



Frank E. Musiek



Gail Chermak

## Testing and treating (C)APD in head injury patients

By Frank E. Musiek and Gail Chermak

Over the past few years, we have received an increasing number of requests for information regarding the assessment of central auditory processing in patients with head trauma. While millions of closed head injuries occur each year, many resulting from motor vehicle and motorcycle accidents, the ongoing U.S. military involvement in Iraq and Afghanistan has further fueled these questions as veterans return home with head injuries. Many audiologists are being asked to evaluate these patients, as they should, given the high prevalence (over 55%) of (central) auditory processing disorder ((C)APD) in adult and pediatric patients with head trauma and acquired brain injury or traumatic brain injury (TBI).<sup>1,2</sup>

If one thinks about the neuropathology associated with TBI, it becomes clear why central auditory system evaluation is crucial in these patients. Typically, brain trauma is related to deformation of the brain from extreme acceleration and deceleration of the head, which then precipitates contusions, hemorrhage, and diffuse axonal injury. This in turn results in secondary damage such as ischemia, hypoxia, edema, increased intracranial pressure, and further axonal compromise.<sup>3</sup> If these pathological actions affect auditory neural substrate, then auditory compromise is highly likely.

Given the potential effects of (C)APD on communication, learning, school and job performance, and social functioning, it is imperative that audiologists assess the integrity of the central auditory nervous system (CANS) in patients with TBI to fully document the scope of system deficits and to maximize treatment efficacy in rebuilding the patients' lives. However, judging from questions we have received, it appears that some audiologists do not feel they have the knowledge and skills needed to evaluate the CANS in this patient population. Perhaps these audiologists would be reassured if they realized that they do not have to reinvent the wheel! Assessment of the CANS does not require a different set of tests and procedures as a function of etiology (e.g., multiple sclerosis, TBI, aphasia). Rather, audiologists should assess the CANS using standard central auditory tests and procedures, selected commensurate with the patient's overall profile and abilities to minimize cognitive, language, and other potential confounds.<sup>4,5</sup> Remember, central auditory processing tests and procedures assess the CANS, not a specific disorder.

Although we are focusing on the importance of assessing the CANS in cases of TBI, it is important to realize that the peripheral auditory system often is damaged by head trauma as well.<sup>6</sup>

The external, middle, and inner ear, as well as the auditory nerve, can be compromised by head trauma; therefore, assessment of both peripheral and CANS integrity cannot be overlooked in these cases.

It is indeed likely that in many head trauma patients, both peripheral and central auditory systems will be involved.<sup>7</sup> Both unilateral and bilateral peripheral hearing losses have been reported in individuals with minor, closed head injuries.<sup>8</sup> In these minor, closed head injuries, sensorineural hearing loss is most often seen. In more severe injuries, temporal bone fracture (longitudinal or transverse) can result in sensorineural and/or conductive hearing loss. Comprehensive audiologic assessment is essential for accurate diagnosis, prognosis, monitoring recovery, and treatment.

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### TESTS OF CENTRAL AUDITORY FUNCTION

Both auditory evoked potentials (AEPs) and behavioral central auditory tests have been employed to evaluate central auditory system compromise from head injury.<sup>1,9-11</sup> The auditory brainstem response (ABR) and middle

and late potentials (including P300) have been used to assess the integrity of the CANS in head injury, but seldom all in one comprehensive test battery.

Given the frequency with which brainstem and cortical lesions are seen in head injury,<sup>1,7,11</sup> it is important to include AEPs that evaluate both the brainstem (ABR) and the thalamic and cortical regions (e.g., MLR or late potentials). The clinician should keep in mind that one can administer the ABR and the MLR concurrently. This can save considerable time, while yielding measures of both brainstem and thalamo-cortical integrity.

The ABR can serve as a benchmark for the MLR to help isolate thalamo-cortical dysfunction. An absence of wave V or an extension of the III-V interwave interval are common ABR findings due to TBI following head injury, both of which are consistent with brainstem dysfunction.<sup>12,13</sup> In addition, poorly formed or absent MLRs have been reported, as well as abnormal late AEPs and P300, indicating compromise of the CANS.<sup>12,14</sup> Reflecting its sensitivity to TBI, the P300 is frequently used to monitor recovery and assess long-term effects of TBI.

Behavioral central tests also have been used successfully with TBI patients. Although language, attention, or memory deficits associated with TBI can confound behavioral test performance, carefully selected tests (i.e., low language and cognitive loading)

can reveal CANS deficits. For example, finding a laterality effect on a central test in the presence of symmetrical peripheral function suggests central auditory dysfunction. Moreover, non-verbal tests, such as gap detection, masking level differences (MLDs), dichotic digits, and pattern perception tests, have documented sensitivity to CANS dysfunction and might be more appropriate for patients with compromised cognition. Comprehensive evaluation of the auditory effects of head injury can be achieved by combining behavioral and electrophysiologic measures of central auditory function with a thorough peripheral test battery (i.e., pure-tone thresholds, speech audiometry, immittance [including acoustic reflexes], and otoacoustic emissions).

## INTERVENTION

The audiologist's comprehensive evaluation of auditory system function must be examined in light of the multidisciplinary evaluations (e.g., speech-language, neuropsychology), which taken together ensure that returning veterans and others suffering from head trauma receive treatment that maximizes recovery. Audiologists must coordinate with speech-language pathologists, psychologists, physical therapists, occupational therapists, social workers, and families (who often are aware of important issues of which the patient is unaware) to ensure a comprehensive approach.

Given the often persistent, long-term language, cognitive, and social functioning deficits accompanying head trauma, it is crucial that sensory and perceptual deficits be addressed to allow for good communication among patient, professionals, and family members and to maximize the impact of auditory-language-based therapies. Intervention to improve central auditory processing and overall auditory function is crucial to the overall success of the multidisciplinary treatment program. Limited access to and/or processing of auditory input will lessen the potential benefit of the team's therapeutic approaches and impede improvements in everyday functioning.

Persistent cognitive and language deficits (see Flood et al.<sup>2</sup> and Duncan et al.<sup>10</sup> for review) will necessitate adjustments to (C)APD intervention approaches. Generally, TBI patients will benefit from a

comprehensive approach that seeks to improve auditory skills through bottom-up auditory training and seeks to compensate for residual deficits by building top-down central resources (i.e., metacognitive, cognitive, and metalinguistic skills and strategies).

Therapy must be customized, of course, to accommodate the special circumstances of each patient. Many of the central resources skills and strategies may be too complex, especially in more severe TBI and in the early stages of recovery, requiring that the clinician modify the exercises. For example, the clinician may need to break the exercises down into smaller, incremental steps. Depending on the severity of the cognitive deficits, the head trauma patient with (C)APD may be

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unable to engage in intense auditory training to the degree and with the scope we have advocated for treatment of (C)APD.<sup>15</sup>

Similarly, metacognitive, cognitive, and metalinguistic central resources intervention strategies that we have advocated for (C)APD may require modifications commensurate with the patient's deficit profile. For example, while working memory exercises might be too demanding, re-auditorization may be a particularly effective memory-building approach with TBI patients.

Patients with TBI typically benefit from structured therapy in a quiet setting with minimal distractions. The audiologist may recommend the use of an FM system to help the patient focus on the auditory signal. Using *clear speech* (i.e., focusing on a slower rate, enunciating, emphasizing key words, and pausing more often) enhances the clarity of the signal and can be effective

when used alone or in combination with an FM system. The audiologist and the multidisciplinary team may determine that computerized therapy over-stimulates some TBI patients leading to a focus on therapy that is less multisensory and more face-to-face with the clinician.

Understanding the full range of deficits resulting from head trauma allows the rehabilitative team to program accessible therapies—which in the case of audition begins with the ability to hear the clinician! Trial placement of hearing aids and assistive listening devices, including an FM system, might be appropriate to achieve the first step toward recovery.

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**Frank E. Musiek**, PhD, is Director of Auditory Research at the University of Connecticut and Editor of Pathways. **Gail D. Chermak**, PhD, is Professor of Audiology and Chair of the Department of Speech and Hearing Science, Washington State University, Pullman. Readers may contact Dr. Musiek at Frank.Musiek@uconn.edu.

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