Why do some older adults show declines in their spatial memory?

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Aging becomes apparent in various ways, one of them being changes in memory function. But some older adults experience a faster decline in memory compared to others.

A new study by University of Arizona psychologists investigated the possible scenarios that could lead to waning memory in some older people. The researchers also studied both age-dependent and age-independent factors that could contribute to memory decline in younger and older people alike.

The study suggests that the hippocampus, a brain region associated with memory and navigation, could contribute to the difficulty in learning new environments and locations in some older adults. Neural representations in the hippocampus could explain why some people have a hard time remembering locations, said Li Zheng, a research scientist in the Department of Psychology and the lead author of the study.

"The study's findings will be helpful in predicting the level of memory decline in early stages of dementia," Zheng said.

Published in the journal *Proceedings of the National Academy of Sciences*, the new study is designed based on a similar study conducted in rats by Carol Barnes, a Regents Professor of psychology, neurology and neuroscience.

Barnes' study investigated specialized cells in the hippocampus called "place cells," or neurons that get triggered and fire when a person or animal enters a particular place. When an individual goes to another location, another place cell fires, helping the brain's hippocampus build a mental representation of each space.

When an animal or human enters a new environment, the place cells undergo a process called "remapping." The study observed that the older rats showed difficulties in remapping for different environments more so than younger rats, indicating an inferior spatial memory performance.

Building on Barnes' study, Zheng and her team recruited 25 younger

adults and 22 older adults, all of them healthy. The participants were instructed to take part in a virtual reality experiment. On a computer screen, the younger and older adults memorized the layouts and locations of six shops in two virtual cities.

The participants were asked to complete a series of questions to test their spatial memory, while the researchers simultaneously scanned the participants' brain using a functional magnetic resonance imaging scanner. The scanner captured the neural signals in the hippocampus.

Researchers found, in line with Barnes' study, that older adults on average showed neural representations that did not differentiate well between environments when compared to younger adults.

However, the study found that there is an age-independent factor that affects memory retention. Suggesting that distinct neurons in the hippocampus serve different functions, Zheng explained that, for instance, one neuron might respond to the shape of an environment, while another responds to the ground color or other features. These neurons collaborate to create a comprehensive representation of the entire environment.

If a group of neurons takes up the same function, there's a risk that some of the features of the environment may not be accurately represented, meaning the fidelity of the neural signals gets compromised and is low, said Arne Ekstrom, a professor of cognition and neural systems at UArizona and a senior author on the paper. At this time, the reason for low-fidelity signals in younger and older adults is not clear, he said.

"Anyone with poor memory performance will show a lower-fidelity neural signal," Zheng said. "Age doesn't have anything to do with that."

The study also mentioned there is an age-dependent factor, which the

researchers describe as the quality of neural signals coming from other parts of the brain into the hippocampus—for example, visual information that comes through the back part of the brain. Even some high-performing older adults in the experiment exhibited a decrease in the quality of incoming neural signals into the hippocampus.

It has long been suspected that one age-related factor influencing memory could be the quality of the signal getting into a brain region, which may relate to changes in plasticity in the aging brain, Ekstrom said. The study's findings linked reductions in the quality of input into the hippocampus with age and worse spatial memory, he said.

Insights gained from the remapping index and fidelity of neural signals can be useful in predicting how much memory decline can occur in people diagnosed with dementia, Zheng said.

In the near future, the research team is planning to replicate the study with immersive virtual reality experiments, which Zheng said would use body-based cues and navigation to the target in a more naturalistic way.

More information: Li Zheng et al, Hippocampal contributions to novel spatial learning are both age-related and age-invariant, *Proceedings of the National Academy of Sciences* (2023). DOI: 10.1073/pnas.2307884120

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