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Songbirds shed light on brain circuits and learning

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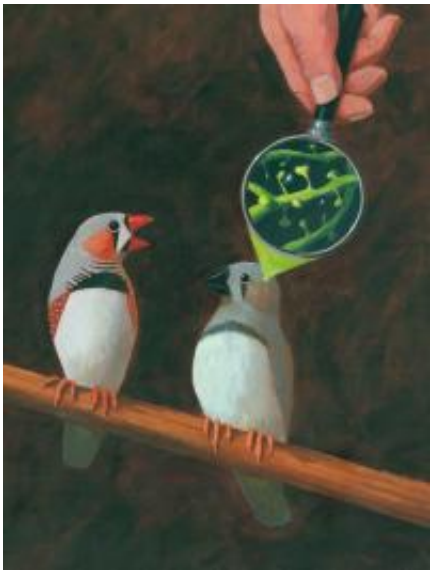

By studying how birds master songs used in courtship, scientists at Duke University have found that regions of the brain involved in planning and controlling complex vocal sequences may also be necessary for memorizing sounds that serve as models for vocal imitation.

In a paper appearing in the September 2012 issue of the journal Nature Neuroscience, researchers at Duke and Harvard universities observed the imitative vocal learning habits of male zebra finches to pinpoint which circuits in the birds' brains are necessary for learning their songs.

Knowing which brain circuits are involved in learning by imitation could have broader implications for diagnosing and treating human developmental disorders, the researchers said. The finding shows that the same circuitry used for vocal control also participates in auditory learning, raising the possibility that vocal circuits in our own brain also help encode auditory experience important to speech and language learning.

"Birds learn their songs early in life by listening to and memorizing the song of their parent or other adult bird tutor, in a process similar to how humans learn to speak," said Todd Roberts, Ph.D., the study's first author and postdoctoral associate in neurobiology at Duke University. "They shape their vocalizations to match or copy the tutor's song."

A young male zebra finch, Roberts said, learns his song in two phases – memorization and practice. He said the pupil can rapidly memorize the song of an adult tutor, but may need to practice singing as many as 100,000 times in a 45-day period in order to accurately imitate the tutor's song.

During the study, voice recognition software was paired with optogenetics, a technology that combines genetics and optics to control the electrical activity of nerve cells, or neurons. Using these tools, the researchers were able to scramble brain signals coordinating small sets of neurons in the young bird's brain for a few hundred milliseconds while he was listening to his teacher, enabling them to test which brain regions were important during the learning process.

The study's results show that a song pre-motor region in the pupil's brain plays two different roles. Not only does it control the execution of learned vocal sequences, it also helps encode information when the pupil is listening to his tutor, Roberts said.

"We learn some of our most interesting behaviors, including language, speech and music, by listening to an appropriate model and then emulating this model through intensive practice," said senior author Richard Mooney, Ph.D., professor of neurobiology and member of the Duke Institute for Brain Sciences. "A traditional view is that this two-step sequence—listening followed by motor rehearsal—first involves activation by the model of brain regions important to auditory processing. This is followed days, weeks or even months later by activation of brain regions important to motor control."

"Here we found that a brain region that is essential to the motor control of song also has an essential role in helping in auditory learning of the tutor song," Mooney said. "This finding raises the possibility that the premotor circuits important to planning and controlling speech in our own brains also play an important role in auditory learning of speech sounds during early infancy." This brain region, known as Broca's area, is located in the frontal lobe of the left hemisphere.

The research has implications for the role of premotor circuits in the brain and suggests that these areas are important targets to consider when assessing developmental disorders that affect speech, language and other imitative behaviors in humans, Roberts said.

Provided by Duke University Medical Center

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