Negative feedback stabilizes memories

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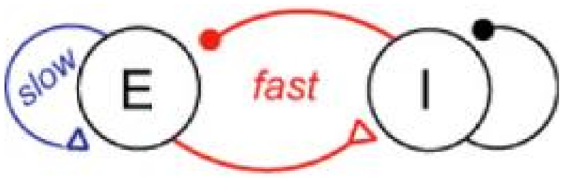

Excitatory (E) neurons hold the memory. If their activity begins to slip, fast negative feedback (red) mediated by inhibitory (I) neurons can correct this slip before slower positive feedback loops (blue) bring the circuit back into balance. Credit: UC Davis graphic

(Medical Xpress)—Memories may be maintained in the brain through a mechanism familiar to any engineer—negative and positive feedback loops, according to researchers Sukbin Lim and Mark Goldman at the UC Davis Center for Neuroscience.

The work was published Aug. 18 in the journal *Nature Neuroscience*.

"The puzzle out there is: How do brain circuits retain a memory without it slipping?" said Associate Professor Goldman. "For example, if you store a memory of the color yellow, why doesn't it slip over time into orange?"

Earlier models used positive feedback to maintain memories. The idea is that, if a memory starts to fade, the circuit gets a boost.

"The problem with positive feedback is that, without some additional mechanism, it's brittle—the system doesn't respond well to being perturbed," said Goldman, who also holds joint appointments in the Department of Neurobiology, Physiology and Behavior within the College of Biological Sciences, and the Department of Ophthalmology and Vision Science within the School of Medicine.

Goldman and Lim, a postdoctoral researcher, thought that these brain circuits might instead be doing something an engineer would do—stabilizing a system with negative feedback. For example, a thermostat uses negative feedback to turn on heating or cooling depending on whether a room's temperature drifts below or above a set point.

The researchers built mathematical models to simulate the kinds of neural circuits found in the cortex of the brain. Neurons are connected to each other through junctions that transmit either positive (excitatory) or negative (inhibitory) signals.

The modeling studies show that negative feedback can stabilize these circuits and allow them to store memories. What's more, the models show that these circuits should be robust to perturbations such as death of individual cells.

"Biological systems tend to be robust, so we wanted our models to reflect this robustness," Goldman said. The models also reflect key features of the circuitry observed in the brain's neocortex, he said.

Lim and Goldman further showed how positive feedback and negative feedback could work together in the same circuit, demonstrating how the brain may exploit multiple mechanisms to store memories.

More information: Balanced cortical microcircuitry for maintaining information in working memory, DOI: 10.1038/nn.3492

Provided by UC Davis

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