Bigger is Not Better: Effects of Hearing Loss on Central Processing

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Older adults who wear hearing aids often report that speech is too loud, yet they have difficulty with the clarity of the message.

With new hearing aid wearers, we often use the analogy of coming out of a theater in the middle of the day and being momentarily blinded by the brightness of the sun. As we know, however, the retinal adjustment to increased light occurs quickly, while adjustment to amplified sound is a longer process.

Part of this difficulty is rooted in the well-known phenomenon of recruitment. However, changes in speech representation in the central auditory system also play a role.

SWAMPING OUT THE TFS

Recruitment effects can be seen in the auditory brainstem response (ABR) to clicks. In an individual with sensorineural hearing loss, brainstem latencies are delayed at low intensities but drop to normal latencies at higher intensities.

The effects of hearing loss on auditory processing of a speech syllable were recently evaluated using the cABR—the ABR to complex sounds (*J Acoust Soc Am* 2013;133[5]:3030-3038).

Brainstem responses were recorded to a 40-ms speech syllable /da/ in quiet and in noise in two groups of older adults. One group had clinically normal hearing and the other had mild to moderate sensorineural hearing loss and had never worn hearing aids.

The group with hearing loss had higher representation of the low frequencies that comprise the speech envelope. In response to the temporal fine structure (TFS), there was no difference in frequency representation between the groups.

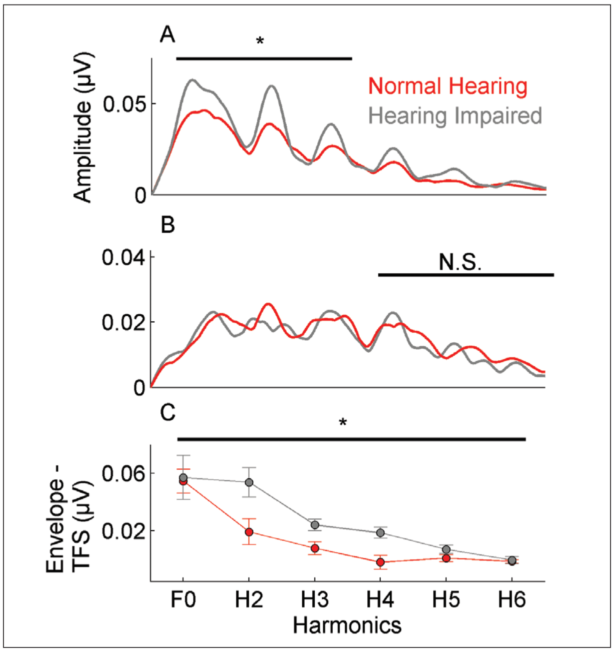
Overall, in the group with hearing loss, there was a greater ratio of envelope to temporal fine structure than there was in the group with normal hearing, suggesting that the augmented response to the speech envelope swamps out the temporal fine structure, leading to a deficit in fine structure coding.

ROLE OF TRAINING AND AMPLIFICATION

These results are in line with the work of Sushrut Kale and Michael G. Heinz, who found greater coding of the envelope in auditory nerve fibers of chinchillas who had noise-induced hearing loss (*J Assoc Res Otolaryngol* 2010;11[4]:657-673). When the stimuli were presented in quiet, Kale and Heinz did not find any differences in temporal fine structure coding.

However, when the stimuli were presented in noise during a later study, chinchillas with hearing loss had a deficit in temporal coding compared with normal-hearing chinchillas (*Nat Neurosci* 2012;15[10]:1362-1364).

Work with cochlear implants has taught us that access to the speech envelope is adequate for hearing in quiet situations,



A: For the envelope-dominated lower frequencies, older adults with hearing loss have larger amplitudes than older adults with normal hearing. B: These differences are not seen in the temporal fine structure (TFS)-dominated high frequencies. C: There is a greater ratio of envelope to temporal fine structure in older adults with hearing loss. (Adapted from J Acoust Soc Am 2013;133[5]:3030-3038.)

but temporal fine structure cues may be important for hearing in background noise (*Science* 1995;270[5234]:303-304). Therefore, a relative deficit in fine structure coding in individuals who wear hearing aids may account for difficulty understanding speech in background noise.

Work is under way to examine the effects of training and amplification on the balance of envelope and temporal fine structure representation of the speech signal.

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