Inaudible High-Frequency Sounds Affect Brain Activity: Hypersonic Effect

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Abstract

Although it is generally accepted that humans cannot perceive sounds in the frequency range above 20 kHz, the question of whether the existence of such "inaudible" high-frequency components may affect the acoustic perception of audible sounds remains unanswered. In this study, we used noninvasive physiological measurements of brain responses to provide evidence that sounds containing high-frequency components (HFCs) above the audible range significantly affect the brain activity of listeners. We used the gamelan music of Bali, which is extremely rich in HFCs with a nonstationary structure, as a natural sound source, dividing it into two components: an audible low-frequency component (LFC) below 22 kHz and an HFC above 22 kHz. Brain electrical activity and regional cerebral blood flow (rCBF) were measured as markers of neuronal activity while subjects were exposed to sounds with various combinations of LFCs and HFCs. None of the subjects recognized the HFC as sound when it was presented alone. Nevertheless, the power spectra of the alpha frequency range of the spontaneous electroencephalogram (alpha-EEG) recorded from the occipital region increased with statistical significance when the subjects were exposed to sound containing both an HFC and an LFC, compared with an otherwise identical sound from which the HFC was removed (i.e., LFC alone). In contrast, compared with the baseline, no enhancement of alpha-EEG was evident when either an HFC or an LFC was presented separately. Positron emission tomography measurements revealed that, when an HFC and an LFC were presented together, the rCBF in the brain stem and the left thalamus increased significantly compared with a sound lacking the HFC above 22 kHz but that was otherwise identical. Simultaneous EEG measurements showed that the power of occipital alpha-EEGs correlated significantly with the rCBF in the left thalamus. Psychological evaluation indicated that the subjects felt the sound containing an HFC to be more pleasant than the same sound lacking an HFC. These results suggest the existence of a previously unrecognized response to complex sound containing particular types of high frequencies above the audible range. We term this phenomenon the "hypersonic effect."

Footnotes

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