Spatio-temporal representation of the pitch of complex tones in the auditory nerve

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Previous studies of the coding of the pitch of complex tones in the auditory nerve suggest that neither a rate-place representation, nor a temporal representation based on interspike interval distributions fully account for psychophysical data. Here we explore an alternative spatio-temporal representation based on rapid changes in the phase of the cochlear traveling wave at the place of each resolved spectral component (Shamma, J. Acoust. Soc. Am. 78: 1622-1632).

We recorded from auditory-nerve (AN) fibers in anesthetized cats in response to equal-amplitude harmonic complex tones with a missing fundamental frequency (F0). For a given fiber, the F0 range was chosen so that the "harmonic number" CF/F0 varied from 1.5 to 4.5 in order to capture low-order harmonics likely to be resolved. We computed the derivative of the period histogram with respect to harmonic number in order to approximate a lateral inhibitory process operating on the spatio-temporal response pattern of the entire AN.

For F0s below about 1 kHz, the spatial derivative shows local maxima when the CF coincides with a harmonic of F0, thereby giving information about the frequencies of resolved harmonics. Resolved harmonics remain apparent in the spatial derivative even at stimulus levels where the average discharge rate is saturated. For F0s above 1 kHz, the spatio-temporal representation degrades due to poorer phase locking, while the rate-place representation improves as harmonics are better resolved. The spatio-temporal representation is thus consistent with the psychophysical upper F0 limit near 1 kHz to the pitch of missing-fundamental stimuli.

These results suggest that the spatio-temporal representation of pitch may be both more stable with respect to stimulus level and more consistent with psychophysical data than the rate-place representation.

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