Brain study: Singing mice show signs of learning

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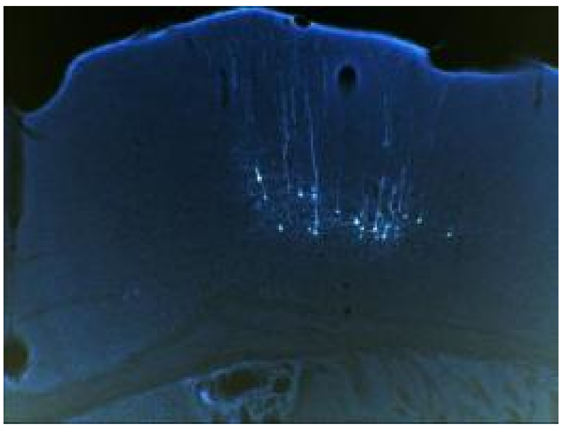

This image shows the motor cortex neurons that directly project to the brainstem and ultimately control the larynx of male mice. Credit: Gustavo Arriaga and Erich Jarvis, Duke.

Guys who imitate Luciano Pavarotti or Justin Bieber to get the girls aren't alone. Male mice may do a similar trick, matching the pitch of other males' ultrasonic serenades. The mice also have certain brain features, somewhat similar to humans and song-learning birds, which they may use to change their sounds, according to a new study.

"We are claiming that mice have limited versions of the brain and behavior traits for vocal learning that are found in humans for learning speech and in birds for learning song," said Duke neurobiologist Erich Jarvis, who oversaw the study. The results appear Oct. 10 in PLOS ONE and are further described in a review article in *Brain and Language*.

The discovery contradicts scientists' 60-year-old assumption that mice do not have vocal learning traits at all. "If we're not wrong, these findings will be a big boost to scientists studying diseases like autism and anxiety disorders," said Jarvis, who is a Howard Hughes Medical Institute investigator. "The researchers who use mouse models of the vocal communication effects of these diseases will finally know the brain system that controls the mice's vocalizations."

Jarvis acknowledged that the findings are controversial because they contradict scientists' long-held assumption about mice vocalizations. His research suggests the vocal communication pathways in mice brains are more similar to those in human brains than to sound-making circuits in the brains of chimpanzees and other non-human primates. The results also contradict two recent studies suggesting mice do not match pitch or have deafness-induced vocalization changes.

"This is a very important study with great findings," said Kurt Hammerschmidt, an expert in vocal communication at the German Primate Center who was not involved in the study. He is cautious about some of the claims but suggested that if mice can learn vocalizations they could become a good model to study the genetic foundation of the evolution of language.

Jarvis, his former graduate student Gustavo Arriaga, and a colleague from Tulane University tested male mice for vocal learning traits as part of a larger project to study speech evolution in humans. Vocal learning appears to be unique to humans, songbirds, parrots and hummingbirds and scientists define it with five features related to brain structure and behavior. Since scientists have never found the features in other animals, "I almost expected every experiment in mice to fail," Arriaga said.

In the study, funded by HHMI, NSF and NIH, Arriaga first used gene expression markers, which lit up neurons in the motor cortex of the mice's brain as they sang. Arriaga then damaged these song-specific neurons in the motor cortex and observed that the mice couldn't keep their songs on pitch or repeat them as consistently, which also happened when the mice became deaf.

Arriaga also used an injectable tracer, which mapped the signals controlling song as they moved from the neurons in the motor cortex to those in the brainstem and then to the muscles in the larynx. "This direct projection from the mice's forebrain to the brainstem and muscles was the biggest surprise," Jarvis said.

"The evidence of direct projection from these motor cortex regions is a great finding," Hammerschmidt said. "And I think it is important to try to understand whether these projections are really able to work in a similar way like such projections known in birds and humans." The question is whether mice can learn a vocalization the way other species do. The researchers found that when two male mice were placed in the same cage with a female, the males' pitch began to converge after seven to eight weeks. Arriaga and Jarvis tested more than 14 mice and repeated the experiment twice to confirm the result.

Hammerschmidt is skeptical. Jarvis and Arriaga's "pitch convergence story is less convincing," he said. Scientists have observed pitch convergences in non-vocal learners and the number of tested animals in this study could be too low to determine whether the discovered effect is reliable, he said.

Jarvis disagrees, but added that more work does need to be done to know if mice can learn other features of vocalizations or if their learning is limited to just pitch.

"Our results show that mice have the five features scientists associate with vocal learning. In mice, they don't exist at the advanced levels found in humans and song-learning birds, but they also are not completely absent as commonly assumed," he said. His team is now searching mouse brains for genes specific to the brain circuits for vocal behavior. So far, these genes have only been found in songbirds and humans but, based on these results, could be in mice too, Jarvis said.

More information: "Of mice, birds, and men: the mouse ultrasonic song system has some features similar to humans and song-learning birds," Arriaga, G. et. al. (2012) *PLOS ONE.* dx.plos.org/10.1371/journal.pone.0046610

"Mouse vocal communication system: are ultrasounds learned or innate?" Arriaga, G. et. al. (2012) *Brain and Language*.

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