Schroeder-phase sensitivity arises in cochlear nucleus octopus cells by detecting temporal response patterns across nerve fibers

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Abstract

Schroeder harmonic complexes are commonly used in psychoacoustic research to study monaural phase sensitivity. The complex consists of equal amplitude harmonics, whose phase relations are specified by phase curvature (C), ranging from -1 to 1. When C is negative/positive, the waveform is equivalent to a series of upward/downward frequency sweeps, respectively. When C=0, the waveform resembles a click train. Previous studies in the periphery (basilar membrane and auditory nerve fibers) have focused on responses from single auditory channels and found somewhat peakier responses to positive C stimuli. However, cross-channel patterns, which are expected to be strongly affected by Schroeder phases, have not been studied. Here we test whether neurons in the central auditory system sense temporal patterns across auditory nerve fibers in response to Schroeder stimuli. In vivo spike and intracellular recordings were obtained from auditory nerve fibers and single cells of the cochlear nucleus in anesthetized gerbils and mice. We found that octopus cells, a cell type receiving convergent auditory nerve fiber inputs and considered across-frequency monaural coincidence detectors, show marked sensitivity to C for a range of sound levels and fundamental frequencies. Surprisingly, the cells not only respond well to C=0 stimuli where phases of all frequencies are aligned, but also to certain non-zero C stimuli where temporal responses from the nerve are highly dispersed across characteristic frequencies. Intracellular recordings reveal that, in contrast to the conventional view, inputs to most octopus cells do not sample a cochlear sector with a continuous range of frequency tuning but rather are dominated by a few "hotspots" tuned to different frequencies. Moreover, sensitivity to C depends on the magnitude and activation sequence of these clustered inputs. We conclude that the sensitivity to Schroeder phase appears at the first stage of ascending auditory pathway in cochlear nucleus octopus cells, whose sensitivity results from detecting temporal sequences rather than coincidences across auditory frequency channels.

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