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Abstract

We hypothesized that the Digit Span (DS) subtest and component tasks (Wechsler, 1991) would show strong relationships with a dichotic listening test (Musiek, 1983). In two sets of archival clinical data ($N = 74$ and $N = 51$) we demonstrated that: (a) individuals with central auditory deficits had lower DS scores, $F(1, 72) = 7.34$, $p = .008$; $\eta^2 = .09$; and (b) left-ear dichotic deficits impacted forward span, $F(2, 48) = 8.45$, $p = .001$. Right-ear dichotic listening performance also accounted for significant variance in digit forward span ($R^2 = 0.17$, $p = .003$). While limited in scope, the studies conclude that forward but not reverse span performance is strongly related to dichotic listening, and can serve as a marker for possible central auditory deficits.

Central auditory processing disorders (CAPDs), defined as "deficits in the information processing of audible signals not attributed to impaired peripheral hearing sensitivity or intellectual impairment" (ASHA, 1996), are thought to disrupt the continuous auditory processing of acoustic, phonetic, and linguistic information. However, little is known from a neuropsychological perspective about this symptom cluster that has been recently identified and named in the audiology literature. Given the posited disruption between peripheral hearing and higher cognitive function, CAPDs can have a broad effect on information processing downstream from sound reception to discourse understanding. In children,

this disruption has been associated with a variety of functional problems, including difficulties with selective attention, temporal processing problems, auditory memory, and sound blending (Jerger & Musiek, 2000). While it may be logical to posit an underlying auditory processing deficit contributing to many neuropsychological profiles or clinical disorders, the relationship between auditory-sensory deficits and clinical disorders is not well understood (Chermak, 1996). For example, two studies examining the comorbidity of CAPD and Attention-Deficit/Hyperactivity Disorder (ADHD) demonstrated substantial overlap of clinical profiles but independence of diagnoses (Chermak, Hall, & Musiek, 1999; Riccio, Hynd, Cohen, Hall, & Molt, 1994). In these studies, ADHD was associated with more global disruption of sensory information processing, while CAPD was only associated with disruption of auditory information. Further, some data suggests that these CAPDs can be successfully rehabilitated (Musiek, 1995, 1999), lending some credibility to the construct as a viable entity. Given the limited research to date on relationships between psychiatric disorders such as ADHD and CAPD, the existence of central auditory processing disorders as an independent phenomenon continues to be hotly debated (Cacace, 1998; Kraus, McGee, et al., 1996).

Psychologists may have difficulty incorporating the putative CAPD construct within their own theoretical frameworks. One reason for this is limited data demonstrating relationships between standardized psychometric measures and the behavioral audiology tests used for assessing central auditory function. Audiologists rely on psychophysical procedures that are often not standardized in the same manner as psychological tests, with limited age-referenced norms, known reliability properties, and evidence of validity. This limits the ability of researchers and clinicians alike to examine associations between such audiologic measures and psychological measures. Yet an understanding of these associations would be an important source of evidence for validity based on convergent data from different methods and perspectives (Campbell & Fiske, 1959).

To begin exploring the overlap between the construct of CAPD and neuropsychological function, we examined two available data sets with both psychometric and central auditory processing evaluation data. These pilot studies were intended as modest steps in establishing evidence, or lack thereof, of relationships between standard tests used to detect central auditory dysfunction and similar psychometric tests. Our preliminary investigation was intended to provide a neuropsychological perspective on a basic procedure used to assess auditory function and the diagnostic entity CAPD itself.

One of the more robust and most commonly used measures of central auditory function is the dichotic listening paradigm (Musiek, 1983). Dichotic listening tasks involve presentation of stimuli to both ears simultaneously. The patient's task is to report either all stimuli heard (binaural) or to report stimuli presented only to one ear while ignoring stimuli presented the other ear (monaural). These measures have been shown to be sensitive to interhemispheric transfer of information via the corpus callosum, based on split-brain studies (Musiek, Kibbe, & Baran, 1984; Musiek, Kurdziel-Schwan, et al., 1989), as well as brainstem and cortical function (Jerger, 1975; Katz, 1962; Kieth, 1977; Musiek, 1983; Willeford, 1994). Although there is a long history of research with the dichotic listening paradigm in neuropsychology (e.g., Kimura, 1967; Springer, 1986), this paradigm has been used primarily for

research and to detect language dominance. It has also been used clinically as a noninvasive test to complement invasive techniques used in evaluating epilepsy surgery candidates (Christianson, Nilsson, et al., 1989).

A few studies have examined relationships between dichotic listening tasks and other psychometric tests. Parkinson (1994) found that approximately 70–80% of the variance in a dichotic digit task was accounted for by digit memory in a college student population. Students were instructed to attend to digits presented in one ear at a time across several trials, then asked to recall as many numbers as they could in order of presentation. The author posited that students with greater digit memory span performance had more spare processing capacity to address the dichotic listening task demands. Parkinson's paradigm, however, did not compare a separate test of span memory, but instead recorded the spans of numbers repeated from the dichotic listening trials.

In a study of reading disordered and nonreading disordered college students, Watson and Miller (1993) used number and letter span tasks together with a battery of auditory processing tests, not including dichotic listening. Performance on the span tasks was modestly related (r = .22 to .39) to speech perception and nonsense word decoding on a staggered spondaic word test and a temporal processing test.

As a measure of auditory short-term, or immediate memory, forward span capacity has a long history in psychology. Although there is much evidence demonstrating that forward and backward span performances and operations are correlated (Daneman & Merikle, 1996; Groeger, Field, & Hammond, 1999), the two span tasks are dissociable (Engle, Tuholski, et al., 1999). The forward span process is language related (Paulesu, Frith, & Frackowiak, 1993) and has been described as the "phonological loop" or "articulatory loop" (Baddeley, 1992). This loop theoretically maintains information in short-term or immediate memory store. The digits reversed or backward procedure requires additional processing demands to manipulate the information, scaffolding onto the forward process (Torgesen, 1996). Rudel and Denkla (1974) hypothesized that the digits forward procedure makes greater demands on auditory processes than does the reverse procedure, which likely involves visualization of the numbers and greater working memory demand.

The need to assess span tasks as separate cognitive functions has long been suggested (Kaplan, Fein, et al., 1991; Rudel, 1974). Farrand and Jones (1996) experimentally demonstrated the involvement of different processes in forward versus backward digit recall across several modalities, noting that recall for digits in reverse order was significantly worse than in forward order in both spatial and verbal modalities. Groeger et al. (1999) examined processes underlying forward and reverse auditory, visual, and motor span tasks. They found that forward and reverse span performances were highly correlated regardless of presentation modality. While forward span performance was related to memory, however, reverse span performance was strongly related to factors other than memory, including general intellectual ability and executive function. Hale et al. (2002) found that reverse digit span was substantially more predictive of attention and executive function than forward digit span, and Reynolds (1997) demonstrated that forward and backward digit span tasks load onto separate factors. In addition to psychometrically based support for separating forward from backward span tasks, functional imaging stud-

ies have demonstrated different areas of activation for these tasks, with dorsolateral prefrontal activation obtained during backward span tasks but not forward span tasks, consistent with greater working memory demand in the former (Hoshi, 2000; Larrabee, 1986).

On the surface, there is considerable overlap in functional demand between dichotic listening tasks and digit span tasks. Both are auditory tasks typically presenting numbers for stimuli and relying on verbal output responses. Some element of short-term memory is required for both. However, the Dichotic Digits test used in audiological evaluation for CAPD requires a maximum span of four numbers presented within 2 s, whereas span length increases in digit span tasks used in psychometric assessment. Physiologically, both are known to activate auditory nerves and processes in the temporal lobe. Given the similarities between the tasks, overlap between the measures might be expected. Further, the Dichotic Digits task may be the more "basic" measure of auditory processing as it is a relatively simple task with clear association to auditory-sensory function and parameters that are held constant over multiple trials. The forward digit span task, on the other hand, has increasing demands across trials, requires concomitant increases in verbal response. Reverse digit span tasks likely place the greatest demand on function, requiring mental manipulation in working memory along with increasing reliance on span and on verbal responses.

This paper presents analyses of two different data sets including children evaluated audiologically in a program for evaluating CAPD, and children who were evaluated for neuropsychological impairments but who also were administered the dichotic listening task. These datasets were available as convenience samples and were seen as pilot studies of relationships between Digit Span (DS) and Dichotic Digits (DD).We hypothesized that significant relationships exist between DD as a measure of central auditory processes (CAPD) and Digit Span (DS), a standard psychometric test of aurally based short-term and working memory. We further hypothesized that unilateral auditory deficits on DD reflect less interference with auditory processing and would impact more basic cognitive function such as forward digit span, while bilateral deficits would be associated with increased cognitive dysfunction on both the simpler forward digit span and the more demanding backward digit span task. Impaired processing limited to one ear was expected to impact basic sensory processing function. Bilateral difficulties were expected to be reflected in these same basic functions, but also in more demanding cognitive processes involving executive functions (i.e., working memory).

Specifically, we hypothesized that there are measurable relationships between tests sensitive to central auditory function and auditorially dependent psychometric tests such that:

1. Auditory processing deficits will interfere with Digit Span performance – Children independently diagnosed with CAPD will exhibit lower overall DS scores collapsing across forward and backward tasks;

2. Children with impaired DD performances will have lower scores on DS than children with normal DD performances;

3. Children with bilateral deficits in DD performance reflecting greater impairment in auditory processing will have lower DS scores than children with only unilateral (left or right) deficits in DD performance;

4. Left-ear DD deficits will be associated with more limited short-term memory, or span, as measured by forward span but not more complex working memory deficits as measured by backward span;

5. Bilateral DD deficits will interfere with auditory processing to the extent that both forward and backward digit span tasks are affected.

Study 1

Method

Participants

A retrospective review of medical records was completed for children and adolescents seen for central auditory processing evaluation in an audiology program. Inclusion criteria included: (1) child aged 7–15 years; (2) the Dichotic Digits test was administered as part of the CAPD battery (Musiek, 1983); (3) the Digit Span subtest of the Wechsler Intelligence Scale for Children, 3rd Edition (WISC-III; Wechsler, 1991) was completed within 1 year of the CAPD evaluation and scaled scores were available in the medical record. Children were included regardless of outcome of the central auditory processing evaluation. CAPD diagnoses were based on a comprehensive central auditory processing disorders assessment. Failure on the DD test was not required for CAPD diagnosis. Overall, 48 of the 74 children who met inclusion criteria, or 65% of the sample, were diagnosed with CAPD. Age, sex, and diagnosis are presented in table 1.

Table 1. Participants by Age, Sex, CAPD Diagnosis, and Dichotic Digits Performance

					Dichotic Digits Performance			
Age	Male	Female	Total	CAPD diagnosis	Pass Both	Fail Left	Fail Right	Fail Both
7	4	2	6	3	4		1	1
8	9	9	18	12	10	2	4	2
9	16	2	18	11	14	4		
10	7	5	12	8	7	2	2	1
11	6	2	8	5	3	2	1	2
12	4	1	5	3	3	1		1
13	3	1	4	4		3		1
14	1	1	2	1	1			1
15	1		1	1	1			
Total	51	23	74	48	43	14	8	9

Measures

The DD test is a well-known standardized test of dichotic listening that is a mainstay of CAPD evaluations. DD is considered one of the more robust measures of CAPD (Jerger, 2000). Participants were presented with auditory stimuli over laboratory headphones calibrated to 50 db HL. Stimuli were discordant, or different, pairs of numbers presented simultaneously to both ears. Each of 20 trials was presented, with each trial consisting of one

presentation of the two number pairs simultaneously for a total of 40 stimuli. Scores were calculated as the percentage correct for each ear. Omitting a number or reporting the wrong number were considered errors. All DD raw scores were transformed to standard scores (*z*-scores) based on published means and standard deviations for the age at testing (Musiek, 1983).

The DS test produces a standard score based on performance on two tasks: repeating increasing strings of numbers verbatim forward (DSF), and repeating increasing strings of numbers in reverse order (DSR). The separate raw scores are combined and transformed to an age-referenced value with a mean of 10 and standard deviation of 3.

Diagnoses of CAPD were provided by a clinical audiologist with specific expertise in CAPD evaluation. The diagnostic algorithm required impaired performance (greater than 2 standard deviations below expectation) on at least two tests for a diagnosis of CAPD as recommended by Jerger and Musiek (2000). Differential diagnosis considered typical test factors (e.g., motivation, medications, fatigue, attention, motivation, native language) as well as auditory neuropathy and hearing sensitivity. The minimal CAPD battery included pure-tone audiometry to identify peripheral hearing loss that might confound CAPD diagnosis, word recognition tests over a wide range of speech levels, the Dichotic Digits test, a duration pattern sequencing test, and a gap detection test (both measures of temporal processing). In the available data set, no diagnostic subtyping was provided (only CAPD or no-CAPD). For some children, CAPD diagnosis was based on failure on two tests including the DD test, while for other children the diagnosis was based on failure of two tests other than the DD test.

Results

Before examining the specific hypotheses, the influence of overall cognitive ability was examined as a potential confound. General intellectual ability is often an important covariate in studies involving psychometric measures. Some participants in the sample were administered the Differential Abilities Scales (DAS; Elliot, 1990) while others were administered the WISC-III. Given the similarities in measurement and the strong correlations between the two standardized batteries at the global level (*r* = .85; Dumont, Cruse, Price, & Whelley, 1996), intellectual scores of the two instruments were combined to examine possible systematic differences between children diagnosed with CAPD and children evaluated but not diagnosed. This analysis was independent of both Digit Span and Dichotic Digits as neither is included in computation of IQ summary measures. In this sample, the mean global IQ score was 97 (*SD* = 15) and ranged from 63 to 130. There was no difference in global IQ scores between the two diagnostic groups, $F(1, 72) = 1.16$, $p = .29$.

In the first analysis of group differences, mean DS scores for children diagnosed with CAPD were compared with DS scores for children evaluated but who did not meet criteria for diagnosis of CAPD. Analysis of variance revealed a significant difference between groups on DS scores, $F(1, 72) = 7.34$, $p = .008$; $\eta^2 = .092$. Children diagnosed with CAPD had lower DS scores (*M* = 7.81, *SD* = 2.86) than children who did not meet diagnostic criteria (*M* = 9.65, *SD* = 2.671). Figure 1 shows the cumulative percentages of Digit Span scores at or below each possible score for children with and without CAPD diagnosis. Eighty-one

percent (81%) of children with Digit Span scores below 7 (< 16th percentile) had positive CAPD diagnoses.
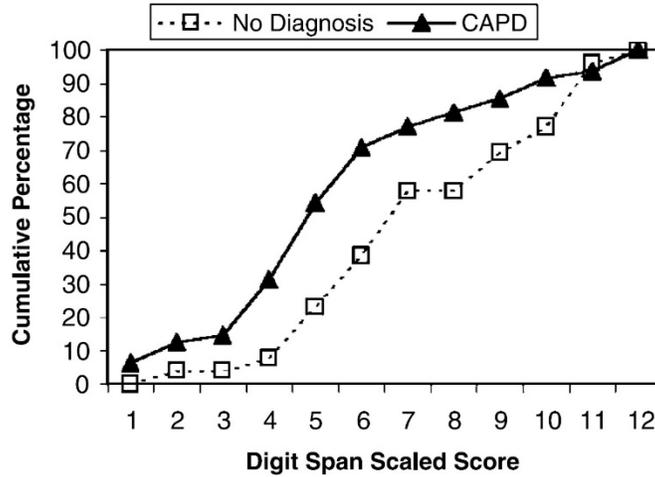
Figure 1. Cumulative percentages of Digit Span scores for children with and without CAPD.

To examine the second hypothesis, that DS test performance would vary with severity of DD test performance, children were stratified based on DD test performance: average performance for both ears (Pass Both; N = 43), left-ear impaired (Fail Left; N = 14), and right-ear impaired combined with both ears impaired (Fail Both; N = 17). Because very few participants failed only in the right ear (N = 8) or both ears (N = 9), these two groups were combined, comprising a single group of children who had right-ear impairments in common. This combination increased power and allowed comparison of those with right-ear deficits on the Dichotic Digits task with children with good right-ear performances but poor left-ear performance. There was an overall effect for DD performance group, $F(3, 70)$ = 5.42, p = .002, η^2 = .19. Planned contrasts showed that the Fail Both group performed significantly worse (M = 6.65, SD = 2.60) than both the Fail Left (M = 7.93, SD = 3.34) and the Pass Both groups (M = 9.35, SD = 2.54). There was no difference between these latter two groups.

Summary

Analysis of data collected from a series of CAP evaluations supported the first three hypotheses: namely, poor performance on Digit Span is a robust characteristic of children diagnosed with CAPD, children with impaired performance on the Dichotic Digits test had lower scores on Digit Span than children with normal DD performances, and Digit Span scores were significantly worse for children with bilateral DD performance deficits than for those with only unilateral or no deficits.

The limited detail available in the data set prevented analysis of the fourth and fifth hypotheses—that forward and backward digit span tasks are associated differently with

dichotic digits tasks. There is strong support for separating forward from backward digit span tasks, as the multifactorial nature of the combined Digit Span score may obscure important relationships. Study 2 attempted to disentangle forward and backward span performances and confirm hypotheses four and five.

Study 2

The purpose of study two was to explore the multifactorial Digit Span subtest and compare the digits forward and digits backward tasks in the context of the Dichotic Digits test. We hypothesized that unilateral, left-ear deficits in performance on Dichotic Digits would negatively impact digit span forward performance (DSF) but not digit span reverse (DSR). This assumed that unilateral deficits would affect only simple memory span as reflected in DSF. As impairment increases with bilateral deficits, however, higher order functioning, such as working memory, might be jeopardized, as reflected in DSR. Hypothesis 5 proposed that deficits in DD performance for both ears would have an impact on both DSF and DSR.

Method

Participants
A second archival data set was examined that provided DD data as well as DSF and DSR scores. Clinical data was analyzed from patients who completed neuropsychological evaluations in the first author's laboratory and had been administered the DS and DD tests as part of the evaluation protocol. The record review identified 51 cases (39 boys, 12 girls) aged 7–17 years ($M = 11.3$, $SD = 2.8$) with appropriate and complete data. Twenty-two participants passed the DD test bilaterally, 18 failed the left ear only, and 11 failed both ears. No participants failed only the right ear. Global IQ scores ranged from 63 to 130 ($M = 99$; $SD = 16$). A variety of clinical diagnoses were represented in the sample, including reading disabilities (40%), Attention-Deficit/Hyperactivity Disorder (30%), PDD/Asperger's Syndrome (20%), Mood disorders (16%), Anxiety disorders (13%), Conduct Disorder (3%), and language impairments (3%). Due to comorbid diagnoses, the total is more than 100%. CAPD diagnoses were not available for all cases and were not analyzed in this study.

Measures
The same Dichotic Digits (DD) and Digit Span (DS) tests used in the first study were examined in Study 2. However, raw Digit Span scores were available, enabling separate analysis of the maximum forward spans (DSF) and maximum reverse spans (DSR). The DS test from the WISC-III is two separate tasks: the first requires the participant to repeat increasingly long strings of numbers verbatim (DSF) while the second requires repetition of increasingly long strings in reverse order (DSR). Age-based normative means and standard deviations for maximum span lengths of DSF and DSR, as provided in the WISC-III manual (Wechsler, 1991), were used to compute standard scores (*z*-scores).

Results

There were no differences between the DD groups on global IQ score, $F(2, 48) = 1.80$, $p = .18$. The third and fourth hypotheses were addressed via MANOVA. *z*-scores for DSF and DSR were entered as dependent variables in a MANOVA with DD group as the between subjects factor (Pass Both, Fail Left, Fail Both). The multivariate test was significant, $F(2, 48) = 8.45$, $p = .001$, $\eta^2 = .27$. Examination of the univariate results revealed a significant difference between groups on both DSF, $F(2, 48) = 6.78$, $p = .003$, $\eta^2 = .22$, and DSR, $F(2, 48) = 3.63$, $p = .043$, $\eta^2 = .12$. Planned contrasts revealed a different pattern of performance on DSF and DSR by DD performance. For DSF, both the Fail Both and Fail Left groups had significantly lower scores ($p < .01$) than the Pass Both group. Although the Fail Both group was somewhat lower than the Fail Left group, the difference was not significant. For DSR scores, there was no difference between the Fail Left and Pass Both groups but the Fail Both group was significantly lower than the Pass Both group ($p = .023$). Figure 2 illustrates DSF and DSR performance by DD group.
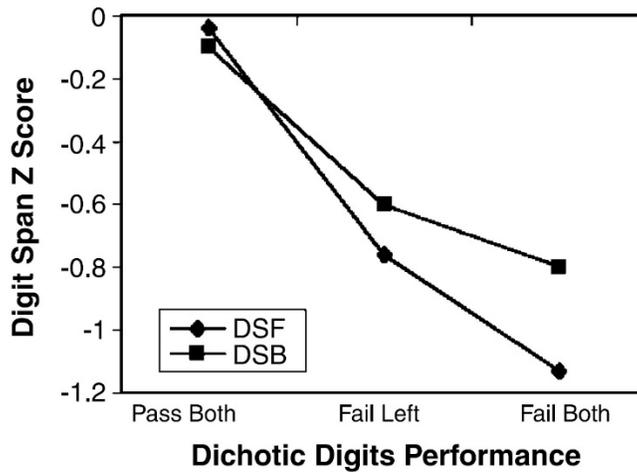
Figure 2. Mean forward and backward Digit Scores for Pass Both, Fail Left, and Fail Both Dichotic Digits Performance Groups.

Without a right-ear only deficit group on DD it was not possible to directly compare right-ear only with left-ear only effects on DS tasks. Only the group that failed DD bilaterally exhibited deficits in right-ear performance. To examine the relative influence of left versus right-ear DD performance on digit span tasks, raw scores for right-ear and left-ear DD performance were entered as predictor variables in a regression analysis with DSF and DSR as dependent variables. Right-ear scores were entered first because most individuals demonstrate a right-ear advantage on the DD task, and because the Fail Both group performed worse than the Fail Left group. The right-ear DD scores accounted for significant variance in DSF scores, $\beta = 0.15$, *SE* $\beta = 0.05$, Standardized $\beta = 0.41$, $t = 2.61$, $p = .003$. No significant additional variance was accounted for by the left ear. However, when only left-

ear scores were entered, there was a significant relationship ($\beta = 0.06$, *SE* $\beta = 0.24$, Standardized $\beta = 0.35$, $t = 2.61$, $p = .012$). Left-ear function was related to DSF only in the presence of a normal right-ear functioning. Right-ear functioning accounted for the majority of performance deficits on DSF. Somewhat surprisingly, DD performance for either ear did not explain a significant amount of variance in DSR scores.

Summary

Consistent with previous assertions (Rudel & Denckla, 1974), forward and reverse digit span tasks reflect different cognitive processes. The present data indicate that individuals with left-ear deficits on a dichotic listening task had lower forward span scores than normal controls but not lower reverse span scores. Groups with bilateral impairments, however, showed deficits on both forward span and reverse span tasks.

Regression analyses demonstrated that right-ear performance on dichotic listening explained the most variance in forward span performance. While left-ear deficits on dichotic listening accounted for some variance in forward span, it was less than right-ear deficits and did not account for additional variance beyond that explained by the right-ear. However, while groups of individuals with bilateral impairments on the dichotic digits task performed worse on reverse digit span, there was not a strong relationship between either right- or left-ear dichotic listening and reverse span.

Discussion

Analysis of two separate clinical data sets revealed strong relationships between performance on standard dichotic listening and digit span tasks. Overall, groups of clinically referred children who were diagnosed with CAPD had lower Digit Span scores than children who were evaluated but did not meet criteria for CAPD. Further, Digit Span scores varied with performance on the Dichotic Digits task: individuals who passed the DD task for both ears or at least the right ear had higher DS scores than those that failed DD for the right ear or both ears.

Analysis of the forward and reverse span components of the Digit Span task showed that poor forward span and impairment on Dichotic Digits for either or both ears tend to co-occur. Poor reverse span, however, was associated only with impairment in both ears on the Dichotic Digits task. Regression analyses demonstrated that right-ear scores were the best predictor of digit span forward, with left-ear deficits explaining significant variance only in the presence of a normal functioning right ear. Reverse digit span was related to dichotic listening scores at the group level: individuals with impaired bilateral performance on DD had lower DSR scores. However, neither right nor left DD scores accounted for significant variance in DSR scores. This suggests that factors other than dichotic digits are needed to explain variance in reverse digit span as suggested by Groeger (1999).

The possibility that attention deficits impact both DD and DS performance cannot be ruled out in this study. Attention problems may obscure or mediate performance on both tasks and the relationships between the tasks. While the independence of CAPD and ADHD continues to be debated, some previous research supports the independence of the two symptom clusters (Chermak, Hall, & Musiek, 1999; Riccio et al., 1994). The audiology

field views CAPD as a contributor to the presentation of a range of clinical disorders and asserts that auditory processes underlie many clinical disorders, such as ADHD.

We make no claim about the validity of CAPD as a diagnostic entity in this paper. Instead, we suggest only that one of the more robust measures of auditory function has a strong relationship with short-term auditory memory and, to a lesser degree, with auditory working memory. In so doing, we hope to find measures with which to better understand and to support or refute the validity of CAPD from a neuropsychological perspective. To date, diagnosis of this disorder is primarily audiological and relies on tests and measures unfamiliar (and often unavailable) to neuropsychologists. The validity of the CAPD diagnosis, and its acceptance across disciplines, will rest on validation through the use of multiple measures to form a nomothetical net that is meaningful across disciplines. To date, however, few studies have examined CAPD from a neuropsychological perspective or considered the contribution of cognitive functions to the CAPD presentation. For example, the role of short-term auditory memory and working memory has not been described in the CAPD literature, but the present data suggest that such basic cognitive functions should be taken into consideration.

A related issue is the subtyping of CAPD. Theoretical work posits that there are several subtypes, with attention more related to one subtype than to other subtypes of CAPD (Bellis & Ferre, 1999). It is likely that CAPD represents several distinct functional entities that are not yet defined.

The present study is limited in several respects. First, it relied on data from archival clinical samples that included a wide range of psychiatric diagnoses. Given the small sample sizes, it was not possible to examine test performance or relationships between tests by psychiatric diagnosis. Second, the small number of children with deficits only for the right ear on dichotic listening prevented direct examination of left- versus right-ear deficits. Third, there was inconsistency in the number and scope of measures available in the archival data, with data available for both Dichotic Digits and Digit Span tests in the cases included in the study. As such, comparison of the larger range of measures typically administered in both neuropsychological evaluations and audiological evaluations was not possible. Within the limited bounds of the present study, results support further exploration of relationships between behavioral measures of CAPD and standard psychometric tests. Larger sample sizes would improve the generalizability of findings, and inclusion of control groups would enhance examination of construct validity and allow for model building.

From a clinical perspective, the role of short-term memory has not been described in the CAPD literature, but as our data show should now be taken into consideration. Not only should this help establish construct validity for this diagnosis, but clinical findings of impaired auditory short-term memory, particularly in relation to auditory working memory, might prove to be a sensitive sign indicating the need for central auditory evaluation.

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