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The representation of intensity and periodicity in the human brain, as revealed by functional MRI and MEG

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Psychoacoustical masking has been widely used to study peripheral and central auditory processing. It is, however, still not completely understood how the physical intensity is exactly transformed into the sensation of loudness and partial loudness/audibility of a signal in a masker. Functional magnetic resonance imaging (fMRI) was used to investigate the representation of changes of level and signal-to-noise ratio (S/N) in human auditory cortex.

Tonal melodies were presented in masking noise for S/N from -18 dB to 24 dB. Functional MRI data were acquired with a 1.5 Tesla MRI system using a sparse imaging paradigm with clustered volume acquisition to separate acoustic stimulation and scanner noise in time. Twenty-one axial slices were acquired covering most of the cortex, including the whole of the temporal lobes.

For small S/N the overall sound level is nearly constant, but the audibility of the tone varies with S/N. For S/N of 0 dB and above, the tone is always clearly audible, and the perceived change is mainly an increase of overall level. This perceptual separation of two effects is reflected by a spatial dissociation of the respective activation in auditory cortex. With fMRI, brain regions mainly sensitive to level changes were found in Planum temporale (PT), while those regions mainly sensitive to S/N changes were located in lateral Heschl's gyrus (HG), with only sparse overlap between these regions. A similar result was previously found in a magnetoencephalographic study on the relationship between the sustained field in auditory cortex and the perception of periodic sounds. Two separate sources were isolated adjacent to primary auditory cortex: One, located in lateral HG, was particularly sensitive to regularity and largely insensitive to sound level. The second, located just posterior to the first in PT, was particularly sensitive to sound level and largely insensitive to regularity.

This double dissociation of the respective regions sensitive to pitch and loudness indicates a different coding mechanism for the overall intensity and the audibility of periodic signals. The audibility of a tone in noise appears to be determined by the overall pitch strength.