

## **Chasing Phantom Noises: Measuring Tinnitus-Related Brain Activity in Humans**

Many research articles nowadays show pictures of brains with colourful spots on them, to show for example which brain regions are activated by specific stimuli. These pictures are visualisations of data obtained with methods like Positron-Emission-Tomography (PET) or functional Magnetic Resonance Imaging (fMRI) that are able to measure human brain activity in a non-invasive way. The application of such methods to tinnitus, however, is not straightforward, as they are best at measuring relative differences or changes in neuronal activity between certain conditions. We cannot simply put someone with tinnitus in a scanner and have the tinnitus-related brain activity light up. Instead, the ideal condition to measure which brain regions are involved in tinnitus would be to measure the same subjects with and without tinnitus, which is a little tricky, as tinnitus cannot be “switched off” easily.

One way around this problem was found by Lockwood and colleagues in 1998: they studied subjects who can modulate their tinnitus through oral-facial movements (OFM), like for example moving the jaw forward. When an OFM creates a difference in tinnitus loudness, two different levels of tinnitus can be measured in one subject, and a measured difference in brain activity reflects the change in the tinnitus percept (and the movement, but that can be disentangled). Lockwood and colleagues found that OFM-induced tinnitus loudness changes lead to changes in neural activity in the auditory cortex on the side opposite to the ear in which tinnitus was perceived. In contrast to that, sound stimulation of the tinnitus ear caused effects on both sides, suggesting that the tinnitus is generated by central auditory structures. This is also in accordance with the results from animal studies, where altered patterns of spontaneous neuronal activity have been observed in the central auditory system (see my previous article).

However, not everyone can modulate their tinnitus by “grimacing”; this might only represent very special cases of tinnitus. A different way to study tinnitus with neuroimaging techniques is to change the tinnitus temporally by giving drugs like lidocaine. Lidocaine is one of the few drugs that have an effect on tinnitus. However, while it suppresses tinnitus in some cases, it may exacerbate it in others, and its side-effects make it unsuitable for tinnitus therapy. After giving their tinnitus patients lidocaine, Reyes and colleagues (2002) observed changes in neuronal activity in areas of the auditory cortex, similar to the findings of the earlier study with OFM-induced changes in tinnitus.

One hope connected to the imaging studies is that once brain areas involved in the generation of the tinnitus percept have been identified, they could be directly targeted for treatment. A step into this direction has recently been undertaken by Plewnia and colleagues (2007). They first used a combination of lidocaine and PET-imaging, as described above, to identify brain areas near auditory cortex that showed tinnitus-related signal changes. As a next step, they used repetitive transcranial magnetic stimulation (rTMS) to directly stimulate these brain areas. In rTMS, a series of short magnetic pulses is used to disrupt the activity in a small area of the brain for a short time period. The magnetic pulses are generated by a device that basically functions like a very strong electromagnet, which is placed outside the head above the brain regions of interest. After application of rTMS to the “tinnitus brain areas”, 6 out of 8 patients in the study reported a temporary tinnitus relief. Hopefully, such approaches might give rise to new treatments for tinnitus.

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