How Poor Spatial Hearing Impedes Communication

By Barbara G. Shinn-Cunningham, PhD

Intuition and experience tell us that many people with hearing loss who can understand speech in a quiet, one-on-one setting run into trouble in situations with simultaneous or competing sounds. Unfortunately, this means every social gathering poses communication difficulties to a hearing-impaired listener: The more "fun" and spontaneous the social scene, the more likely that people interrupt one another in overlapping conversations—amidst a noisy and chaotic backdrop. Yet the scientific reasons for why listening to speech in noise is especially difficult are not entirely clear. A recent study identified one contributing factor: Poor spatial resolution, which makes it difficult for hearing-impaired listeners to focus on one sound source and ignore sounds from other directions (*Proc Natl Acad Sci U S A.* 2018 Apr 3; 115(14):E3286).

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SPATIAL DIFFICULTIES

The study found that hearing-impaired listeners were worse than normal-hearing listeners at detecting changes in interaural time differences (ITDs, the difference between when sound arrives at the left and right ears), one of the dominant cues for determining a sound source location. Hearing-impaired listeners were also worse at identifying a simple melody while ignoring competing melodies from competing directions. The difficulties of the hearing-impaired listeners were especially pronounced when they tried to listen to a melody directly in front of them that was flanked by distracting melodies from left and right—the deficits were not as large when the leftmost or rightmost melody was the target. In the study, only ITDs were used to control the perceived directions of the melodies; there were no "head shadow" cues, which can cause large differences in the levels of different sounds reaching the ears. Because only ITDs were present, the level of the target melody and that of the distractor melodies were the same whether the target melody was at midline or to one side, yet the hearing-impaired listeners had greater difficulty when the target melody was surrounded by distracting melodies. The study thus proved that hearing-impaired listeners were particularly bad at using spatial cues to focus attention on a target.

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IMPACT ON AUDITORY ATTENTION

Neural data from the same study further support these conclusions. As listeners listened to the competing melodies, electroencephalography was used to measure voltages on the scalp evoked by the notes in each of the melodies. Many previous studies have shown that when listeners successfully focus their attention on a target sound amidst competing sound streams, they suppress the neural representation of the competing streams and enhance the neural representation of the target sound (*Cereb Cortex.* 2015 Jul;25(7):1697; *Front Hum Neurosci.* 2016 Oct 20;10:530; *Neuroimage.* 2018 May 15;172:206). Consistent with behavioral measures, neural results showed that hearing-impaired listeners were worse than normal-hearing listeners at suppressing competing sounds when they flanked a central target.

Interestingly, individual normal-hearing and hearing-impaired listeners varied in their ITD acuity, performance on the melody task, and ability to modulate neural responses based on attentional focus. In both groups, all three of these measures were correlated. In other words, differences in spatial acuity affect the ability to focus auditory attention even among normal-hearing listeners–but hearing impairment systematically reduces spatial acuity, contributing to the communication problems that hearing-impaired listeners have in social settings.

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There is growing interest in developing hearing aids that can incorporate neural signals and suppress unwanted and distracting sounds before they enter the ear. Unfortunately, this approach can only work if the hearing aid user effectively modulates neural responses based on attentional focus. This study suggests that the very listeners who need the most assistance from such listening devices have the weakest neural signatures of attention, making the development of a useful "cognitively-guided hearing aid" even more challenging.