How Children Learn to Hear in Noise

By Nina Kraus, PhD, and Travis White-Schwoch

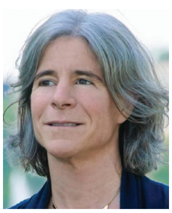
One of the most complex yet crucial tasks a child has to learn is to hear in noisy environments. Successful hearing in noise is critical to academic and social development. Classrooms, playgrounds, and lunchrooms provide important opportunities for learning and social bonding, yet they tend to be quite noisy.

As we've discussed in previous columns in *The Hearing Journal*, hearing in noise is a difficult task for listeners of any age. It requires the tight integration of cognitive, sensory, and language skills—domains that undergo a protracted development throughout early childhood. And although the cochlea is thought to be structurally and functionally mature at birth, the central auditory system continues to mature into adolescence.[1]

This prolonged maturational course can make it difficult to evaluate individual differences in young children's listening-in-noise abilities. While children can typically perform relatively simple listening-in-noise tests, such as identifying single words amid multiple talkers, it can be challenging to evaluate the underlying skills that support their performance on these tests. This limits our ability to develop a comprehensive account of why certain children struggle to listen in noise. Are there specific domains that pose challenges to certain children, such as memory or attention? Are other children just late bloomers who will eventually catch up with their peers?

To better understand the origins of individual differences in the development of children's listening-in-noise skills, Thompson and colleagues tested the word-in-noise understanding of 59 preschoolers between 3 and 5 years old.[2] They measured the children's ability to identify words in noise, attention skills, and neural responses to speech. They retested the same children on the same measures one year later.

The children's overall performance improved over a year, to the point where they could tolerate about one additional decibel of noise. While this is a small improvement, each additional decibel of word-in-noise recognition is thought to correspond to about a 10 to 15 percent increase in real-world speech understanding. This improvement in performance was also meaningful because, on average, the children needed the speech to be louder than the noise during the first year of the study. However, by the second year of the study, they were able to understand speech even when it was quieter than noise.



Dr. Kraus, left, is a professor of auditory neuroscience at Northwestern University, investigating the neurobiology underlying speech and music perception and learning-associated brain plasticity. **Mr. White-Schwoch** is a data analyst in the Auditory Neuroscience Laboratory (www.brainvolts.northwestern.edu), where he focuses on translational questions in speech, language, and hearing.

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Thompson, et al., then dug deeper into their data to test for individual differences in listening-in-noise development. They identified four groups of children:

1. High performers, who did very well on the test in both years and, on average, only improved slightly between years. In both years, they were able to tolerate noise that was louder than the speech.
2. Low performers, who did poorly on the test in both years and, on average, only improved slightly between years. In both years, they needed noise to be quieter than speech.
3. Catch-up, who began performing similarly to the low performers, but whose performance improved dramatically between years—to the point of performing like the high performers in the second year.
4. Reverse, who began performing well (in the general range of high performers in year one) but whose performance declined over time, reaching the range of low performers in year two.

These results suggested that there are individual differences in children's listening-in-noise abilities and in the development trajectories of these abilities. To understand the mechanisms underlying these individual differences, Thompson, et al., measured each group's neural development. They looked specifically at neural responses to the fundamental frequency of speech (F0), which has consistently been linked to speech-in-noise perception.[3] They found that F0 development exactly paralleled speech-in-noise development. High performers had consistently large responses to F0 and poor performers had consistently low responses to F0. Moreover, the catch-up group showed a dramatic improvement in their F0 response, and the reverse group's F0 responses declined between years. This suggests that neural processing of F0 is a key factor that contributes to children's listening-in-noise abilities. Why the F0? It is a crucial clue for grouping and isolating auditory objects. When trying to process speech, the F0 can help a listener focus on the sound of one speaker and track him or her through a complex auditory scene.

Thompson and colleagues also compared the children's performance on an attention task. All of the groups showed improved performances across one year, and most of the groups performed similarly. However, the catch-up group's attention skills were significantly worse in the first year and improved dramatically in the second. This suggests that, for a subset of children, attention can be a bottleneck that constrains the development of their listening skills.

Together, these results emphasize the multiple mechanisms that underlie children's listening-in-noise skills. When evaluating young children's listening skills, it is important to consider multiple potential strengths and weaknesses that may be developing along with speech-in-noise perception, including attention and neural processing of F0.

References for this article can be found at http://bit.ly/HJcurrent.