Discovery helps to unlock brain's speech-learning mechanism

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USC scientists have discovered a population of neurons in the brains of juvenile songbirds that are necessary for allowing the birds to recognize the vocal sounds they are learning to imitate.

These neurons encode a memory of learned vocal sounds and form a crucial (and hitherto only theorized) part of the neural system that allows songbirds to hear, imitate, and learn its species' songs – just as human infants acquire speech sounds.

This discovery will allow scientists to uncover the exact neural mechanisms that allow songbirds to hear their own self-produced songs, compare them to the memory of the song that they are trying to imitate, and then adjust their vocalizations accordingly.

This brain-behavior system is thought to be a model for how human infants learn to speak, so understanding it could prove crucial to future understanding and treatment of language disorders in children. In both songbirds and humans, feedback of self-produced vocalizations is compared to memorized vocal sounds and progressively refined to achieve a correct imitation.

"Every neurodevelopmental disorder you can think of – including Tourette syndrome, autism, and Rett syndrome – entails in some way a breakdown in auditory processing and vocal communication. Understanding mechanisms of vocal learning at a cellular level is a huge step toward being able to someday address the biological issues behind the behavioral issues," said Sarah Bottjer, senior author of an article on the research that appears in the *Journal of Neuroscience* on Sept. 4.

Bottjer collaborated with lead author Jennifer Achiro, a graduate student at USC, to examine the activity of neurons in songbirds brains using electrodes to record the activity of individual neurons.

In the basal ganglia—a complex system of neurons in the brain responsible for, among other things, procedural learning—Bottjer and Achiro were able to isolate two different types of neurons in young songbirds: ones that were activated only when the birds heard themselves singing, and others that were activated only when the birds heard the songs of adult birds that they were trying to imitate.

The two sets of neurons allow the songbirds to recognize both their current behavior and a goal behavior that they would like to achieve.

"The process of learning speech requires the brain to compare feedback of current vocal behavior to a memory of target vocal sounds," Achiro said. "The discovery of these two distinct populations of neurons means that this brain region contains separate neural representation of current and goal behaviors. Now, for the first time, we can test how these two neural representations are compared so that correct matches between the two are somehow rewarded."

The next step for scientists will be to learn how the brain rewards correct matches between feedback of current vocal behavior and the goal memory that depicts memorized vocal sounds as songbirds make progress in bringing their current behavior closer to their goal behavior, Bottjer said.

Provided by University of Southern California