

## **ABNORMAL fMRI ACTIVATION IN THE AUDITORY MIDBRAIN OF PEOPLE WITH TINNITUS**

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Functional MRI (fMRI) can be used to examine brain activity directly in people with tinnitus. To illustrate this point, we will present an fMRI study showing abnormal activation in the auditory midbrain of people with tinnitus.

14 tinnitus and 17 non-tinnitus subjects were imaged. Audiograms were normal (N=25), approximately normal (30 dB HL at one frequency, N=4) or showed a high-frequency loss (N=2). Images were acquired while a binaural sound (55 dB SL, broadband noise) was alternately turned on for 30 s and off for 30 s. During some scans, a background sound was also presented (~65 dB SPL, generated by the scanner coolant pump, present during both stimulus on and off periods). Activation was detected by comparing image signal between on and off periods.

In the inferior colliculus of the midbrain, two significant differences were found between tinnitus and non-tinnitus subjects: (1) In response to the sound stimulus, fMRI activation in the inferior colliculi of tinnitus subjects was elevated compared to non-tinnitus subjects. (2) Presenting on-going background noise in addition to the sound stimulus systematically reduced stimulus-evoked activation in the colliculi of tinnitus subjects, but not non-tinnitus controls.

Based on the first result we hypothesize abnormal “gain” within the auditory pathway that results in (a) the tinnitus percept (by amplifying normally unheard spontaneous neural activity) and (b) the heightened sensitivity to moderate and high-level sounds (i.e., hyperacusis) that often accompanies tinnitus (by amplifying sound-evoked activity). The second result is consistent with this hypothesis because amplified spontaneous activity (related to tinnitus) and activity from the background noise may have increased total neural activity in the inferior colliculus to the point that any further increase in response to sound was limited by saturation (i.e., activity reached a maximum). We hypothesize that activity in tinnitus subjects increased in response to the stimulus (without saturating) when the background noise was absent, but could not increase to the same degree (because of saturation) when background noise was added (hence the reduced fMRI activation with added background noise).

The results indicate that fMRI can be used to understand the physiological bases of tinnitus. They also represent progress in the development of objective markers for tinnitus.

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