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Central Auditory Processing Disorders and Reduced Motivation: Three Case Studies

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Abstract

The central auditory test results for three normal-hearing children who were initially diagnosed as having a central auditory processing disorder and learning disability are presented. They were referred to the authors for second-opinion consultations. Central auditory processing retesting was performed by the authors under the condition of no reinforcement and then the condition of reinforcement with the child's favorite food, hobby, or toy. For all three cases, the central auditory test scores improved markedly bilaterally under the condition of reinforcement as compared with the condition of no reinforcement. We hypothesize that the improvement was related to increased motivation associated with the reinforcement and that these children represented false-positive results on the central auditory test battery. Large-sample studies are needed to investigate the effect of reinforcement on test performance in children with reduced central auditory test scores.

Key Words: Central auditory processing disorder, central auditory testing, learning disability, SCAN test, Willeford battery

Abbreviations: BFT = Binaural Fusion Test, CAPD = central auditory processing disorder, CST = Competing Sentences Test, FST = Filtered Speech Test

Willeford's early paper (1974) and publications (1976, 1977) gave impetus to the evaluation of central auditory processing skills in children with learning disabilities and normal or above-normal intelligence.

The American Speech-Language-Hearing Association Task Force on Central Auditory Processing Consensus Development (1996) defined a central auditory processing disorder (CAPD) as an observed deficiency in one or more of the following auditory skills: sound localization and lateralization; auditory discrimination; auditory pattern recognition; perception of the temporal aspects of audition including temporal resolution, masking, integration, and ordering; auditory performance in the presence of competing signals; and auditory performance with degraded acoustic signals. It is hypothesized that CAPDs can result from a specific impairment of auditory processes and mechanisms and/or general impairment of processes and mechanisms across the modalities. They can be observed in disorders with demonstrable evidence of central nervous system pathology or in conditions, such as developmental language disorder or learning disability, lacking clear evidence of central nervous system pathology.

It has become common audiologic practice to perform a central auditory test battery on children who have been diagnosed as having a learning disability. The results of the seventh survey of audiometric practices in the United States (Martin et al, 1998) reveals that approximately half of the respondents perform tests to assess CAPDs in children diagnosed as learning disabled.

The nature, etiology, assessment, and management of CAPDs remain controversial and validation of the concept has not been fully established (McFarland and Cacace, 1995;

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Musiek and Chermak, 1995; ASHA Task Force, 1996). For example, it has been asserted that persons with learning difficulties, including difficulty with learning written language and/or spoken language comprehension, who show deficits on central auditory test batteries that are not associated with known neurologic lesions, have a language disorder rather than a CAPD (Rees, 1973, 1981). Also, approaches to management of CAPDs generally have had limited success to date; the issue of efficacy has been confounded by inadequate study designs (ASHA Task Force, 1996, pp. 48–49). Finally, the results of studies that have attempted to predict the presence of learning disability based upon performance on central auditory processing tests have been contradictory (Harris, 1963; Willeford, 1976, 1977; Tobey et al, 1979; Roeser et al, 1983; Roush and Tait, 1984; Ferre and Wilber, 1986).

The ASHA Task Force (1996) indicated the need for research on many aspects of CAPDs, including the following:

> ...Determine whether central auditory processing disorders in children result from neurologic abnormality, neuromaturational disorder, developmental delay, or some combination of factors. Determine the interrelationships among central auditory processing, attention, cognition, and language...Establish efficiency (i.e., sensitivity and specificity) of behavioral and physiologic measures of central auditory processing... (p. 50).

Because reinforcement has been so successfully used with play audiometry, visual reinforcement audiometry, and tangible reinforcement audiometry during pediatric assessment, we decided to investigate the effect of reinforcement on central auditory processing test performance in children. In the authors' experiences, children perform best on audiologic tests when their favorite reinforcer is used.

This report illustrates the central auditory processing test findings under the reinforcement and no reinforcement conditions for three children with the diagnosis of CAPD and learning disability. During the reinforcement condition, for each case, the child's favorite reinforcer (edible treat, toy, or hobby) was used. All obtained normal results on the central auditory processing test battery under the condition of reinforcement using a reinforcer that represented the child's favorite object, edible treat, or hobby. The implications are discussed in relation to the role of a previously unreported factor, motivation, on performance on tests of central auditory processing.

CASE 1

The reported symptoms for this girl, who was 9 years, 3 months of age, included short attention span, difficulty hearing in noise, auditory comprehension problems, and mild reading difficulties. A CAPD evaluation was performed to rule out a CAPD as a contributing factor in the child's learning disability. The results of the initial CAPD evaluation are shown in Table 1. The Competing Sentence Test (CST) was presented with the primary message at 35 dB SL and the competing messages at 50 dB SL re: SRT. The patient's task was to repeat the primary sentences while ignoring the competing messages. The Filtered Speech Test (FST) was presented

Table 1 Willeford Central Auditory Test Scores for Case 1

Test	*Ear*	*Competing Sentences Unilateral Response (%)*	*Filtered Speech (%)*	*Binaural Fusion (%)*
Normative range at 9 yrs		90–100 (strong)	56–92 (LE)	70–100 (LE)
		70–100 (weak)	56–92 (RE)	70–100 (RE)
Normative range at 10 yrs		90–100 (strong)	66–84 (LE)	75–100 (LE)
		90–100 (weak)	64–82 (RE)	75–100 (RE)
Initial*	Right	40†	52†	65†
	Left	60†	50†	65†
Second opinion: no reinforcement‡	Right	0†		
	Left	60†		
Second opinion: reinforcement‡	Right	100		
	Left	100		

*Girl was 9 years, 3 months of age at the time of this test.
†Score fell below normative range for age.
‡Girl was 10 years of age at the time of this test.

at 50 dB SL re: SRT. With the Binaural Fusion Test (BFT), the low-frequency band was presented at 30 dB SL re: 500-Hz pure-tone threshold and the high-frequency band was presented at 30 dB SL re: 2000-Hz pure-tone threshold.

Note that scores bilaterally fell below the normative range for age on all measures on the initial CAPD evaluation. On the CST, slightly worse performance was obtained for the right than for the left ear. Based on these findings, in the presence of normal hearing sensitivity, the child was diagnosed as having CAPD, and resource-room educational services were recommended. The school had already implemented the recommendation of the resource-room educational services by the time that the parents had pursued a second-opinion consultation from the authors.

At the second-opinion CAPD consultation, which was performed when the girl was 10 years of age, the results of the audiologic evaluation revealed hearing sensitivity within normal limits with slightly reduced suprathreshold speech-recognition scores bilaterally (Table 2). Because of time constraints, only one CAPD measure, the CST, was administered. The results of CST retesting by the authors confirmed the initial finding of performance below the normative range for age (see Table 1). At both the initial and retest evaluations, the strong ear on the CST was the left ear. The weak-ear score was markedly poorer at the retest than initial evaluation.

The marked drop in weak-ear score prompted a CST retest by the authors under the condition of reinforcement 3 weeks later. In response to the query concerning the child's favorite edible treat, hobby, or toy, the mother indicated that her daughter loved roasted marshmallows. The child was informed that each time she correctly repeated two words, a marshmallow would be given to her. When the child saw the marshmallows, she demanded that they be toasted. Accordingly, the testers cooked the marshmallows to the child's specifications prior to the test. The results of the CAPD re-evaluation with marshmallow reinforcement are shown in Table 1. Note that the CST scores bilaterally surged to 100 percent in the reinforcement condition and fell within the normative range for age. The magnitude of the improvement from the without reinforcement to reinforcement condition was 100 percent for the right ear and 40 percent for the left ear. Referral to the school psychologist for counseling was recommended.

CASE 2

The reported symptoms for this 10-year-old boy included short attention span, difficulty hearing in noise, auditory comprehension difficulties, and moderate reading difficulties. A CAPD evaluation was performed to rule out a CAPD as a contributing factor in the child's learning disability. The results of the initial CAPD evaluation are shown in Table 3. As for Case 1, the CAPD measures included the CST, FST, and BFT. Note that the scores bilaterally fell below the normative range for age on all of the measures on the initial CAPD evaluation. On the FST and BFT, performance was slightly poorer in the left than in the right ear. Based on these findings, in the presence of normal hearing sensitivity, the boy was diagnosed as having a CAPD, and resource-room educational services were recommended. The school had not yet implemented the recommendations of the resource-room educational services by the time that the parents had solicited the second-opinion consultation by the authors.

At the second-opinion CAPD consultation, which was performed approximately 1 month after the initial CAPD evaluation, the results of the audiologic evaluation revealed hearing sensitivity within normal limits with excellent suprathreshold speech-recognition scores bilaterally (Table 4). Because of time constraints, only one CAPD measure, the FST, was administered.

At the second-opinion CAPD re-evaluation, performance on the FST was very slightly improved in the right ear and declined in the left

Table 2 Pure-Tone Air-Conduction Thresholds, SRTs, and W-22 Scores for Case 1*

	Frequency (Hz)								
	250	*500*	*1000*	*2000*	*3000*	*4000*	*8000*	*SRT† (dB HL)*	*W-22 (%)†*
Right	10	10	5	0	5	0	0	10	80
Left	15	10	0	0	0	0	0	10	84

*Girl was 10 years of age at the time of this test.
†Recorded materials.

Table 3 Willeford Central Auditory Test Scores for Case 2

Test	Ear	Competing Sentences Unilateral Response (%)	Filtered Speech (%)	Binaural Fusion (%)
Normative range at 10 yrs		90–100 (strong) 90–100 (weak)	66–84 (LE) 64–82 (RE)	70–100 (LE) 70–100 (RE)
Initial*	Right	40†	60†	50†
	Left	40†	42†	40†
Second opinion: no reinforcement*	Right		64	
	Left		28†	
Second opinion: reinforcement*	Right		84	
	Left		80	

*Boy was 10 years of age at the time of this test.
†Score fell below normative range for age.

ear (see Table 3). The slight improvement in the right-ear score brought performance to within the normative range for age but the left-ear score remained below the normative range for age.

Given our findings with reinforcement with Case 1, the authors decided to repeat FST testing 3 weeks later under the reinforcement condition. In response to the query concerning the child's favorite edible treat, hobby, or toy, the mother indicated that her son loved to save quarters in order to see movies in the neighborhood. Accordingly, the child was informed that he would be given a quarter for each two words correctly repeated. The child shouted "yay!" and gave the examiner a "high five."

The results of the CAPD re-evaluation under the condition of reinforcement are shown in Table 3. Note that the FST scores bilaterally improved substantially in the reinforcement condition, becoming nearly equivalent and falling within the upper limits of the normative range for age. The magnitude of the improvement from the without reinforcement to reinforcement condition was 20 percent for the right ear and 52 percent for the left ear. Referral to the school psychologist for counseling was recommended.

CASE 3

The reported symptoms for this 8-year, 4-month-old boy included short attention span, distractibility, hyperactivity, auditory comprehension difficulties, and mild-to-moderate reading difficulties. A CAPD evaluation was performed to rule out a CAPD as a contributing factor in the child's learning disability. The results of the initial CAPD SCAN Screening Test for Auditory Processing Disorders are shown in Table 5. Note that each subtest (Competing Words, Filtered Words, and Auditory Figure Ground) score reflected performance at two or more standard deviations below the mean for age. A CAPD was diagnosed and the child was placed in a resource class for learning-disabled children with CAPDs.

Approximately 9 months after the initial CAPD evaluation, the child's mother sought a second-opinion consultation from the authors. At the second-opinion consultation, which was performed when the child was 9 years, 1 month of age, the results of the audiologic evaluation revealed hearing sensitivity within normal limits with excellent suprathreshold speech-recognition scores bilaterally (Table 6). Because of time constraints, only two CAPD measures,

Table 4 Pure-Tone Air-Conduction Thresholds, SRTs, and W-22 Scores for Case 2*

	Frequency (Hz)								
	250	500	1000	2000	3000	4000	8000	SRT† (dB HL)	W-22 (%)†
Right	5	0	5	0	5	0	0	5	88
Left	5	0	10	5	0	0	0	0	92

*Boy was 10 years of age at the time of this test.
†Recorded materials.

Table 5 Case Raw Scores (RS) and Standard Scores (SS) on the SCAN

Test	*Right-Ear RS*	*Left-Ear RS*	*Total RS*	*SS*
Initial*				
Competing Words	20	10	30	3†
Filtered Words	11	8	19	3†
Auditory Figure Ground	11	10	21	4‡
Second opinion: no reinforcement§				
Competing Words	20	12	32	3†
Filtered Words	10	7	17	3†
Second opinion: reinforcement§				
Competing Words	40	38	78	9#
Filtered Words	16	18	34	10#

*Boy was 8 years, 4 months of age at the time of the initial test.
†SS reflects performance at 3 standard deviations below the mean.
‡SS reflects performance at 2 standard deviations below the mean.
§Boy was 9 years, 1 month of age at the time of the second-opinion test.
#SS reflects performance within ±1 standard deviation of the mean (SS between 7 and 13 falls within ±1 standard deviation of the mean SS of 10).

Competing Words and Filtered Words, were administered at 50 dB SL re: SRT.

At the second-opinion CAPD re-evaluation, performance remained at three standard deviations below the mean for the Competing Words and Filtered Words subtests (see Table 5). No significant ear advantage was found for either the right-ear-first or the left-ear-first conditions.

The Competing Words and Filtered Words subtests were repeated 3 weeks later under the reinforcement condition. In response to the query concerning her child's favorite edible treat, hobby, or toy, the mother indicated that her son loved baseball cards. Accordingly, the child was instructed that he would be given a baseball card for each two words repeated correctly. The results of the CAPD re-evaluation under the reinforcement condition are presented in Table 5. The standard score for the Competing Words subtest reflected improved performance to within one standard deviation below the mean for age and was close to the normative mean for age. The standard score for the Filtered Words subtest also reflected improved performance and fell at the normative mean for age. No significant ear advantage was obtained for either the right-ear-first or left-ear-first conditions.

DISCUSSION

Case 1 had central auditory test scores that fell below normative limits on all measures at the initial evaluation. Slightly better performance was obtained for the left than for the right ear on the CST measure. Upon retesting without reinforcement, performance remained below normative limits on the CST and there was marked deterioration in the right-ear score. When testing was repeated with reinforcement, maximal scores were obtained. Case 2 had central auditory test scores that fell well below normative limits on all measures at the initial evaluation. Upon retesting without reinforcement, performance remained essentially unchanged in the right ear and slightly declined in the left ear. The right-ear scores were better than the left-ear scores at the initial test and retest without reinforcement on the FST

Table 6 Pure-Tone Air-Conduction Thresholds, SRTs, and W-22 Scores for Case 3*

	Frequency (Hz)							*SRT†*	*W-22†*
Ear	*250*	*500*	*1000*	*2000*	*3000*	*4000*	*8000*	*(dB HL)*	*(%)*
Right	0	5	0	0	10	0	5	5	92
Left	0	5	5	0	5	15	15	5	96

*Boy was 9 years and 1 month of age at the time of this test.
†Recorded materials.

measure. When testing was repeated with reinforcement, scores improved to well within normative limits, and the ear advantage had essentially disappeared. Case 3 had central auditory test scores that fell well below normative limits on all measures at the initial evaluation. No significant ear advantage was observed. Upon retesting without reinforcement, performance remained well below the normative limits on the Filtered Words and Competing Words subtests. When testing was repeated with reinforcement, the scores improved to meet or approach the mean for age. In all three cases, analysis of the errors failed to reveal any error pattern, consistent with the findings reported by Bellis and Ferre (1999).

In all three cases, due to time constraints, only limited second-opinion testing could be given. The limited time was not related to any patient fatigue. For Case 1, the test selected for retest was the test on which the worst performance had been obtained at the initial test. For Case 2, the test selected for retest was the one with the largest asymmetry at the initial test. In Case 3, the two tests selected for retest were those on which the worst performance had been obtained at the initial test.

These cases are not selected cases. They represent all of the CAPD cases referred to the authors over a 5-year period. In all three cases, there was a marked improvement in the scores under the reinforcement condition, as compared with scores in the condition without reinforcement. These findings suggest that the reduced performance on central auditory processing tests under the condition of no reinforcement reflected lack of motivation in these children; with reinforcement, the children were motivated to attend to the speech-recognition test under adverse listening conditions. If a child truly has a CAPD, then motivation should not have improved the score to within normative limits. The reduced central auditory test scores upon initial testing and normal-for-age scores upon retesting with reinforcement further suggests that these children initially presented false-positive results on the central auditory processing tests. Because of the discrepancy between performance without reinforcement and performance with reinforcement, counseling was recommended.

It is unlikely that a learning effect accounted for the improvement in these children for the following reasons:

1. The improvement was substantial in all cases;
2. There was a 3-week interval between the retest without reinforcement and the retest with reinforcement;
3. Improvement was seen only between the retest without reinforcement and retest with reinforcement and did not occur between the initial test and retest without reinforcement.

If, in fact, the improvement reflected a learning effect, then the results of numerous CAPD studies that had been reported in the literature using test–retest designs must be re-evaluated in light of such an effect.

Follow-up contact could be established for only one of these children. The mother of Case 2 indicated that the child was doing well in a regular classroom and was not receiving any resource-room services. The child had received psychological counseling from the school psychologist over a 1-year period.

Further studies are needed to evaluate the role of motivation in attending to speech-recognition tests, under adverse listening conditions, in children with significantly reduced central auditory test scores. The finding that motivation was a factor accounting for the reduced scores in these subjects has enormous ramifications for detection of CAPDs. Of the children who have been labeled as having a CAPD under the standard condition of no reinforcement, what percentage would have yielded normal performance on CAPD testing under the condition of reinforcement? It is disconcerting to consider that numerous children may have been misidentified as having a CAPD because of a motivational problem affecting their ability to attend to a CAPD test, and that these children are receiving inappropriate management and school placement.

These findings also raise the question of lack of motivation on test performance in children who have been diagnosed as having learning disabilities without, as well as with, CAPDs.

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