Concussions Impair Listening-in-Noise Abilities

By Nina Kraus, PhD, and Travis White-Schwoch

Concussions are diffuse, non-penetrating brain injuries following a sudden hit to the head or body, leading to neurologic and cognitive difficulties. One of the emerging ideas in concussion science is that neurosensory systems can be acutely affected, including vision and balance.

The potential for auditory processing deficits after a concussion has received less attention. Some studies have reported difficulties in tone-in-noise and dichotic listening tasks among patients with brain injuries (*Brain Inj.* 2017;31(9):1183). Additionally, as we have discussed in previous articles in the Hearing Matters column in *The Hearing Journal*, neurophysiological responses to sound can indicate if an adolescent has sustained a concussion (see Brainvolts, 2018).

Do these neurophysiological processing deficits have a behavioral consequence? Thompson and colleagues tested this hypothesis in a recent study (*Brain Inj.* 2018; in press). They tested 20 adolescents recovering from a concussion in a sports medicine specialty clinic. As a control group, they recruited 20 patients from the same clinic who had musculoskeletal sports injuries such as joint sprains and bone fractures. This is an important strength of this study because it means that the demographics of the two groups were quite similar. Study participants from both groups completed the Hearing in Noise Test (HINT), which required them to repeat simple sentences presented in speech-shaped noise. Two conditions were tested: one where speech and noise emanated from the same location, and another where speech and noise were separated in space, making it easier to understand the sentences.

Across both listening conditions, the group with a concussion had worse speech-in-noise performance than the control group, and performed more poorly relative to the HINT's norms. In the co-located condition, 70 percent of the concussion group performed at or below the 50th percentile on the HINT, compared with 35 percent of the control group. In the spatially separated condition, 100 percent of the concussion group performed at or below the 50th percentile on the HINT, compared with 65 percent of the control group.

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 and colleagues also evaluated participants' performance across multiple sentences in the HINT (each condition consisted of 10 sentences). The HINT is adaptive, meaning that if a patient successfully understands one sentence, the next sentence is more difficult to discern (the sentences get quieter, and vice versa, if the patient responds incorrectly). In the spatially separated condition, they observed a consistent pattern, where all children perceived the first few sentences correctly, which were the easiest. Both groups' performance quickly leveled off, with participants with a concussion needing the sentences to be about 2-3 dB louder to achieve the same performance as the control group.

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In contrast, a distinct pattern emerged in the co-located condition. Once again, both groups responded to the first few sentences correctly. Whereas the control group continued to perform stably, the concussion group trailed off and their performance worsened over time. By the end of the task, they needed the sentences and noise to be at almost

the same level, with the sentences nearly 4 dB louder than the control group required to achieve the same performance. While 4 dB may not sound like a lot, in speech-in-noise perception tasks, each 1 dB difference in signal-to-noise ratio corresponds to about 10 percent word intelligibility.

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These findings–impaired speech-in-noise perception following a concussion–have important ramifications for the clinical management of concussions:

- When is a patient ready to return to learn? Given that concussions can affect cognitive functions, such as the ability to maintain attention on a task for a prolonged period of time, children with a concussion often receive academic accommodations. Thompson, et al., suggested that the trail-off in the concussion group's performance reflected this cognitive fatigue. Speech-in-noise testing might provide a quick evaluation of whether a child can sustain cognitive energy on a task. Moreover, given that classrooms are noisy listening environments, testing for speech-in-noise deficits could indicate whether they need accommodations such as preferential seating to support their classroom listening.
- When is a patient ready to return to sports? Fields, courts, and arenas are complex listening environments. To safely play sports, an athlete needs to be able to follow signs from their teammates, coaches, and officials. If an athlete cannot effectively process sounds in noise, their ability to navigate a field might be compromised. In turn, their risk of additional injury could be elevated if they return too soon.

This work provides additional evidence that concussions affect auditory processing. Speech-in-noise testing is a fast and reliable way to evaluate auditory function in children, and results can inform important questions in concussion management. These findings reinforce the idea that audiologists can play an active role in a clinical team managing children with concussions.