain has the answer.

Johns Hopkins University neuroscientists have identified the part of the hippocampus that creates and processes this type of memory, furthering our understanding of how the mind works, and what's going wrong when it doesn't. Their findings are published in the current issue of the journal *Neuron*.

"You see a familiar face and say to yourself, 'I think I've seen that face.' But is this someone I met five years ago, maybe with thinner hair or different glasses—or is it someone else entirely," said James J. Knierim, a professor of neuroscience at the university's Zanvyl Krieger Mind/Brain Institute who led the research. "That's one of the biggest problems our memory system has to solve."

Neural activity in the hippocampus allows someone to remember where they parked their car, find their home even if the paint color changes, and recognize an old song when it comes on the radio.

Brain researchers theorized that two parts of the hippocampus (the dentate gyrus and CA3) competed to decide whether a stimulus was completely new or an altered version of something familiar. The dentate gyrus was thought to automatically encode each stimulus as new, a process called pattern separation. In contrast, CA3 was thought to minimize any small changes from one experience to the next and classify the stimuli as being the same, a process called pattern completion. So, the dentate gyrus would assume that the person with thinner hair and unfamiliar glasses was a complete stranger, while CA3 would ignore the altered details and retrieve the memory of a college buddy.



A cross-section of a rat's brain, showing where the key decisions are made about what is a new memory being made and what is old and familiar. Credit: Johns Hopkins University

Prior work by Knierim's group and others provided evidence in favor of this long-standing theory. The new research shows, however, that CA3 is more complicated than previously thought—parts of CA3 come to different decisions, and they pass these different decisions to other brain areas.

"The final job of the CA3 region is to make the decision: Is it the same or is it different?" Knierim said. "Usually you are correct in remembering that this person is a slightly different version of the person you met years ago. But when you are wrong, and it embarrassingly turns out that this is a complete stranger, you want to create a memory of this new person that is absolutely distinct from the memory of your familiar friend, so you don't make the mistake again."

Knierim and Johns Hopkins postdoctoral fellows Heekyung Lee and Cheng Wang, along with Sachin S. Deshmukh, a former assistant research scientist in Knierim's lab, monitored rats as they got to know an environment and as that environment changed.

Research assistant Jeremy Johnson feeds a rat on the behavioral track. (Credit: Johns Hopkins University)

The team implanted electrodes in the hippocampus of the rats. They trained the rats to run around a track, eating chocolate sprinkles. The track floor had four different textures—sandpaper, carpet padding, duct tape and a rubber mat. The rat could see, feel and smell the differences in the textures. Meanwhile, a black curtain surrounding the track had various objects attached to it. Over 10 days, the rats built mental maps of that environment.

Then the experimenters changed things up. They rotated the track counter-clockwise, while rotating the curtain clockwise, creating a perceptual mismatch in the rats' minds. The effect was similar, Knierim said, to if you opened the door of your home and all of your pictures were hanging on different walls and your furniture had been moved.

"Would you recognize it as your home or think you are lost?" he said. "It's a very disorienting experience and a very uncomfortable feeling."

Even when the perceptual mismatch between the track and curtain was small, the "pattern separating" part of CA3 almost completely changed its activity patterns, creating a new memory of the altered environment. But the "pattern completing" part of CA3 tended to retrieve a similar activity pattern used to encode the original memory, even when the perceptual mismatch increased.

The findings, which validate models about how memory works, could help explain what goes wrong with memory in diseases like Alzheimer's and could help to preserve people's memories as they age.

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