PhD Dissertation Defense

Neural Code for Sound Envelope Shape and Repetition Information in the Inferior Colliculus

By

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Abstract:

Temporal variations in the amplitude of a sound waveform are an essential information-bearing attribute of all natural sounds. Temporal cues are critical for basic auditory percepts of pitch, rhythm and timbre and are essential for sound recognition and speech intelligibility. In this study, we examined the neuronal representation to modulated broadband noises in the cat central nucleus of the inferior colliculus (CNIC), a structure believed to be crucial for encoding temporal cues.

Traditional models for temporal coding in the IC assume that sound periodicity information is represented either by the firing discharge of tuned modulation filters or synchrony in the discharge pattern. Although IC neurons exhibit tuning to amplitude modulations, this model is limited because it does not account for how non-periodic yet important features of sounds such as the envelope shape are encoded. To address this, we developed a sound paradigm that allows us to study how envelope periodicity and shape temporal cues are concurrently encoded in the CNIC. We demonstrate that sustained and onset neuronal responses are complementary response patterns by which CNIC neurons can encode envelope shape and repetition information in natural sounds. We examine the role of precise spike timing and firing reliability using information theoretic and shuffled correlogram techniques. Spike timing precision extends from sub-microseconds for brief transient sounds up to tens of milliseconds for sounds with slowly varying envelope shape. Surprisingly, spike-timing precision is largely independent of the sound periodicity a prominent cue for pitch. In contrast, firing reliability decreased systematically with increasing periodicity. This suggest that single neurons employ a proportional spike timing code in which spike-timing precision co-varies with the sound envelope shape and reliability co-varies with the periodicity to provide an efficient representation of the stimulus.

Overall, these findings demonstrate that sound envelope shape and periodicity greatly impact the spike-timing precision, firing reliability, and consequently, the temporal discharge pattern of IC neurons in a manner that allows for efficient and complementary temporal codes.