Scientists image brain at point when vocal learning begins

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Duke University Medical Center scientists crowded around a laser-powered microscope in a darkened room to peer into the brain of an anesthetized juvenile songbird right after he heard an adult tutors' song for the first time.

Specifically, they wanted to see what happened to the connections between nerve cells, or synapses, in a part of the brain where the motor commands for song are thought to originate.

In the first experiment of its kind, they employed high resolution imaging to track changes to individual dendritic spines, important points of contact between nerve cells.

"We expected to see the building of new spines and loss of old spines accelerate when the juvenile heard a tutor's song for the first time," said senior author Richard Mooney, Ph.D., a Duke professor of neurobiology. "Instead, we saw exactly the opposite: hearing a tutor song rapidly stabilized previously dynamic synapses."

Juveniles with initially higher levels of spine turnover before hearing the tutor song subsequently learned more from their tutors. Because the scientists studied birds during their late adolescence, some may have been past their optimal learning period. "Juveniles in which spines were already highly stable weren't able to learn from their tutors," said Todd Roberts, Ph.D., a postdoctoral fellow in the Department of Neurobiology who is lead author on the study, which was published online in the journal *Nature* on Feb. 17.

In the "learners," hearing a tutor song rapidly stabilized spines.

Roberts said they were expecting to find higher "plasticity," the brain's ability to remodel connections in response to learning or injury. "We thought we would see an initial stage of higher plasticity, because it can take weeks or even months for a juvenile to copy the tutor song." .

The findings provide fundamental insight into how the brain changes during the juvenile's critical periods for behavioral learning. They also can guide future research aimed at restoring plasticity to synapses after the critical period closes, an important therapeutic goal in helping people regain function after an injury like hearing loss or stroke, Mooney said.

The researchers studied juvenile male songbirds that were kept only with females, which do not sing. They had been exposed to other calls and noises, but not the critically important song of a male tutor. "The adult male's song is a signal that the juvenile's brain seems to crave," Mooney said.

As to why this rapid stabilization of dendritic spines might be important, Mooney said that the songbird brain, like people's brains, is learning for an important goal, which is to perform a highly precise skill. "Many skills, including communication skills, require great precision if you want to stay in the gene pool," Mooney said. "A male songbird has to learn to sing precisely or he won't attract a mate."

The finding that a stable network of synapses rapidly forms after a young bird hears the tutor song suggests that an experience can act in a young brain to build stable connections between neurons, providing a foundation for learning new behaviors, like singing or speaking.

Roberts detailed the painstaking way that he and colleagues set up the experiment and imaged the individual dendritic spines. They used an engineered virus to infect certain nerve cells, which then expressed green fluorescent protein. "Hit with the right wavelength of light from a powerful and concentrated laser beam, the neuron glows and we can even see its dendritic spines, which are tiny components of excitatory synapses," Roberts said. The same neurons and spines were tracked and photographed for up to a month.

Provided by Duke University

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