Bat brains parse sounds for multitasking

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Imagine listening to music while carrying on a conversation with friends. This type of multi-tasking is fairly easy to do, right? That's because our brains efficiently and effectively separate the auditory signals – music to the right side; conversation to the left. But what researchers have not been able to do in humans or animals is to see a parsing of duties at the single neuron level – until now.

Publishing in the *European Journal of Neuroscience*, renowned bat researcher Jagmeet Kanwal, PhD, associate professor in the department of neurology at Georgetown University Medical Center, reports on how and in which hemisphere of the brain, bats process incoming signals that allow them to orient and navigate while at the same time, make sense of what other bats are trying to tell them.

To understand auditory brain function, bats are especially interesting animals to study because they process sound through echolocation, which is a kind of biological sonar. Bats emit loud pulses and then listen to their own echoes produced when those pulses bounce off nearby objects. And while bats aren't blind, as is the common myth, they exclusively use echoes to navigate and to hunt while flying.

Not only do the brains of bats have to process a constant stream of pulses and echoes, they also have to simultaneously process the bats' social communications. Bats make angry sounds such as "back off," warning sounds like "watch out!" and other sounds for communicating messages such as "please don't hurt me, or even "I love you!"

In his study, Kanwal shows that neural circuits within the two brain halves allow a bat to navigate or "see" its surroundings and at the same time carry on a conversation, but the division of labor isn't equal, leading to what Kanwal describes as the lopsided brain.

At Washington University in St. Louis, Kanwal inserted a fine tungsten wire (thinner than a human hair) into the brains of awake bats. He presented an array of echolocation signals and communication calls from a digital library of species-specific sounds while recording miniature voltage spikes from neurons -- first in the left side and then the right side of the same bat.

Back at Georgetown University, Kanwal analyzed these data and discovered that neurons in the right cerebral cortex responded more strongly to echolocation than to communication sounds or "calls". This difference was absent on the left side where neurons were more sensitive to changes in the loudness of a call.

Kanwal separated the echolocation sounds into two parts (outgoing pulse and returning echo). Neurons on both sides of the brain responded vigorously to the combination of parts (pulse and echo) and poorly to each part presented by itself, indicating a functional specialization for echolocation. Neurons on the left side of the brain, but not the right, exhibited a similar specialization for processing other bats' social calls.

This phenomenon, known as combination-sensitivity, is ubiquitous in the brains of animals. Kanwal says it is likely the way humans perceive combinations of phonemes (units of speech) as a syllable or word.

"It appears that the cerebral cortex halves are wired differently, allowing one side, usually the left, to more effectively process speech or speech-like communication sounds than the other," Kanwal says. "The right half processes small changes in the pitch of the navigation signals akin to the pitch contour in a melody.

Kanwal says understanding the neurologic basis of speech and music processing is critical for alleviating communication deficits in children (hearing and language impairments, such as dyslexia), and repairing damage to speech areas (aphasias) after a stroke, that otherwise lead to a failure of verbal communication

"This type of lopsided processing has been known in humans for quite some time, but we have not been able to study single neurons at this level of detail in the human brain. Being able to examine the nature of lopsidedness at the level of single neurons in a non-human mammal opens the door to an in-depth understanding of this phenomenon."

More information: Kanwal is author of 'Bats Sing, Mice Giggle: The Surprising Science of Animals' Inner Lives,' first published in 2010 with co-author Karen Shanor, Ph.D. A paperback edition with a new chapter on "De-stressing the Distress" was released this year.

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