Effects of reverberation on neuronal sensitivity to fine time structure and envelope ITD in the inferior colliculus of awake rabbit

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In reverberant rooms, the superposition of acoustic reflections on the direct wavefront results in temporal fluctuations in the interaural time difference (ITD) and decorrelation of the ear-input signals. In the mammalian inferior colliculus (IC), low characteristic frequency (CF) neurons are typically sensitive to ITD in the fine time structure (ITD_{fs}) of sounds, while high-CF neurons are sensitive to ITD in the envelopes (ITD_{env}) of broadband noise induced by cochlear filtering. In an effort to improve our understanding of the neural basis of sound localization in reverberant environments, we characterized the effects of reverberation on ITD_{fs}- and ITD_{env}-sensitivity of neurons in the IC with a wide range of CFs.

We simulated anechoic and reverberant binaural room impulse responses (BRIRs) that contained ITD but not interaural level difference cues. Acoustic stimuli consisted of 400-ms bursts of Gaussian noise filtered with the BRIRs. We measured responses as a function of virtual azimuth for single units in the IC of awake Dutch-belted rabbits. To assess the effects of reverberation on each unit's ITD-sensitivity, we computed the mutual information (MI) between stimulus azimuth and spike count separately for anechoic and reverberant conditions. For the anechoic condition, MI did not obviously depend on CF over the range 250-8500 Hz. However, reverberation led to a greater reduction in MI in high-CF neurons than in low-CF neurons. Therefore, at the level of the IC, ITD_{fs}-sensitive units more accurately encode stimulus azimuth than ITD_{env}-sensitive units in reverberation. Preliminary analysis of our stimuli with a peripheral auditory model indicates that the effects of reverberation on both fine time structure and stimulus envelope are more severe with increasing CF, suggesting that our IC results may be a consequence of the frequency-dependent nature of ITD_{fs}- and ITD_{env}-sensitivity in the auditory pathway.

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