CICSD

Intervention Approaches for Individuals With (Central) Auditory Processing Disorder

Teri James Bellis
Ashley M. Anzalone
The University of South Dakota, Vermillion

Intervention for (central) auditory processing disorder, or (C)APD, has become an increasing area of focus for speech-language pathologists (SLPs) and audiologists in recent years. Although the importance of identifying children with central auditory dysfunction was emphasized long ago by Myklebust (1954), formal "consensus" guidelines for diagnosing and treating/ managing (C)APD did not appear in the literature until relatively recently (e.g., American Speech-Language Hearing Association [ASHA], 1996, 2005a; Jerger & Musiek, 2000).

ABSTRACT: In recent years, the treatment and management of (central) auditory processing disorder, or (C)APD, have received increasing focus in the audiology and speech-language pathology literature. Although the diagnosis of (C)APD falls within the scope of practice of the audiologist, intervention for the disorder requires a multidisciplinary team endeavor. This article provides an overview of the definition and diagnosis of (C)APD as they apply to intervention for the disorder. Also discussed are general principles that should be employed when designing deficit-specific intervention plans for children and adults with (C)APD. Three case studies are presented that illustrate the application of the intervention principles discussed and provide guidance regarding the selection of appropriate, deficit-specific environmental modifications, compensatory strategies, and targeted auditory training activities.

KEY WORDS: (central) auditory processing disorder, dichotic listening, temporal processing, monaural low-redundancy speech, treatment, management

The first official position statement specifically addressing the topic of (C)APD appeared in 2005 (ASHA, 2005b). This document supported the existence of the disorder as a distinct diagnostic entity; emphasized that diagnosis of the disorder is within the scope of practice of the audiologist, whereas SLPs collaborate in the assessment of individuals suspected of (C)APD for differential diagnosis and intervention purposes; and set forth guidelines relative to defining, diagnosing, and treating (C)APD. A key point of emphasis in all of these documents is the need for accurate diagnosis of the disorder for the development of deficit-specific, ecologically valid intervention plans.

This article will focus on the key elements of intervention for (C)APD. Included will be an overview of the definition and nature of (C)APD as well as a brief discussion of methods of diagnosing the disorder, as these topics are critical to appropriate intervention. General principles and components of intervention plans will be discussed, with an emphasis on individualization of intervention recommendations based on diagnostic test results and presenting complaints. Finally, case studies will be presented that will illustrate the application of these principles to individuals with (C)APD.

INTRODUCTION

Central auditory processing is defined as "the perceptual processing of auditory information in the central nervous system (CNS) and the neurobiologic activity that underlies that processing and gives rise to the electrophysiologic

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auditory potentials" (ASHA, 2005a, p. 2). An important element of this definition is the focus on underlying neural mechanisms and neuroanatomical substrates in the central auditory nervous system (CANS) that support a variety of auditory behaviors, including sound localization and lateralization, auditory discrimination of speech and nonspeech signals, auditory performance with competing or degraded acoustic information, a variety of auditory temporal processing and patterning abilities, and others (ASHA, 1996, 2005a). As such, to diagnose (C)APD, it must be shown that a disorder exists in the CANS using tests that have been demonstrated to have validity and efficiency for the identification of CANS dysfunction (ASHA, 2005a, 2005b; Bellis, 2003a; Musiek & Chermak, 2007). In short, (C)APD is considered to be a *diagnostic* term rather than a descriptive one; many individuals exhibit listening and related difficulties that mimic (C)APD, but only those shown to have CANS dysfunction using sensitized tests designed for that purpose should be diagnosed with (C)APD. It follows, then, that the diagnostic label of (C)APD should not be used to describe the listening difficulties that are exhibited by individuals with disorders outside of the CANS, such as those with higher order language, cognitive (including diminished intellectual capacity, autism, and attention-related deficits), and related disorders unless a specific concomitant deficit in the CANS can be demonstrated conclusively (ASHA, 2005a; Bellis, 2003a).

Because of the need for sensitized tests with documented validity and efficiency for identification of CANS dysfunction, diagnosis of (C)APD falls within the scope of practice of the audiologist (ASHA, 2004b, 2005a, 2005b). SLPs are charged with assessing the cognitive–communicative and/or language functions that may be associated with (C)APD (ASHA, 2004a, 2005a). A multidisciplinary team approach is critical to elucidate fully the auditory, communicative, language, learning, and related sequelae that may be associated with (C)APD so that a comprehensive intervention plan can be developed (ASHA, 2005a; Bellis, 2003a; Musiek, Bellis, & Chermak, 2005). It is important to emphasize that speech-language, psychoeducational, neuropsychological, and related measures designed to assess how well a particular individual deals with verbally presented information may be useful in determining real-world functional strengths and weaknesses exhibited by children and adults suspected of (C)APD; however, they are not considered diagnostic tests of (C)APD, even if the term auditory processing is included in their titles. In addition, it also is critical to note that screening tools cannot be used for central auditory diagnosis. Instead, diagnosis of (C)APD requires the use of a multitest battery that assesses multiple processes and regions/levels within the CANS (ASHA, 2005a; Bellis, 2003a). Current recommended criteria for a diagnosis of (C)APD include abnormal performance on at least two tests of central auditory function along with a pattern of performance across tests that is consistent with CANS dysfunction (ASHA, 2005a).

(C)APD may be diagnosed at any point in the life-span; may occur secondary to neurological disease, insult, or injury; or may be of unknown etiology. Although a large focus of (C)APD service provision has been on children, it should be recognized that (C)APD also occurs in adults. It has been estimated that the prevalence of (C)APD in the school-aged population is approximately 2% to 5% (Bamiou, Musiek, & Luxon, 2001; Chermak & Musiek, 1997), whereas prevalence in the older adult population may be as high as 76% (e.g., Golding, Carter, Mitchell, & Hood, 2004; Golding, Mitchell, & Cupples, 2005; Jerger, Jerger, Oliver, & Pirozzolo, 1989; Stach, Spretnjak, & Jerger, 1990; see Bellis, 2007a for review).

Often, children with (C)APD also exhibit difficulties in academic subjects related to the use of language (e.g., reading, spelling, other "auditory-reliant" topics) and in some, social deficits are noted as well (ASHA, 2005a; Bellis, 2003a). However, not all children with (C)APD exhibit these types of academic difficulties, and certainly not all reading, spelling, or other learning difficulties are associated with an underlying auditory deficit. Nonetheless, it has been shown that a subset of children with language, learning, and related difficulties exhibits abnormal neurophysiologic representation of auditory stimuli, which supports a neurobiological basis for (C)APD in this population (e.g., Banai, Abrams, & Kraus, 2007; Cunningham, Nicol, Zecker, & Kraus, 2000; Jerger, Martin, & Jerger, 1987; King, Warrier, Hayes, & Kraus, 2002; Kraus, McGee, Carrell, Zecker, Nicol, & Koch, 1996; Moncrieff, Jerger, Wambacq, Greenwald, & Black, 2004; Wible, Nicol, & Kraus, 2005).

When (C)APD is diagnosed in adulthood, it is possible that the disorder had been present (but undetected) since childhood, was acquired through neurological disease (e.g., multiple sclerosis, space-occupying lesion) or insult (e.g., stroke, traumatic brain injury), or occurred secondary to the aging process (e.g., Bellis, 2002b, 2003b, 2007a; Bellis, Nicol, & Kraus, 2000; Bellis & Wilber, 2001; Jerger & Chmiel, 1997; Musiek, Baran, & Pinheiro, 1990; Musiek, Baran, & Shinn, 2004). Therefore, intervention for central auditory dysfunction may be implemented in individuals of all ages, and SLPs and audiologists looking to add (C)APD intervention to their service provision armamentarium should be aware that the intervention principles discussed herein apply equally to children and adults with the disorder.

BASIC PRINCIPLES OF INTERVENTION FOR (C)APD

There are several basic principles that should be used to guide (C)APD intervention efforts. This section will provide a brief overview of these principles. For a detailed review, readers are referred to Bellis (2003a, 2007b) and Chermak and Musiek (2007). First, intervention should be deficit specific. Therefore, it must be personalized to the individual's strengths and weakness and arise accordingly from the specific auditory deficits that the individual exhibits, as indicated by the diagnostic testing results and the individual's functional difficulties and behavioral complaints (ASHA, 2005a; Bellis, 2002a, 2002b, 2003a, 2007b; Bellis & Ferre, 1999). This means, therefore, that there is no one-size-fits-all intervention approach that is appropriate for every individual with (C)APD; as with other disorders of communication, use of a person-centered approach that emphasizes individualization of treatment and management recommendations is critical.

Second, intervention should, in most cases, be multidisciplinary, involving input from a variety of areas including but not limited to audiology, speech-language pathology, education, psychology, family members, and others. Intervention also should be ecologically valid. That is, it should address the real-world listening complaints exhibited by the individual so that improvements in day-to-day function can be realized.

Third, recommendations for intervention should employ both bottom-up and top-down treatment approaches (ASHA, 2005a; Chermak & Musiek, 2007). Bottom-up treatments focus on access to and acquisition of the auditory signal and include auditory training as well as environmental modifications to improve the listening environment and enhance access to the acoustic signal. Top-down approaches address higher level central resources such as language, cognitive, memory, and related functions, along with environmental modifications to instructional, communicative, and other methods of imparting and learning information.

Finally, intervention should be undertaken as soon as a diagnosis of (C)APD has been confirmed. However, it should be emphasized that due to the extreme variability in neuromaturation of the CANS before approximately 7 or 8 years of age, many behavioral diagnostic tests of central auditory processing cannot be administered and interpreted reliably until a child is that age (ASHA, 2005a; Bellis, 2003a; Musiek, Gollegly, & Baran, 1984). In younger children for whom a diagnosis cannot be made, recommendations for auditory enrichment activities that address suspected areas of weakness or concern can be implemented (Bellis, 2003a; Chermak, Bellis, & Musiek, 2007). However, it should be made clear that a definitive, formal diagnosis of (C)APD has not yet been obtained.

COMPREHENSIVE (C)APD INTERVENTION

Comprehensive (C)APD intervention approaches can be divided into three primary categories: (a) environmental modifications, (b) compensatory strategies and central resources training, and (c) direct skills remediation (ASHA, 2005a; Bellis, 2002a, 2002b, 2003a; Bellis & Ferre, 1999). In other words, treatment and management of CAPD should focus on changing the environment; improving higher order listening, language, and cognitive skills; and remediating the disorder, with the primary goal of increasing the individual's ability to use information presented in the auditory mode (Bellis, 2003a). All three of these areas should be addressed in any intervention plan for individuals with (C)APD. A description of each of these components follows.

Environmental Modifications

Environmental modifications are intended to improve the individual's access to auditory information by enhancing the clarity of the acoustic signal and facilitating listening and learning in the academic, home, work, or social environment (ASHA, 2005a; Bellis, 2003a; Chermak & Musiek, 2007). Included in this category are acoustic-based, bottom-up modifications such as the use of hearing assistive technology, architectural interventions to reduce reverberation and improve the signal-to-noise ratio, preferential seating with a direct visual line to the speaker, and reduction or removal of mechanical or other competing noise sources within or outside the room. Top-down environmental modifications focus on the manner in which information is imparted and learned, and may include activities such as making frequent checks for comprehension, employing visual or multimodality cues and hands-on demonstrations to augment verbally presented information, slowing speaking rate, repeating key information, rephrasing information using less complex linguistic units, providing instructions in writing, preteaching new information and vocabulary, and providing a note taker, among others (Bellis, 2003a). These modifications are implemented with the goal of creating a highly redundant listening and learning environment.

The importance of individualizing recommendations for environmental modifications cannot be overemphasized. Although there exist many general lists of recommendations assumed to be appropriate for "all" individuals with (C)APD, Bellis (2003a) cautioned clinicians to avoid use of these lists, as none of them are appropriate for every child or adult with the disorder. Instead, selection of appropriate modifications should be made systematically and should be based entirely on the individual's presenting difficulties and auditory deficits, and the efficacy of the modifications implemented should be monitored on an ongoing basis.

Compensatory Strategies/ Central Resources Training

Compensatory strategies, also referred to as central resources training, are designed to assist individuals in overcoming residual dysfunction and to address secondary motivational or related deficits by strengthening higher order, top-down cognitive, language, and related abilities (ASHA, 2005a; see Bellis, 2003a; Chermak, 1998, 2007 for reviews). Through the use of these strategies, individuals with (C)APD learn to become active rather than passive, listeners and learners and are encouraged to take responsibility for their own listening and learning successes. These strategies do not directly target deficient central auditory processes, per se, but instead enhance the benefit provided by direct remediation and other interventions by addressing functional deficits and promoting improved listening and spoken language comprehension (Chermak, 1998, 2007). Activities include training in utilization of metalinguistic and metacognitive (including memory and attention) strategies to aid listeners in actively monitoring and self-regulating their own auditory comprehension and retention abilities, as well as in developing general problem-solving skills.

Direct Remediation (Auditory Training)

Direct remediation via auditory training aims to improve an individual's auditory performance by altering the way the brain processes sound (Bellis, 2003a). It involves targeted, bottom-up activities that maximize neuroplasticity and can be formal (i.e., in a sound-treated booth with acoustically controlled stimuli) or informal (in the home or school setting using targeted games and activities) (Chermak & Musiek, 2007). The framework for identifying which targeted activities should be employed is provided by the results of the diagnostic central auditory evaluation, which reveals the specific auditory processes or mechanisms that are deficient in a given individual.

A large body of evidence supports the existence of neurophysiologic changes accompanied by functional auditory skills improvement following auditory training (see Chermak et al., 2007 for review). However, in order for auditory training to be effective, it must be both frequent and intense, often requiring daily sessions for several weeks (Bellis, 2002a, 2002b; Chermak & Musiek, 2002; Musiek, Chermak, & Weihing, 2007; Musiek, Shinn, & Hare, 2002). In addition, training must be sufficiently challenging. This can be accomplished by working near skill threshold, or at a 30%–70% accuracy level with incremental difficulty levels where 70% accuracy must be achieved before increasing the difficulty of the task (Chermak & Musiek, 2002; Chermak et al., 2007).

Finally, auditory training activities should involve active participation on the part of the listener accompanied by provision of immediate feedback and salient reinforcement in an effort to maximize long-term potentiation in the CANS (Beninger & Miller, 1998; Blake, Strata, Churchland, & Merzenich, 2002; Holroyd, Larsen, & Cohen, 2004).

In summary, intervention for (C)APD should include both bottom-up and top-down approaches and should address methods of modifying the listening and learning environment, improving higher level central resources to buttress deficient auditory skills, and reducing or ameliorating the auditory deficits via targeted auditory training activities.

CASE STUDIES

The following three cases illustrate how clinicians may use the results of behavioral central auditory testing, along with information from other sources, to develop a deficit-specific, individualized intervention plan. It should be emphasized, however, that the plans discussed below should not be construed to advocate a cookie-cutter approach to (C)APD intervention. As previously discussed, recommendations for the management and treatment of (C)APD should arise from the deficit areas that were identified during testing, as well as from the behavioral difficulties reported by the individual. Therefore, even if multiple children or adults present with a similar pattern of deficits on central auditory testing, each will require different recommendations for intervention that address his or her unique functional areas of difficulty. For a comprehensive review of the behavioral central auditory tests used for diagnostic purposes, readers are referred to Bellis (2003a) and Musiek and Chermak (2007).

Case #1

Case #1 involved an 8-year-old boy who presented with reading and spelling difficulties primarily in the area of word attack, or phonological decoding. Auditorily, he complained of difficulty hearing in noisy environments, and his parents and teachers reported that he frequently "misheard" what was said to him. Although the boy's speech and language abilities overall were judged to be within the normal range for age at the time of central auditory testing, he did exhibit some weaknesses in the area of vocabulary, and he had a past history of phonological disorder that involved substitutions of stop consonants (e.g., /d/ for /g/) and weak-syllable deletions. Further, phonological awareness concerns were noted, particularly in the areas of discrimination and manipulation of similar-sounding phonemes.

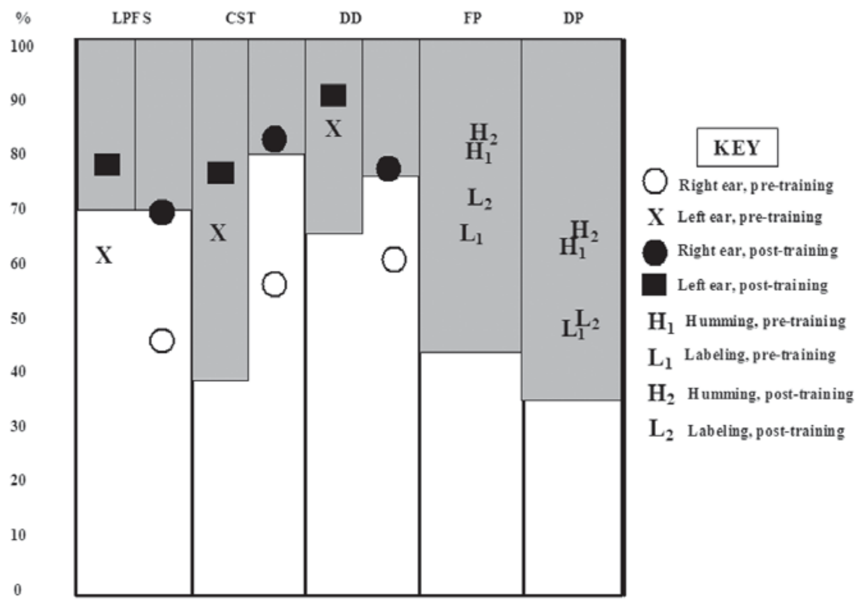
The boy's medical history was unremarkable except for a history of chronic ear infections between approximately 6 months and 3 years of age. At age 3, pressure-equalizing tubes were inserted, and no recurrence of otitis media was noted thereafter. When seen in the audiology clinic, the boy was receiving special education services in the area of specific learning disability (reading), with goals that included improvement in reading fluency, reading rate, and reading comprehension.

Peripheral hearing evaluation revealed the boy's hearing to be within normal limits bilaterally, with excellent word recognition abilities for monosyllabic words presented at a comfortable listening level in quiet. Distortion-product otoacoustic emissions (DPOAEs) were present bilaterally, as were ipsilateral and contralateral acoustic reflexes. Tympanometry was, likewise, well within normal limits, which is indicative of normal middle-ear function.

The boy's central auditory test results are presented in Figure 1. When compared to age-specific normative values, pretreatment test results indicated a right-ear deficit on both the Dichotic Digits Test (DD; Musiek, 1983) and the Competing Sentences Test (CST; Willeford & Burleigh, 1994) for age. Results also indicated a bilateral deficit on Low-Pass Filtered Speech (LPFS; NU-6, 1000 Hz cutoff, Auditec of St. Louis version) with the right ear worse than the left ear. Results of both frequency patterns (FP; Musiek & Pinheiro, 1987) and duration patterns (DP; Pinheiro & Ptacek, 1971) testing were within normal limits for age for both the linguistic labeling (L) and humming (H) response conditions.

The pattern of right-ear deficit on dichotic speech tasks such as DD combined with bilateral deficit on monaural low-redundancy speech tests such as LPFS has been shown to be consistent with presumed left-hemisphere, likely primary auditory cortex dysfunction (Bellis, 2003a). The

Figure 1. Pre- and posttraining central auditory test results for Case #1 on Low-Pass Filtered Speech (LPFS), Competing Sentences Test (CST), Dichotic Digits (DD), Frequency Patterns (FP), and Duration Patterns (DP).



Note. Gray areas represent normative ranges as defined as <2 *SD* below the mean for age.

normal findings on both tests of temporal patterning, FP and DP, are suggestive of intact interhemispheric and right-hemisphere pathways. Therefore, the results of the central auditory evaluation were consistent with a (C)APD likely involving left-hemisphere CANS regions, including primary auditory cortex. Because this region also subserves discrimination of speech sounds involving rapid spectrotemporal acoustic changes such as stop consonants (Kraus et al., 1994; Phillips & Farmer, 1990), it is probable that this child's auditory discrimination difficulties may have arisen from poor speech-sound representation in the brain. Poor speech-sound representation also has been linked to poor reading and spelling skills, as well as to difficulties in phonological awareness abilities (Bellis, 2003a; Kraus et al., 1996).

Qualitatively, test results indicated that this child exhibited difficulty with the process of auditory closure, or the ability to fill in missing elements of a speech signal, as evidenced by abnormal performance on LPFS (Schow & Chermak, 1999; Schow, Seikel, Chermak, & Berent, 2000). A deficit in auditory closure will impact speech-in-noise abilities and was a likely contributor to this child's difficulties hearing in noisy environments. Similarly, difficulties with both binaural integration (the ability to attend to disparate signals presented to both ears simultaneously, as assessed by DD) and binaural separation (the ability to attend to one ear while ignoring a competing message delivered simultaneously to the other, as assessed by CST) also were a likely contributing factor to his speech-in-noise difficulties.

To address this child's presenting complaints, the following recommendations were made: Modify the classroom environment to include preferential seating in a place away from sources of extraneous noise and with a direct line of vision to the teacher; preteach new vocabulary to assist with auditory closure abilities; employ sensory summation via the generous use of visual cues, including written instructions; and try using a hearing assistive device (personal FM system). His parents and teachers also were instructed in the use of clear speech by slowing speaking rate, enunciating key words, and introducing frequent but natural pauses during lengthy communications.

Recommendations for central resources training focused heavily on active listening techniques as well as on anticipating and problem solving difficult listening situations in advance. Active listening involved sitting up straight, watching the speaker, and avoiding extraneous fidgeting or moving (Bellis, 2002b, 2003a).

In addition to active listening, attribution training was implemented. Attribution training emphasizes the adoption of an internal locus of control in which communicative or listening failures are attributed to insufficient effort or other factors under the listener's direct control (Chermak, 1998; Torgeson, 1980). Through this approach, individuals learn to take responsibility for their own listening success and to problem-solve solutions to difficult listening situations independently. Additional training was implemented in the area of contextual derivation to encourage the use of context to derive meaning from a communication involving missing (or misunderstood) elements. Activities to facilitate contextual derivation skills included auditory closure activities, using stimuli in which words, syllables, or phonemes were excised, along with context-based vocabulary building, which focuses on using surrounding context to derive the meaning of unfamiliar words that are encountered during reading (Musiek, 1999).

Specific auditory training activities focused on speech-sound discrimination using consonant-vowel syllables and words with minimal pair contrasts (e.g., *ten*/*pen*), especially those involving stop consonants in initial, medial, and final positions of words (Ferre, 1997; Sloan, 1995). This training was combined with basic phonological awareness training and, ultimately, speech-to-print skills training for transfer of trained contrasts and application to orthographic symbols. To facilitate this process, a computer-based auditory training program, Earobics (Cognitive Concepts, 1998), was employed 30 min per day, 5 days a week, for 6 weeks. Because of scheduling constraints in the child's school setting, this therapy was conducted in the audiology clinic using a computer and a quiet therapy room. Once fundamental discrimination of problematic phonemes in various word positions was mastered, training of the same skills in various backgrounds of noise was undertaken. The speech-in-noise training, along with additional discrimination and phonological awareness activities, was integrated into the speech and language services that were already being provided to the child to address his reading and spelling difficulties.

A central auditory reevaluation was conducted 3 months (12 weeks) after the initial test date (see Figure 1). Posttraining results indicated an improvement in auditory closure abilities as measured by LPFS, with performance in the normal range for age for the left ear and in the borderline normal range for the right ear. Despite the fact that binaural separation and integration had not been specifically trained, dichotic listening test results demonstrated a similar improvement, with posttherapy scores within the normal range for CST and in the borderline range for the right ear for DD. The child's parents and teachers reported a significant improvement in the child's ability to understand speech in the classroom under noisy conditions. It was determined that further goals would continue to focus on improving reading speed and fluency as well as reading comprehension, although these skills also were reported to demonstrate some improvement following therapy, likely due to the incorporation of phonological awareness, contextual derivation, and speech-to-print skills training in the intervention program.

Case #2

Case #2 involved a 46-year-old male who presented with complaints of hearing difficulties that were significantly exacerbated when he was in noisy environments. He reported that his symptoms had begun in his mid-30s and seemed to be getting progressively worse to the point that they were beginning to interfere both with his relationship with his spouse (who was becoming increasingly frustrated with him) as well as in his place of employment, a retail sales business. He had no history of auditory, learning, or language difficulties in the past, and medical history was likewise unremarkable.

An evaluation of the man's peripheral hearing status revealed that his hearing was within normal limits bilaterally with good word recognition abilities for monosyllabic words presented at soft listening levels in quiet. DPOAEs were present bilaterally, and immittance testing revealed normal tympanometric and acoustic reflex results.

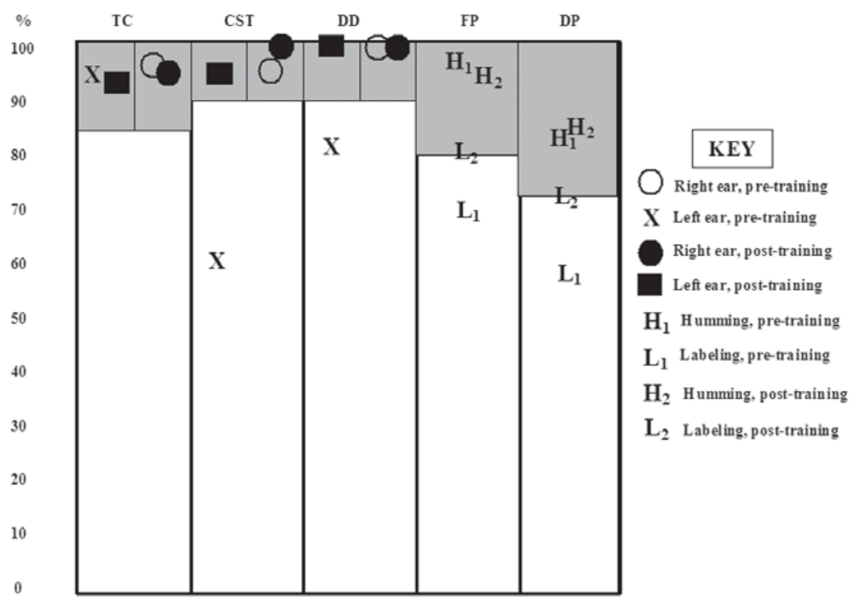
Results of the man's central auditory evaluation are presented in Figure 2. Pretreatment results revealed a left-ear deficit on both DD and CST, combined with a deficit on both FP and DP testing in the linguistic labeling report condition only. In contrast, test results were within normal limits for monaural low-redundancy speech, as measured by Time-Compressed Speech (NU-6, 45% compression; Wilson, Preece, Salamon, Sperry, & Bornstein, 1994). The pattern of left-ear deficit on dichotic speech tasks combined with deficits on temporal patterning tests in the linguistic labeling condition has been associated only with dysfunction of the interhemispheric auditory pathways, likely subserved by the corpus callosum (Musiek et al., 1984). It is important to note that there is evidence to suggest that interhemispheric processing declines as a result of the natural aging process, and that this decrease in function begins earlier in males as compared to females (Bellis & Wilber, 2001). The primary auditory processes identified as being areas of particular concern included binaural integration and binaural separation, as measured by DD and CST.

Environmental modifications thought to be particularly important for this client focused on both the home and the work environment, and counseling sessions included his employer and his spouse in order to facilitate understanding of his disorder and the implications thereof. At home, it was recommended that critical information be provided in the absence of background noise or other distracters, and that particularly important or detailed information (e.g., grocery lists, appointment times, directions) be written down. The client was encouraged to rephrase information both at home and at work in order to identify potential misunderstandings and clarify instructions. A visit to the man's place of work revealed that he was required continually to listen and respond to information presented via a hip-worn two-way radio system, which was problematic during noisy business hours. A modification to the communication system was implemented that allowed for signal delivery via an insert ear-bud, which significantly enhanced the client's ability to hear and respond accurately to communications.

As with the child presented in the previous case, a primary focus of central resources training for this man was on anticipating and problem solving difficult listening situations and employing active listening techniques. The client was encouraged to clarify information with his employer and spouse frequently in an effort to reduce misunderstandings.

To address the client's auditory difficulties in the processes of binaural separation and integration, dichotic listening training was implemented (Bellis, 2002b, 2003a). This technique may be implemented formally in a sound

Figure 2. Pre- and posttraining central auditory test results for Case #2 on Time-Compressed Speech (TC), CST, DD, FP, and DP.



booth with a two-channel audiometer or informally in a home or other setting. Because of the client's work schedule, in-clinic training was not possible; therefore, training was conducted in the home setting, 30–45 min per day for 6 weeks. Training consisted of presentation of a book on tape of the client's choice to the left ear via a standard insert ear-bud. A competing message (talk radio) was routed from the client's stereo system to the right ear, also via a standard ear-bud. The client was instructed to adjust the interaural intensity levels of the stimuli so that the target book was challenging but not impossible to hear and understand. As the target became easier to hear (often within a single test session), the client was to decrease the intensity of the target and increase the intensity of the competition in order to maintain a consistent level of challenge. During the 6 weeks of training, the client reported that he often adjusted the target-to-competition ratio several times within test sessions and that by the end of the 6-week period he was able to hear the target at a much quieter level and with significantly greater intensity of competition than when he had begun the training. The efficacy of using dichotic stimuli to remediate deficits in binaural separation and integration has received a great deal of attention in the recent literature (e.g., Moncrieff & Wertz, 2008; Musiek et al., 2004).

Posttraining central auditory test results conducted immediately following dichotic listening training (6 weeks after the initial evaluation) as shown in Figure 2. Results indicated a complete recovery of the left-ear deficit on dichotic speech tasks, with results well within normal limits for both DD and CST. This was accompanied by a report of significant improvement in speech-in-noise abilities that was confirmed independently by the client's spouse and employer. Indeed, the client's complaints of difficulties hearing in backgrounds of noise had improved so noticeably that, after 3 months of using the ear-bud communication system at work, he returned to the hip-worn two-way radio system with little to no difficulty. Although FP and DP testing remained in the borderline range for the linguistic labeling condition, it was not felt that additional therapy was indicated as the client reported no language or related difficulties. A final retest 1 year following treatment indicated stability of these central auditory findings and continued reported improvement in speech-in-noise skills.

Case #3

Case #3 involved a 14-year-old girl who was 2 years posttraumatic brain injury due to a car accident. Magnetic resonance imaging immediately following the accident showed a mild subdural hematoma across the right superior temporal and inferior parietal lobes, which subsequently resolved. The girl reported a relatively brief period of unconsciousness; paramedics noted that she was awake but somewhat disoriented on their arrival at the scene. She was discharged after 3 days of hospitalization.

Following her injury, the girl complained of short-term memory and sequencing difficulties as well as visual figure-ground difficulties and photophobia (extreme sensitivity to bright light). In addition, she began to exhibit a relatively flat affect that was described as a "near-monotonic" speaking style. Her physicians suspected posttraumatic stress disorder manifesting in depressive symptoms, and she was placed on antidepressant medication. According to parent report, the medication was discontinued after 3 months due to lack of effectiveness.

Upon her return to school in the fall, 6 weeks after the accident, the girl began to exhibit academic difficulties that had not been apparent previously. In particular, math calculation was a significant area of difficulty for her, as were note taking, reading comprehension (specifically relative to identifying the main idea or overarching theme of a passage or story), and following complex directions in sequence. The girl also began to complain of difficulties during piano lessons, which she had been involved in for 7 years. Specifically, she reported repeatedly that the piano sounded “out of tune;” however, her piano teacher disagreed. She also had difficulty with the rhythm and timing of piano passages that she had played with ease in the past and was unable to learn new passages. The school guidance counselor and her parents became concerned regarding socialization as the girl began to get into arguments with friends and often overreacted to communications, particularly those involving sarcasm, humor, or abstract/nonliteral language (including hints). Because of these difficulties, a psychological evaluation was recommended.

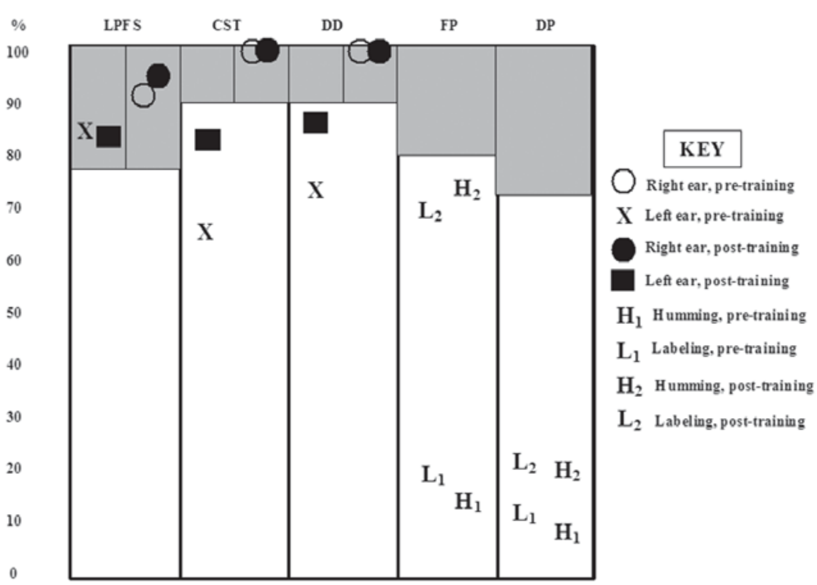
Cognitive testing revealed verbal capacity within the average range; however, nonverbal capacity was measured in the below average range. The girl exhibited notable weaknesses in visual–spatial skills, mathematics, and abstract reasoning. The psychologist also noted that the girl responded in a monotone during testing and conversational speech. The possibility of a nonverbal learning disability was suggested. Because of her reported difficulties with music perception, combined with her social communication concerns, the girl was recommended for a (C)APD evaluation.

An evaluation of the girl’s peripheral hearing status revealed hearing to be within normal limits, with the exception of a mild 6000 Hz notch bilaterally (25 dBHL right, 30 dBHL left). Word recognition abilities were excellent for monosyllabic words presented at soft listening levels in quiet. It should be noted that, before her accident, the girl reported frequent and regular use of an iPod at high intensity levels; interestingly, she reported that she had “lost her interest” in music following the accident and no longer listened to her iPod on a regular basis. Prior hearing screening at 12 years of age also had suggested a possible mild hearing loss at 6000 Hz; however, the family had not obtained comprehensive audiologic follow-up as recommended. DPOAEs were present through approximately 5000 Hz and absent in the 6000 Hz region, suggesting cochlear pathology in this region. Immittance testing, including tympanometric and acoustic reflex testing, was well within normal limits bilaterally. Based on reported history, it appeared likely that the 6000 Hz notch predated the auto accident and, as such, was not likely to be related to the onset of auditory and related complaints following her trauma.

The girl’s central auditory test results are presented in Figure 3. Pretreatment results indicated a left-ear deficit on both DD and CST. In addition, the girl performed at chance level on FP and DP in both the linguistic labeling and humming conditions. When queried, the girl reported that she was unable to discriminate the differences in frequency and duration required for these tests, and that all of the tones “sounded the same” to her. Monaural low-redundancy speech testing (LPFS) was within normal limits bilaterally.

The pattern of left-ear deficit on dichotic speech tasks combined with temporal patterning deficits as measured by FP and/or DP in both the linguistic labeling and humming

Figure 3. Pre- and posttraining central auditory test results for Case #3 on LPFS, CST, DD, FP, and DP.



conditions has been associated with dysfunction in the right hemisphere (Bellis, 2003a). From a multidisciplinary perspective, mathematics calculation, visual spatial skills, Gestalt pattern processing (including deriving the main idea from a communication), prosody perception, and other difficulties reported by this client also have been attributed to right-hemisphere dysfunction (see Bellis, 2003a for a review). These findings are consistent with site-of-injury in this client. It has been hypothesized that auditory deficits related to an inability to appreciate acoustic contours and other suprasegmental perception difficulties may lead to difficulties interpreting tone-of-voice and other prosodic cues, and also may affect production of appropriate prosody, leading to a flat or monotonic speaking style and social communication concerns (Bellis, 2002b, 2003a). This coincides with the key auditory and communicative difficulties reported by this client.

Recommendations for intervention included environmental modifications that focused on the manner in which information was presented, including encouraging teachers and parents to make generous use of prosodic elements of speech and to present information in a concrete, rather than abstract, manner with an avoidance of hints and abstract language forms. Because note taking relies on the ability to identify and extract key words and concepts from an ongoing verbal communication—areas that have been shown to be difficult for individuals with presumed right-hemisphere dysfunction—a note taker was recommended to assist the girl in the classroom. It is important to note that this client reported no difficulty with speech-in-noise skills; therefore, enhancing the acoustic clarity of the signal was not a focus of classroom modifications beyond what would be beneficial for the general classroom student.

A significant focus of the intervention recommendations for this client was on compensatory strategies and central resources training. Because memory and sequencing were of concern, metamemory techniques that are intended to enhance the memory trace were employed (Chermak, 2007). These included reauditorization and rephrasing of instructions and information and use of chunking and related strategies to facilitate retrieval. Another focus of central resources training was on recognizing and extracting key words from communications of increasing length. Finally, schema induction training was initiated with the client and the clinician role-playing social communication scenarios in which variations in tone of voice, stress-related cues, and nonverbal cues (i.e., body language) affected the meaning or intent of the message. The client was counseled to avoid knee-jerk reactions to questionable communicative events, particularly when misperception of tone-of-voice cues might lead to anger or defensiveness, and to employ analysis and clarification strategies before making a judgment about the intent of a message.

Direct remediation focused first on temporal patterning training or discrimination of nonverbal acoustic contours of increasing length. Specifically, training began with a focus on discrimination and imitation of two-tone segments differing in frequency or duration, with rhythm (or interstimulus interval) held constant. Next, training moved to imitation of two-tone segments in which both frequency and duration differed, with rhythm held constant. This was followed by imitation of two-tone sequences varying in frequency, duration, and interstimulus interval. Once this level was mastered, tonal patterns of increasing length were introduced, with frequency/duration/rhythm variations also increasing in complexity. Because this client had a long history of piano training, a piano was used for these activities, with the major and minor keys providing frequency variations and the foot pedal providing duration variations. It should be noted, however, that temporal patterning training such as this can be accomplished in a variety of ways, including formally in a sound booth with an audiometer and other signal delivery equipment.

Auditory training also focused on perception of rhythm, stress, and intonation patterns in speech, or prosody training. Stimuli included words and sentences in which relative differences in stress resulted in different meaning (e.g., *sub<u>ject</u>* vs. *<u>sub</u>ject, <u>You</u> can't go to the store with me* vs. *You can't go to the <u>store</u> with me)*. The central resources and auditory training activities were undertaken by an interdisciplinary team consisting of both an SLP and an audiologist, with integration of additional therapy focusing on prosodic production and social communication (pragmatics) skills.

It is important to note that the interventions discussed above focused on the client's auditory and communication difficulties. Other right-hemisphere-based complaints, including mathematics calculation difficulties and visual–spatial disturbances, were addressed by appropriate members of the multidisciplinary team. Similarly, regular visits with the guidance counselor were implemented to monitor for recurrence of depressive symptoms or concerns.

Central auditory testing was re-administered 1 year following the initial evaluation (Figure 3). Results indicated some improvement in left-ear scores on dichotic listening tasks as well as a significant improvement in performance on FP, although results on each of these tests remained in the below-normal range. Performance on DP remained significantly depressed, although some improvement was noted. Functionally, the client reported an improvement in her ability to perceive prosodic cues and gauge communicative intent, resulting in a subjective improvement in social communication skills that was verified by her parents and guidance counselor. Although the client stated that she still had some difficulty with interpretation of tone-of-voice cues, especially when communicating with unfamiliar speakers, employment of compensatory strategies such as schema induction and avoidance of knee-jerk reactions has had a beneficial impact on her communicative exchanges with friends, family members, and others. Her speech production, although not as animated as it had been before her injury, was no longer considered monotonic. Her ability to glean the main idea from a spoken or written passage, along with key word extraction and note-taking abilities, likewise had improved; however, difficulties persisted when the communication was lengthy or complex. The use of a note taker during lecture-based classes was judged to be extremely effective, and her grades had improved significantly. At the time of this writing, multidisciplinary team intervention continues to focus on note taking and related skills as well as on mathematics and visual–spatial abilities.

Case #3 illustrates an important point in (C)APD intervention: For many individuals, auditory and related deficits may persist following deficit-specific intervention. However, by coupling appropriate environmental modifications and central resources training with direct auditory remediation, adequate compensation for residual deficit areas can be achieved.

CONCLUSION

This article has provided a general overview of intervention approaches for children and adults with (C)APD. Of particular emphasis has been the importance of accurate diagnosis of the disorder for purposes of identifying auditory deficits and informing deficit-specific treatment. Intervention for (C)APD should be individualized and should include environmental modifications, central resources training, and targeted auditory training activities. Finally, a multidisciplinary approach to intervention is critical in order to address fully the presenting functional sequelae and complaints of the individual with (C)APD.

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Contact author: Teri James Bellis, Department of Communication Disorders, The University of South Dakota, 414 East Clark Street, Vermillion, SD 57069. E-mail: tbellis@usd.edu.