Brain responses found to originate from previously unknown source

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Robert Zatorre, Professor of Neurology and Neurosurgery at McGill University, and Ph.D. candidate Emily Coffey at the MEG lab of the Montreal Neurological Institute and Hospital. Credit: Shawn Hayward

Scientists at the Montreal Neurological Institute and Hospital at McGill University have made an important discovery about the human auditory system and how to study it, findings that could lead to better testing and diagnosis of hearing-related disorders.

The researchers detected frequency-following responses (FFR) coming from a part of the brain not previously known to emit them. FFRs are neural signals generated in the brain when people hear sounds.

To help pinpoint the source of FFRs, the team used magnetoencephalography (MEG), a technique that allowed them to determine the source of the FFR, because it is not affected by interference from brain and skull tissues like electroencephalography (EEG), the more commonly used method to study electrical signals in the brain.

Twenty people were selected to take part in the study after testing showed they were neurologically healthy and had normal hearing. Subjects' neural responses to sound were measured using MEG, which records fluctuations in magnetic fields caused by neural activity.

From the MEG signal, researchers were able to detect FFR signals coming from the auditory cortex, in addition to the known sub-cortical generators, something that had not previously been detected.

The discovery of FFRs originating from the auditory cortex better informs research on neuroplasticity and its potential to improve auditory processing.

Neuroplasticity is the ability of our brain to adapt to external stimuli with training. For example, studies have shown that children exposed to music have better language skills, possibly due to subcortical sound processing. The ability to understand speech in a noisy environment has also been shown to improve with musical training.

The effects of training on the brain have been inferred using FFR. A better understanding of FFR and its origins will therefore allow researchers to more accurately measure how the brain changes with experience.

FFR has also been used to study learning disabilities and autism. Children with these disorders have been shown to have altered FFRs, a finding attributed to functional impairments at the brainstem level. The researchers' findings provide a clearer picture of how FFRs are generated, and thus aids further research into hearing-related disorders.

"Traditionally FFRs were called the 'auditory brainstem responses', so we were very surprised when our method revealed that they also included a big contribution from the cortex," says Robert Zatorre, Professor of Neurology and Neurosurgery at McGill University, and senior author. "This changes everything, because now we know to look both in the brainstem and in the cortex for effects related to enhanced hearing, due to musical training for instance, or for effects related to impaired hearing, as in aging, or some disorders."

"I think we'll be able to learn something new about several disorders," says Emily Coffey, a PhD candidate with Robert Zatorre at the MNI and first author of the paper. "We will be able to more effectively think about and test treatments because this technique allows us to observe the interactions of components of the auditory system as we process sound, and maybe target training to improve poorly functioning parts."

In addition to the discovery of new FFR origins, the use of MEG to pinpoint FFR origin is itself an important step forward for research into the human auditory system.

Previously, MEG was considered unsuited to study early auditory responses in the brain, as the strength of the signal decreases rapidly as distance from the sensors increases. To study deeper parts of the brain such as the brainstem, EEG was the preferred method. However, advances in MEG technology over the past decade allowed the team to gather accurate data about the origins of FFRs using MEG.

The researchers recorded responses to 12,000 sounds per person to average out the effect of random noise. They also applied some of the latest distributed source modelling techniques, allowing them to mathematically reconstruct where the signal was coming from in the brain.

Because of these new MEG methods, scientists will now be able to look at FFR sources separately, and figure out where changes and differences in the FFR can be found.

"We have opened up a new research area by developing a new tool," says Coffey. "Researchers will be able to ask new and useful questions about how the auditory system is organized and what has gone wrong when it's not working properly."

More information: Emily B. J. Coffey et al. Cortical contributions to the auditory frequency-following response revealed by MEG, *Nature Communications* (2016). DOI: 10.1038/ncomms11070

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