Coding of pitch in the auditory nerve: Two simultaneous complex tones

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Often, we listen to sounds consisting of harmonic complex tones in the presence of other harmonic complex tones, for example in symphonic music or in cocktail party situations. Perceptually, listeners can match the pitches of two instruments playing different notes, and a pitch difference aids in segregating sound sources. Physiologically, little is known about the neural basis for this ability. Thus, we investigated the representation of simultaneous pitches in the auditory nerve of anesthetized cats.

We measured the responses of single neurons to two simultaneous complex tones (missing fundamental, equal-amplitude harmonics) with a wide range of fundamental frequencies. The fundamental frequencies of the two tones differed by either 7% or 22%. Each harmonic was about 15 dB above the threshold at CF, corresponding to 20-50 dB SPL. Pitch estimates were obtained from both rate-place (average discharge rate against CF) and temporal (interspike interval distribution) representations of the stimulus.

Highly accurate (rms errors about 1%) estimates of both pitches of the two complex tones were obtained over nearly the entire range of fundamental frequencies that was investigated using either of the two neural representations. For fundamental frequencies below about 1 kHz, best pitch estimates were obtained from the temporal representation. Also, the lower tone tended to be more prominently represented than the higher tone in interspike interval distributions, an effect reflecting the asymmetry of cochlear filtering. For fundamental frequencies above about 1.5 kHz, best pitch estimates were obtained with the rate-place representation. This limit may be lower in human, if cochlear tuning is sharper than in cat.

In conclusion, the auditory nerve faithfully transmits pitch information for simultaneous complex tones to higher auditory centers.

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