Predicting lateralization performance at high frequencies from auditory-nerve spike timing

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Psychophysical sensitivity to interaural time differences (ITD) in the envelope of high-frequency sinusoidally amplitude-modulated (SAM) tones is generally poorer than that to low-frequency pure tones (PT). ITD sensitivity at high frequencies might be improved using "transposed stimuli" (TS), which seek to produce the same temporal discharge patterns in high-frequency neurons as in low-frequency neurons for PT. Here, we study ITD sensitivity for PT, SAM tones and TS using neurophysiology, psychoacoustics and computational models.

Phase locking of auditory-nerve fibers in anesthetized cats was characterized using both the synchronization index and autocorrelograms. With both measures, phase locking is stronger for PT than for TS, and for TS than for SAM tones. Phase locking to SAM tones and TS degrades with increasing stimulus level, while remaining more stable for PT.

ITD discrimination was measured in humans for stimuli presented either in quiet or with band-reject noise intended to restrict listening to a narrow frequency band. Performance improves slightly with increasing stimulus level for all three stimuli both with and without noise. ITD sensitivity to TS is comparable to PT performance only in the absence of noise.

To relate psychophysical performance to auditory-nerve activity, we used an optimal binaural processor model with delay lines and coincidence detectors. In the no-noise condition, model performance is stable with stimulus level, consistent with psychophysics. However, in the band-reject noise condition, model performance for SAM tones and TS degrades with increasing level. The model also predicts worse-than-observed performance for TS relative to PT.

These results have implications for the relative roles of peripheral patterns of activity and the binaural processor in accounting for ITD sensitivity at low versus high frequencies.

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