Dual Representation of the Pitch of Complex Tones in the Auditory Nerve

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Previous auditory-nerve studies of the coding of the pitch of complex tones have documented a temporal representation based on interspike intervals, but have largely neglected possible rate-place cues to pitch available when the individual harmonics are resolved by the peripheral auditory system. We investigated the resolvability of harmonics of complex tones in the cat, and compared the effectiveness of rate-place and interval codes over a wide range (110-3520 Hz) of fundamental frequencies (F0).

We recorded responses of single AN fibers in anesthetized cats to periodic complex tones with a missing fundamental at moderate sound levels (10-50 dB SPL per component). The harmonics were all of equal amplitude and spanned a spectral region of 2.2 octaves around a fiber's CF. We used three phase conditions: cosine-phase, Schroeder-phase and alternated sine-cosine phases.

The average discharge rate of a fiber was greater when the CF was a small integer multiple of F0 than when the CF fell between two harmonics. In general, harmonics up to the 5th were thus resolved in rate responses, although this number decreased at higher stimulus levels. Using data from 12 to 47 single units, we could estimate F0 from rate-vs-CF profiles with errors smaller than 2-3%. However, few reliable estimates were obtained below 400 Hz, due to the broad cochlear tuning at low frequencies in the cat.

We generated "pooled" interspike interval distributions by summing all-order interval histograms from all the sampled fibers. By finding the best fitting periodic template to the pooled distributions, we were able to estimate F0 with errors smaller than 1%, up to 1200 Hz. Phase had no obvious effect on either rate-CF profiles or pooled interval distributions.

In summary, both rate-place and interspike-interval codes are viable over a wide range of F0 in the cat, but the intervals code is more useful at lower F0s, and the rate-place code at higher F0s.

Supported by NIH Grant DC02258.