Doing the math for how songbirds learn to sing

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Credit: AI-generated image (disclaimer)

(Phys.org)—Scientists studying how songbirds stay on key have developed a statistical explanation for why some things are harder for the brain to learn than others.

"We've built the first mathematical model that uses a bird's previous sensorimotor experience to predict its ability to learn," says Emory biologist Samuel Sober. "We hope it will help us understand the math of learning in other species, including humans."

Sober conducted the research with physiologist Michael Brainard of the University of California, San Francisco.

Their results, showing that adult birds correct small errors in their songs more rapidly and robustly than large errors, were published in the Proceedings of the National Academy of Sciences (PNAS).

Sober's lab uses Bengalese finches as a model for researching the mechanisms of how the brain learns to correct vocal mistakes.

Just like humans, baby birds learn to vocalize by listening to adults. Days after hatching, Bengalese finches start imitating the sounds of adults. "At first, their song is extremely variable and disorganized," Sober says. "It's baby talk, basically."

A Bengalese finch outfitted with headphones. Research on how the birds learn to sing may lead to better human therapies for vocal rehabilitation. Credit: Sam Sober

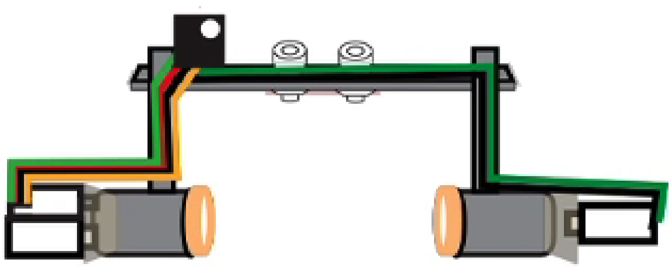
The young finches keep practicing, listening to their own sounds and fixing any mistakes that occur, until eventually they can sing like their elders.

Young birds, and young humans, make a lot of big mistakes as they learn to vocalize. As birds and humans get older, the variability of mistakes shrinks. One theory contends that adult brains tend to screen out big mistakes and pay more attention to smaller ones.

"To correct any mistake, the brain has to rely on the senses," Sober explains. "The problem is, the senses are unreliable. If there is noise in the environment, for example, the brain may think it misheard and ignore the sensory experience."

The link between variability and learning may explain why youngsters tend to learn faster and why adults are more resistant to change.

"Whether you are an opera singer or a bird, there is always variability in your sounds," Sober says. "When the brain receives an error in pitch, it seems to use this very simple and elegant strategy of evaluating the probability of whether the error was just extraneous 'noise,' a problem reading the signal, or an actual mistake in the vocalization."



The researchers wanted to quantify the relationship between the size of a vocal error, and the probability of the brain making a sensorimotor correction. The experiments were conducted on adult Bengalese finches outfitted with light-weight, miniature headphones.

As a bird sang into a microphone, the researchers used sound-processing equipment to trick the bird into thinking it was making vocal mistakes, by changing the bird's pitch and altering the way the bird heard itself, in real-time.

"When we made small pitch shifts, the birds learned really well and corrected their errors rapidly," Sober says. "As we made the pitch shifts bigger, the birds learned less well, until at a certain pitch, they stopped learning."

The researchers used the data to develop a statistical model for the size of a vocal error and whether a bird learns, including the cut-off point for learning from sensorimotor mistakes. They are now developing additional experiments to test and refine the model.

"We hope that our mathematical framework for how songbirds learn to sing could help in the development of human behavioral therapies for vocal rehabilitation, as well as increase our general understanding of how the brain learns," Sober says.

More information: Click to watch video of how the headphones are made.

Provided by Emory University