Investigating the effect of synaptopathy on envelope following responses using a model of the auditory nerve

The healthy auditory system enables communication in challenging situations with high levels of background noise. Despite normal sensitivity to pure tones, many listeners complain about having difficulties in such situations. Recent animal studies demonstrated that noise over-exposure that produces temporary threshold shifts can cause the loss of auditory nerve (AN) fiber synapses (i.e., cochlear synaptopathy), assumed to be selective for medium- and low spontaneous rate (SR) fibers. In the present study, envelope following response (EFR) level-growth functions were recorded in normal-hearing (NH) threshold and mildly hearing-impaired (HI) listeners at frequencies above 2 kHz. EFRs were elicited by sinusoidally amplitude modulated (SAM) tones with a carrier frequency of 2 kHz that was modulated at 93 Hz with modulation depths of 85% (strong) or 25% (shallow). Whereas the EFR level-growth functions for strongly modulated tones were similar for all listeners, EFR level-growth functions for shallowly modulated tones were reduced at medium stimulation levels in some of the NH threshold listeners and saturated in HI the listeners for the whole level range. A phenomenological model of the AN was considered to investigate the effects of off-frequency contributions (i.e., displaced from the characteristic place of the stimulus) and the differential loss of different AN fiber types on EFR level-growth functions. The model simulations suggest that: (1) EFRs are dominated by the activity of high-SR fibers at all stimulus intensities, and (2) EFRs at medium-to-high stimulus levels are dominated by off-frequency contributions. Postulated synaptopathy led to simulations generally consistent with the recorded data; however, a substantial reduction in the number of all types of AN fibers was required to account for the results.

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