How do we learn to learn? New research offers an education

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Cognitive training designed to focus on what's important while ignoring distractions can enhance the brain's information processing, enabling the ability to "learn to learn," finds a new study on mice.

"As any educator knows, merely recollecting the information we learn in school is hardly the point of an education," says André Fenton, a professor of neural science at New York University and the senior author of the study, which appears in the journal *Nature*. "Rather than using our brains to merely store information to recall later, with the right mental training, we can also 'learn to learn,' which makes us more adaptive, mindful, and intelligent."

Researchers have frequently studied the machinations of memory—specifically, how neurons store the information gained from experience so that the same information can be recalled later. However, less is known about the underlying neurobiology of how we "learn to learn"—the mechanisms our brains use to go beyond drawing from memory to utilize past experiences in meaningful, novel ways.

A greater understanding of this process could point to new methods to enhance learning and to design precision cognitive behavioral therapies for neuropsychiatric disorders like anxiety, schizophrenia, and other forms of mental dysfunction.

To explore this, the researchers conducted a series of experiments using mice, who were assessed for their ability to learn cognitively challenging tasks. Prior to the assessment, some mice received "cognitive control training" (CCT). They were put on a slowly rotating arena and trained to avoid the stationary location of a mild shock using stationary visual cues while ignoring locations of the shock on the rotating floor. CCT mice were compared to control mice. One control group also learned the same place avoidance, but it did not have to ignore the irrelevant rotating locations.

The use of the rotating arena place avoidance methodology was vital to the experiment, the scientists note, because it manipulates spatial information, dissociating the environment into stationary and rotating components. Previously, the lab had shown that learning to avoid shock on the rotating arena requires using the hippocampus, the brain's memory and navigation center, as well as the persistent activity of a molecule (protein kinase M zeta [PKM?]) that is crucial for maintaining increases in the strength of neuronal connections and for storing long-term memory.

"In short, there were molecular, physiological, and behavioral reasons to examine long-term place avoidance memory in the hippocampus circuit as well as a theory for how the circuit could persistently improve," explains Fenton.

Analysis of neural activity in the hippocampus during CCT confirmed the mice were using relevant information for avoiding shock and ignoring the rotating distractions in the vicinity of the shock. Notably, this process of ignoring distractions was essential for the mice learning to learn as it allowed them to do novel cognitive tasks better than the mice that did not receive CCT. Remarkably, the researchers could measure that CCT also improves how the mice's hippocampal neural circuitry functions to process information. The hippocampus is a crucial part of the brain for forming long-lasting memories as well as for spatial navigation, and CCT improved how it operates for months.

"The study shows that two hours of cognitive control training causes learning to learn in mice and that learning to learn is accompanied by improved tuning of a key brain circuit for memory," observes Fenton. "Consequently, the brain becomes persistently more effective at suppressing noisy inputs and more consistently effective at enhancing the inputs that matter."

More information: André Fenton, Cognitive control persistently enhances hippocampal information processing, *Nature* (2021). DOI: 10.1038/s41586-021-04070-5. www.nature.com/articles/s41586-021-04070-5

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