University of Rochester
Department of Biomedical Engineering

Ph.D. Defense Seminar

"The Impact of Sensitivity to Fast Spectrotemporal Chirps on Speech Coding in the Mammalian Inferior Colliculus: Physiology and Modeling"

by

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Zoom: https://rochester.zoom.us/j/97892864598

Abstract: Recordings of auditory midbrain neurons in the inferior colliculus (IC) have revealed large rate differences in response to fast frequency chirps of different directions or velocities. This observation has implications for IC responses to perceptually-important sounds such as speech: neural response rates may be substantially impacted by chirp cues in a way not predicted by more commonly studied response properties, such as characteristic frequency (CF) or modulation transfer function (MTF) shape. In vowels, the phase transitions associated with resonances of the vocal tract suggest that chirp cues may arise near formant frequencies. Thus, it is important to account for the effect of chirp cues in IC speech responses.

To characterize chirp-sensitive neurons, recordings were made of IC units. A novel stimulus was developed to characterize IC neuron velocity sensitivity in an aperiodic context using rate-velocity functions (RVFs). RVFs were shown to be independent from CF or MTF shape. The majority of IC neurons displayed direction-selectivity to chirps for at least one velocity—this selectivity was most often observed at lower chirp velocities compared to higher velocities.

IC chirp sensitivity was incorporated into a computational model that retained tuning to frequency and AM. The mechanism of chirp sensitivity in the IC was hypothesized to originate in octopus cells of the posteroventral cochlear nucleus, which display a similar diversity of chirp sensitivity to the IC. Octopus cell chirp sensitivity was modeled using sequence detection, whereby correct arrival order of auditory-nerve inputs is required to elicit a response. Octopus-cell output was an inhibitory input the IC, alongside an inhibition to produce band-enhanced MTFs. The model was capable of simulating neurons with physiologically valid CFs and RVFs.
The impact of chirp sensitivity on vowel coding was assessed with a combination of physiology and modeling strategies. IC responses to vowel stimuli were classified based on average rate and spike timing. Overall classification accuracy was found to be correlated with directionless velocity-sensitivity and high-velocity direction bias. Additionally, individual neurons' vowel responses were examined in the chirp model, but the relationship of model neuron RVFs and vowel classification remained unclear.