Research identifies new pathways for sensory learning in the brain

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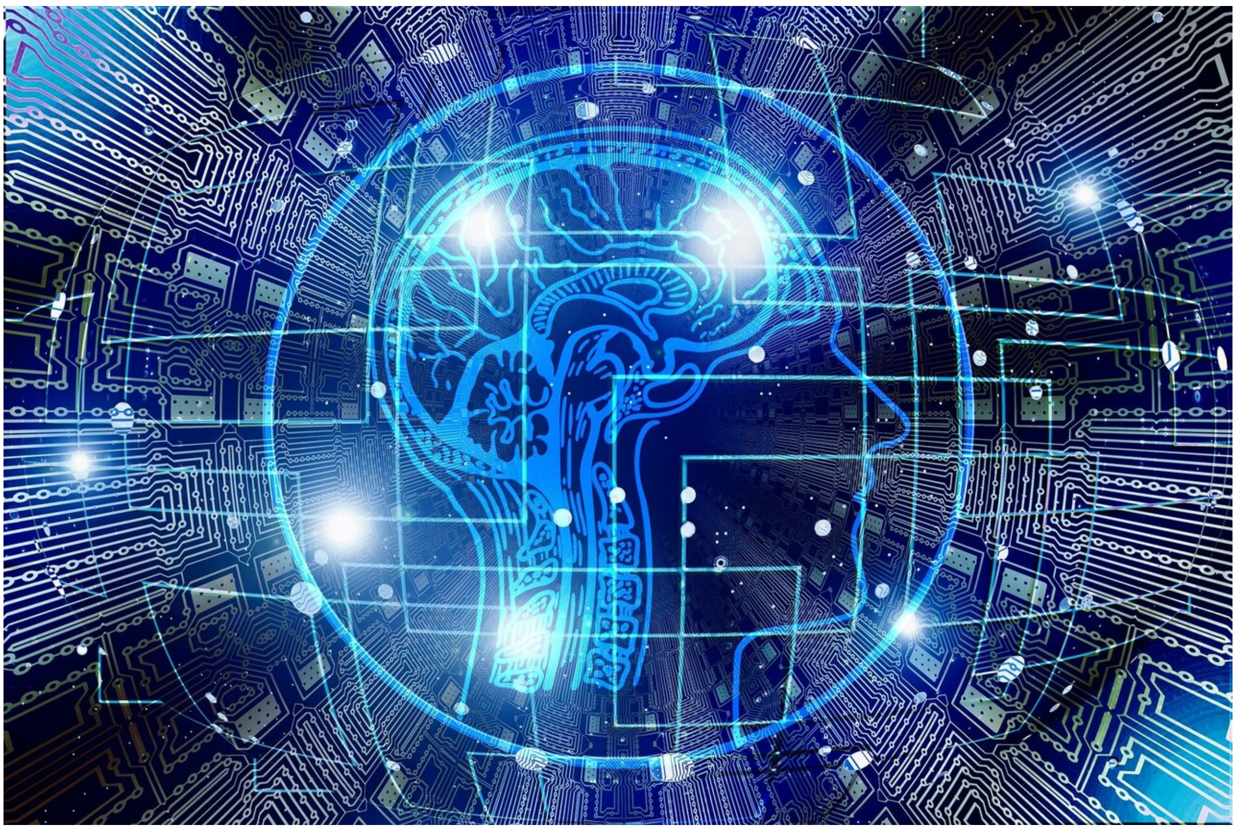

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We've all heard the saying that individuals learn at their own pace. Researchers at Carnegie Mellon University have developed an automated, robotic training device that allows mice to learn at their leisure. The technology stands to further neuroscience research by allowing researchers to train animals under more natural conditions and identify mechanisms of circuit rewiring that occur during learning.

A research team led by Carnegie Mellon neuroscientist Alison Barth has used the automated technology to identify new, previously unidentified pathways activated when the brain rewires its circuits in response to experience. Their findings are published in the July 17 issue of *Neuron*.

Barth's lab focuses on understanding the process by which cortical circuits receive sensory information and adapt to it in order to learn. Understanding the algorithm that underlies the changes in the brain's learning circuitry will have important implications for creating engineered systems that use deep learning and artificial intelligence.

"Neural circuits in the cerebral cortex have had 3.5 billion years to evolve to become perfectly adapted to learning things," said Barth, a professor of biological sciences and member of the Carnegie Mellon Neuroscience Institute. "There is valuable information about what happens in the brain that can be used to inform computations that need to change based on experience."

To better study how the brain changes during sensory learning, the researchers constructed an army of automated robotic devices, in an effort that was spearheaded by Sarah Bernhard, an undergraduate student in Carnegie Mellon's Department of Biological Sciences. These devices allowed mice to voluntarily approach a water port in their home cage where they would receive a gentle puff of air to their whiskers followed by a drop of water. If they approached the port and didn't feel a puff of air, they wouldn't get a drop of water. Eventually, they learned that a puff of air meant water and they would start to drink when they felt it.

"It was almost like we gave the mice homework. Some took 50 tries to learn, others took 400. Some learned early in the evening, others learned late at night. But they all learned and learned quickly," said Barth. "One thing that is critical to learning is that you have to be ready to learn. This device let mice learn when they wanted and at their own pace."

They found that when they used the device, the mice learned quickly and independently, with no intervention from the researchers. As a result, they could capture a larger data set that more accurately reflects the individual diversity in learning.

In the *Neuron* study, Barth and colleagues used the robotic device to determine what sensory learning pathways were conserved across the population, regardless of how long learning took. They found some surprising results.

The pathways that changed the most in response to the sensory stimulus, indicating learning, were not the ones they expected. It was commonly thought that in sensory learning information came from the skin, traveling rapidly to the neocortex through the thalamus. However, the research team found that this pathway remained relatively unchanged during sensory learning. Instead, they were surprised to find that the cortical synapses, responding to a high-order and more integrative part of the thalamus, were much more plastic.

"Our results suggest that the brain maintains the pathway that represents the fast sensory input, things that you want to know for certain in any given situation. The pathway that is responsible for processing more context-rich information is the one that is flexible," Barth said. "The brain keeps the original file but edits a copy of it."

The results provide insight into the algorithm that the neocortex uses to rewire itself during learning. Barth plans to use this training paradigm to understand how and when different types of tasks and rewards can change the brain.

More information: Nicholas J. Audette et al, Rapid Plasticity of Higher-Order Thalamocortical Inputs during Sensory Learning, *Neuron* (2019). DOI: 10.1016/j.neuron.2019.04.037

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