Medical Xpress

Human auditory neurons more sensitive than those of other mammals

January 16 2008

The human ear is exquisitely tuned to discern different sound frequencies, whether such tones are high or low, near or far. But the ability of our ears pales in comparison to the remarkable knack of single neurons in our brains to distinguish between the very subtlest of frequency differences.

Reporting in the Jan. 10 issue of the journal *Nature*, Dr. Itzhak Fried, professor of neurosurgery and director of the UCLA Epilepsy Surgery Program, and colleagues from Hebrew University and the Weizmann Institute of Science in Israel, show that in humans, a single auditory neuron in the brain exhibits an amazing selectivity to a very narrow sound-frequency range, roughly down to a tenth of an octave.

In fact, the ability of such neurons to detect the slightest of differences in sound frequency far surpasses that of the human auditory nerve, which carries information from the hair cells of the inner ear to the brain's auditory cortex — by as much as 30 times greater sensitivity. Indeed, such frequency tuning in the human auditory cortex is substantially superior to that typically found in the cortex of nonhuman mammals, with the exception of bats.

It is a paradox, the researchers note, that even the auditory neurons of musically untrained people can detect very small differences in frequency much better than their peripheral auditory nerve. With other peripheral nerves, such as those in the skin, the human ability to detect differences between two points — say from the prick of a needle — is limited by the receptors in the skin; the neurons associated with those peripheral nerves display no greater sensitivity. With hearing, however, the sensitivity of the neuron actually exceeds that of the peripheral nerve.

The researchers, including senior author Israel Nelken and first author Yael Bitterman from Hebrew University, determined how neurons in the human auditory cortex responded to various sounds by taking recordings of brain activity from four consenting clinical patients at UCLA Medical Center. These patients had intractable epilepsy and were being monitored with intracranial depth electrodes to identify the focal point of their seizures for potential surgical treatment.

Using clinical criteria, electrodes were implanted bilaterally at various brain sites that were suspected to be involved in the seizures, including the auditory cortex. The recording of brain activity was carried out while patients listened to artificial random chords at different tones per octave and to segments from the film "The Good, the Bad and the Ugly." Thus, the sounds the patients heard were both artificial (the random chords) and more natural (the voices and noise from the movie soundtrack).

The results surprised the researchers. A single auditory neuron from humans showed an amazing ability to distinguish between very subtle frequency differences, down to a tenth of an octave. This, compared to a sensitivity of about one octave in the cat, about a third of an octave in rats and a half to a full octave in the macaque.

"This is remarkable selectivity," said Fried, who is also co-director of UCLA's Seizure Disorder Center. "It is indeed a mystery why such resolution in humans came to be. Why did we develop this? Such selectivity is not needed for speech comprehension, but it may have a role in musical skill. The 3 percent frequency differences that can be detected by single neurons may explain the fact that even musically untrained people can detect such frequency differences.

"There is also evidence that frequency discrimination in humans correlates with various cognitive skills, including working memory and the capability to learn, but more research is needed to clarify this puzzle," he said.

This study, Fried noted, is the latest example of the power of neurobiological research that uses data drawn directly from inside a living human brain at the single-neuron level. Previous studies from Fried's lab have identified single cells in the human hippocampus specific to place in human navigation, and single cells that can translate varied visual images of the same item — such as the identity of an individual — into a single concept that is instantly and consistently recognizable.

Source: UCLA

Citation: Human auditory neurons more sensitive than those of other mammals (2008, January 16) retrieved 20 April 2024 from https://medicalxpress.com/news/2008-01-human-auditory-neurons-sensitive-mammals.html