FirstRand

Decoding birds' brain signals into syllables of song

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Could the unique song of a bird someday, miraculously, help give a voice to people who have lost the ability to speak?

Such an achievement would be a crowning one in the world of vocal prostheses that could see the humble bird's brain hold the key to a scientific moment of biblical proportions - making the mute speak.

Researchers in the United States have developed the ability to predict when a bird will sing by reading electrical signals in its brain. The work has been hailed as a first step towards building more advanced vocal prostheses that can predict human speech.

The link between how birds and humans vocalise

"We're studying birdsong in a way that will help us get one step closer to engineering a brain-machine interface for vocalisation and communication," said Daril Brown, an electrical and computer engineering PhD student at the University of California, San Diego Jacobs School of Engineering, and the first author of the study, which was published in PLoS Computational Biology.

In this instance, a brain-machine interface for vocalisation and communication is the holy grail, but first, smaller building blocks need to be established, like the link between how birds and humans vocalise – a complex process of learned behaviour.

The project brought together engineers and neuroscientists at the University of California, San Diego, led by Vikash Gilja, a professor of electrical and computer engineering, and Timothy Gentner, a professor of psychology and neurobiology.

So how do they predict a bird's brain?

Silicon electrodes were implanted in the brains of adult male zebra finches. The electrodes recorded the birds' neural activity when they sang. A specific set of electrical signals called 'local field potentials' allows birds to learn and produce a song.

What's interesting about this is that local field potentials are used to predict vocal behaviour in humans too, and although this has been studied in human brains, their behaviour in bird brains has largely been ignored.

Contrary to popular belief, in most species of birds, it is the male who sings to attract a mate or proclaim his wondrous territory. Birdsong is a critical survival function for the species, as their repertoire moves into overdrive during the breeding season.

Birds communicate on a daily basis using calls such as chirps, whistles, and twitters (before the other Twitter). The sounds birds make are categorised as either songs or calls, with songs being more musical. Calls are used to communicate within large families of birds to signal anything from warnings about predators to information about food.

Cracking the code of birdsong

Now, researchers have cracked the code and are able to predict changes in the sequence of the birdsong by identifying features in "local field potentials".

“Our motivation for exploring local field potentials was that most of the complementary human work for speech prostheses development has focused on these types of signals,” Gilja said. “In this paper, we show that there are many similarities in this type of signalling between the zebra finch and humans, as well as other primates. With these signals, we can start to decode the brain’s intent to generate speech.”

The reason birdsong is of special interest is the similarities in vocalisations to human speech. (Probably why it’s fairly easy for some humans to imitate birdsongs or whistles.)

Birdsong is also among the most soothing and cognitively stimulating sounds to the human brain. Julian Treasure, author of Sound Business and chairman of noise consultancy The Sound Agency, says birdsong creates a state he calls “body relaxed, mind alert”.

Finches are fairly common birds, and, because they mate often, sing much more frequently than most birds. At eight to ten months of age, zebra finches are ready to mate. The team’s work revealed that separate features in the local field potentials translate into specific syllables of the bird’s song, including when the syllables will occur during a song.

Communication prosthesis can improve quality of life

“Using this system, we’re able to predict with high fidelity the onset of a songbird’s vocal behaviour – what sequence the bird is going to sing, and when it is going to sing it,” Brown explained.

What the team learns from this sequencing brings them one step closer to being able to build highly advanced vocal prostheses for those with speech impediments.

“In the longer term, we want to use the detailed knowledge we are gaining from the songbird brain to develop a communication prosthesis that can improve the quality of life for humans suffering a variety of illnesses and disorders,” added Gentner.

The researchers say they can even predict variations in a bird’s song sequence. If, for example, a bird’s song consists of mainly four syllables 1-2-3-4, they are now able to predict when the sequence will change to 1-2-3 or 1-2-3-4-5.

“These forms of variation are important for us to test hypothetical speech prostheses because a human doesn’t just repeat one sentence over and over again,” said Gilja. “It’s exciting that we found parallels in the brain signals that are being recorded and documented in human physiology studies to our study in songbirds.”