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Learning and Memory Performance of Children with Specific Language Impairment (SLI)

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The purpose of this study was to examine learning and memory in children with Specific Language Impairment (SLI) as compared to 30 normally functioning children on the Children's Memory Scale. Results indicated that children in the SLI group exhibited impaired performance on the Attention/Concentration Index (working memory), as well as significantly lower scores on both the immediate and delayed auditory/verbal indices and subtests relative to the control group. In contrast, no between group differences emerged for the visual/non-verbal indices and subtests. Results demonstrated that children with SLI possess normal ability to process, maintain and manipulate visual/non-verbal information in working memory along with normal ability to store and retrieve visual/non-verbal material from long-term storage. These results provide support for the contention that children with SLI have a "diminished verbal capacity" to process, organize, and maintain auditory information in working memory.

Key words: auditory memory, specific language impairment, visual memory

Specific language impairment (SLI) is a developmental disorder defined by unexplained delayed language learning in children with normal global intellectual functioning, hearing acuity, and exposure (Stark & Tallal, 1981; Tomblin et al., 1997). Children with SLI typically exhibit limited vocabulary knowledge, underdeveloped or unusual syntax, and impaired grammatical morphology (Bishop, 1992). Depending on how it is defined, SLI occurs in approximately 3 to 15% of children ranging in age from 3 to 21 years (American Psychiatric Association, 2000; Leonard, 1998; Riccio & Hynd, 1993; Tomblin, Smith, & Zhang, 1997). In research, children with SLI are those children who exhibit a deficit in expressive and/or receptive language despite normal non-verbal ability (Bartlett, Flax, Logue, Vieland, Bassett, Tallal et al., 2002; Newbury, Bishop, & Monaco, 2005; Williams, Stott, Goodyear, & Sahakian, 2000). In the *Diagnostic and Statistical Manual of Mental Disorders-Fourth Edition-Text Revision* (DSM-IV-TR; American Psychiatric Association, 2000), there are three types of specific language disorders identified. These include Expressive Language Disorder, Mixed Receptive-Expressive Language Disorder, and Phonological Disorder. Expressive Language Disorder is the most prevalent language disorder among young children (Lewis, Freebairn, & Taylor, 2000) and is characterized by a child's limited ability to learn new vocabulary and restricted speech production. Children with Mixed Receptive-Expressive Disorder not only exhibit limited vocabulary, but also demonstrate comprehension difficulties. Receptive deficits have been linked with verbal short-term memory deficits as well as phonological processing problems in adulthood (Clegg, Hollis, Mawhood, & Rutter, 2005). Phonological Disorder is characterized by the child's inability to make age appropriate speech sounds. These language deficits hinder a child's ability to acquire new vocabulary contributing to

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deficits in global language learning and academic difficulties (Tallal, 2003, 2004).

An intact memory system is thought to be an essential component for language learning. Specifically, Baddeley, Gathercole, and Papagno (1998) asserted that short-term auditory memory, as represented by the phonological loop, has an important role in language acquisition and vocabulary development. Within this context, short-term auditory memory can be defined as the retention of small amounts of information over brief periods of time (Baddeley, 2000a). Working memory provides a system for holding (via rehearsal) and manipulating incoming information during the performance of a complex cognitive task (Baddeley, 2000a); thus, working memory requires one to attend to, concentrate on, and manipulate auditory information. Based upon clinical observation, Johnson and Myklebust (1967) were among the first to suggest that children with SLI had difficulty rehearsing verbal information. In addition, early research demonstrated that children with SLI experienced difficulty-repeating sentences of increasing length (Menyuk & Looney, 1972) and they performed more poorly on the Token Test as the length of the command increased (Tallal, 1975). Further, Cohen, Riccio, and Hynd (1999) demonstrated that children with SLI experienced deficient immediate auditory working memory as the linguistic/semantic demands of the tasks increased contrasted by spared immediate visual working memory.

In one of the first studies designed to examine learning and immediate recall (of pictured objects), Kirchner and Klatsky (1985) demonstrated that children with SLI had decreased verbal short-term storage "capacity" do to diminished ability to process, organize, and maintain information in working memory. The authors concluded that these children had "less capacity for verbal processing than normal children." More recent studies employing different list learning procedures such as the California Verbal Learning Test—Children's Version (CVLT-C; Shear, Tallal, & Delis, 1992) and the Rey Auditory Verbal Learning Test (Records, Tomblin, & Buckwalter, 1995), as well as a study that used a digit span backward test (Williams et al., 2000) provide further support for the "diminished verbal capacity" theory.

Deficits in auditory short-term memory and working memory not only hinder the language development of children with SLI but they also have been shown to place them at risk for inadequate academic achievement (Adams & Gathercole, 2000). Research has found that children with auditory short-term memory deficits have impaired expressive language ability (Cohen, Vallance, Barwick, Im, Menna, Horodezky et al., 2000), lagged behind their counterparts on standardized measures of language by 18 to 24 months (Gathercole & Baddeley, 1989, 1990), have difficulty learning the phonological form of new words (Baddeley, Papagno, & Vallar, 1988; Newbury et al., 2005; Trojano & Grossi, 1995), and exhibit deficits in retaining sequentially ordered information (Montgomery, 1996). Furthermore, phonological working memory and vocabulary growth were highly correlated (Gathercole, Willis, Emslie, & Baddeley, 1992), while working memory skills were shown to predict performance on phonemic awareness tasks in 7 and 8-year-old students (Oakhill & Kyle, 2000). Supporting the connection between auditory working memory ability, language development, and achievement, Gathercole and Pickering (2001) found that children with poor attainment on reading comprehension and vocabulary subtests on standard achievement tests at age 7 demonstrated significantly impaired performance on working memory assessment. Differences in auditory short-term memory have been found to be related to, and predictive of, vocabulary skills depending on the age of the subjects (Jarrold, Baddeley, Hewes, Leeke, & Phillips, 2004). In effect, the connection is greater for younger children and decreases after age 8 years.

While research to date appears to support the contention that children with SLI exhibit poorer performance on auditory short-term memory tasks and auditory working memory tasks, there is little research available that has looked at auditory long-term retention and visual/non-verbal learning and memory in this population. In the Shear et al. (1992) study, the children with SLI were not significantly impaired on the delayed free recall component (20 min delay) of the CVLT-C. This would appear to indicate that although the children with SLI were less efficient in learning the word list, their delayed recall of the list was not significantly below that of the normal children.

The present study was conducted in order to further examine the nature and extent of the learning and memory deficits in children with SLI. Children with SLI were administered the Children's

Memory Scale (CMS: Cohen, 1997) in order to evaluate their performance on tasks designed to not only assess auditory short-term memory and working memory, but their rate of learning and delayed recall (30 min) of auditory/verbal material as well as visual/non-verbal material. Although some of the information reported here is referenced in the manual for the CMS, this study further explored the data obtained with the clinical sample and expanded on the information reported previously. This study was undertaken to expand our understanding regarding the verbal capacity exhibited in children with SLI and to determine if these children have a more global deficit that involves their ability to process, maintain, and manipulate visual/non-verbal material, as well as verbal material.

Table 1. *Demographic Data*

	Specific Language Impairment (n = 30)	Normal Control Group (n = 30)
Ethnicity:		
African American	5	5
Hispanic	2	2
Caucasian	23	23
Sex:		
Male	16	16
Female	14	14
Parent Educational Level:		
≤ 8 years	1	1
9–11 years	1	1
12 years	12	12
13–15 years	6	6
16 + years	10	10
Age Range (years)	6–12	6–12
Mean (*SD*)	8.4 (1.7)	8.4 (1.7)

METHOD

Participants

The SLI group consisted of 30 children who were diagnosed and receiving services as SLI according to the State Department of Education/Special Education criteria for the child's home state. In addition, to be included in the study, each child with SLI was required to have normal vision and hearing, and cognitive ability within the average range as evidenced by a performance on the WISC-III PIQ or FSIQ (Wechsler, 1991), the Leiter International Performance Scale (Leiter, 1969), or the Test of Non-verbal Intelligence—2nd Edition (Brown, Sherbenou, & Johnsen, 1997) that was ≥ 85. Further, the children in the SLI group had to exhibit a one-standard-deviation (≥ 15 points) discrepancy from IQ on the Expressive Language Scale, Receptive Language Scale, or both from the Clinical Evaluation of Language Fundamentals —Third Edition (CELF-3; Semel, Wiig, & Secord, 1987). Finally, children were excluded if they exhibited any co-occurring psychopathology or had a diagnosed neurological disorder (e.g., epilepsy, Tourette's Syndrome). The control group ($n = 30$) was selected from the standardization sample for the CMS and matched for age, ethnicity, sex, and parent educational level. Comparison of the two groups using analysis of variance (ANOVA) and chi-square procedures indicated that the groups did not differ significantly ($p > .05$) on any of the demographic variables (see Table 1).

Procedure

Participants for both groups were recruited as part of the standardization process for the CMS. Psychologists were recruited and trained by The Psychological Corporation or the test author. These psychologists administered the CMS to the children with SLI and the control children in accordance with the standardization procedure outlined in the CMS manual.

Instrument

Children's Memory Scale (CMS: Cohen, 1997)

The CMS was developed to assess learning and memory in children and has been described as "a novel measure of new learning and memory" (Hildebrand & Ledbetter, 2001, p. 21). The CMS examines memory function in three domains: (a) Auditory/Verbal Learning and Memory, (b) Visual/Non-verbal Learning and Memory, and (c) Working Memory, Attention and Concentration. Each domain is comprised of several indices. Within the Core Battery, The General Memory composite score is derived from the Verbal and Visual Immediate and Delayed Memory indices scores and represents global memory functioning (Cohen, 1997). These indices are derived from combinations of subtests, some of which include delay and recognition components.

The standardization sample for the CMS consisted of 1000 U.S. children ranging from five to 16 years of age; the sample was stratified by age, sex, race/ethnicity, geographic region, and parents' education. Reliability coefficients were reported for all age groups across all subtests. Split-half reliability on the indices ranged from 0.76 (Visual Immediate and Visual Delayed) to 0.91 (General Memory). Test-retest reliability coefficients across indices ranged from 0.29 (Visual Immediate, ages 13–16 years) to 0.89 (Attention/Concentration, ages 9–12 years). The CMS General Memory Index produced a moderate, positive correlation across all areas of these cognitive abilities measures. Also, correlations between the CMS and academic achievement measures, language skills measures, and executive functioning measures produced moderate, positive relationships (Stein, 2001). Construct validity was demonstrated through confirmatory factor analysis that produced a three-factor model consisting of auditory/verbal, visual/non-verbal, and attention/concentration. Thus, the psychometric properties of the CMS are adequate.

RESULTS

Analysis of variance was completed across the eight CMS core battery indices (see Table 2). Results indicated that children in the SLI group exhibited significantly lower performance on the Attention/Concentration (auditory working memory) Index as well as on both the immediate and delayed auditory/verbal indices relative to the control group. In contrast, no significant between group differences emerged for the visual/non-verbal memory indices. Table 3 presents selected index comparison differences between the SLI and control groups. Analysis of variance revealed that the children with SLI did not exhibit significant performance differences between the immediate and delayed Verbal Indices or between the Verbal Delayed and Delayed Recognition Indices. The SLI group demonstrated a general tendency (non-significant) of lower Verbal Immediate versus Visual Immediate and lower Verbal Delayed versus Visual Delayed Indices providing additional support for the finding that the children with SLI exhibited performance decrements on the auditory/verbal indices contrasted by average performance on the visual/non-verbal indices.

A similar pattern was found when subtest performance was considered as well (see Table 4). The mean performance of children with SLI was significantly below that demonstrated by the control group (average) on both of the subtests comprising the Attention/Concentration Index (Numbers and Sequences) contrasted by an average performance on the Picture Locations subtest which did not significantly differ from that of the control group. Of the auditory/verbal subtests, the significant differences emerged only on story recall (immediate and delayed) and word lists (immediate), but not on word pairs (immediate or delayed). Effect sizes indicate large effects of group membership for those variables that were significant. Thus, with the exception of the Word Pairs subtest, children in the SLI group demonstrated a pattern of significant modality specific performance deficits (auditory/verbal subtests vs. visual/non-verbal subtests) on immediate or immediate and delayed components, as compared with the control group. As noted, when examining index differences, children with SLI consistently performed comparable to the control group on visual/non-verbal subtests, as well as on the visual/non-verbal indices. Taken together, the mean performance of the children with SLI was

Table 2. *CMS Index Means (Standard Deviations)*

CMS Index	Specific Language Impairment	Normal Control Group	*F*	Cohen's *d*	Effect Size (*r*)
General Memory	94.71 (17.72)	105.43 (13.23)	6.87	–	–
Attention/Concentration	85.63 (14.09)	100.77 (17.98)	13.17**	−0.94	−.42
Verbal Immediate	90.52 (15.13)	103.50 (17.19)	9.45*	−0.80	−.37
Verbal Delayed	90.21 (17.22)	102.77 (12.66)	10.24*	−0.83	−.38
Delayed Recognition	88.83 (17.42)	100.57 (13.17)	8.66*	−0.76	−.36
Visual Immediate	102.50 (15.13)	104.30 (13.46)	0.24	–	–
Visual Delayed	100.87 (15.18)	102.10 (13.87)	0.11	–	–
Learning	98.40 (13.92)	105.07 (15.07)	3.17	–	–

Note. CMS = Children's Memory Scale; adapted from M. J. Cohen, 1997.
$^{**}p < .001$; $^{*}p < .01$.

Table 3. *Selected CMS Index Differences: Means (Standard Deviations)*

Indexes Compared	Specific Language Impairment	Normal Control Group	*F*
Visual Immediate—Verbal Immediate	11.66 (18.30)	0.80 (23.72)	3.86
Visual Delayed—Verbal Delayed	10.69 (19.73)	−0.67 (17.79)	5.40
Visual Immediate—Visual Delayed	1.63 (10.84)	2.20 (10.68)	0.04
Verbal Immediate— Verbal Delayed	.54 (7.87)	0.73 (11.55)	0.006
Verbal Delayed—Delayed Recognition	2.07 (16.56)	2.20 (13.41)	0.001

Note. CMS = Children's Memory Scale.

significantly lower than that of the control group on immediate and delayed assessment of auditory/verbal memory contrasted by non-significant differences (average performance) on all of measures of visual/non-verbal memory.

DISCUSSION

The purpose of this study was to further examine the nature and extent of the auditory/verbal learning and memory deficits previously reported in children with SLI and to determine if these children have a more global deficit that involves their ability to process, maintain and manipulate visual/non-verbal material as well. As reported in previous studies (Cowan, 1996; Daneman & Merikel, 1996; Gathercole, Hitch, Service, & Martin, 1997; Menyuk, & Looney, 1972; Records et al., 1995; Shear et al., 1992; Tallal, 1975; Williams et al., 2000) children with SLI performed significantly below normal control children on measures of auditory/verbal short-term memory and auditory/verbal working memory supporting Kirchner and Klatsky's (1985) contention that children with SLI have a "diminished verbal capacity" to process, organize, and maintain auditory information in working memory.

Further, both the children with SLI and the control children performed better on verbal immediate as compared to verbal delayed recall. The expected decline from immediate to delay would support the

Table 4. *Selected CMS Subtest Means (Standard Deviations)*

CMS Verbal Subtests	Specific Language Impairment	Normal Control Group	*F*	Cohen's *d*	Effect Size (*r*)
Numbers	7.80 (2.62)	10.37 (3.35)	10.94*	−0.85	−.39
Sequences	7.50 (2.81)	9.90 (3.23)	9.42*	−0.79	−.37
Stories Immediate	7.41 (2.85)	10.10 (3.30)	11.15*	−0.87	−.40
Stories Delayed	7.59 (3.20)	10.07 (3.45)	8.17*	−0.75	−.34
Stories Delayed Recognition	8.30 (2.94)	9.30 (2.58)	1.97	–	–
Word Pairs Learning	9.47 (3.00)	11.03 (3.49)	3.48	–	–
Word Pairs Total (Learning + Immediate)	9.27 (2.95)	11.17 (3.87)	4.58	–	–
Word Pairs Delayed	9.20 (3.42)	10.83 (2.52)	4.44	–	–
Word Pairs Delayed Recognition	8.10 (4.36)	10.9 (2.68)	8.98*	−0.77	−.36
Word List Learning	8.30 (2.35)	11.37 (3.11)	18.54**	−1.11	−.49
Word List Delayed	9.27 (3.20)	10.53 (3.14)	2.39	–	–
Word List Delayed Recognition	8.60 (3.95)	10.83 (2.00)	7.62*	−0.71	−.34
CMS Visual Subtests					
Picture Locations	9.40 (2.93)	9.67 (3.12)	0.12	–	–
Faces Immediate	10.20 (3.09)	10.77 (2.81)	0.55	–	–
Faces Delayed	9.23 (2.91)	10.17 (2.45)	1.81	–	–
Dot Locations Learning	10.63 (3.03)	10.63 (3.59)	0.00	–	–
Dot Locations Total (Learning + Immediate)	10.20 (2.78)	10.50 (3.54)	0.13	–	–
Dot Locations Delayed	11.07 (2.95)	10.53 (3.31)	0.43	–	–
Family Pictures Immediate	9.60 (2.72)	10.53 (2.13)	2.19	–	–
Family Pictures Delayed	9.10 (3.08)	10.17 (2.34)	2.29	–	–

Note. CMS = Children's Memory Scale.
$^{**}p < .001$; $^{*}p < .01$.

earlier work of Shear et al. (1992) with the CVLT-C. Also of note is the finding that, although it is expected that the meaningful context of stories would support recall, children with SLI appeared to do more poorly on immediate story recall than they did on immediate recall of a list of word pairs or a list of words. This would suggest that the episodic buffer proposed by Baddeley (2000b) is not sufficiently intact or does not provide sufficient contextual support for children with SLI for recall. At the same time, however, children with SLI did better on story recognition than on word list recognition tasks, suggesting that the contextual support was sufficient for recognition.

Finally, this study demonstrates that children with SLI possess normal ability to process, maintain, and manipulate visual/non-verbal information in working memory with normal ability to store and retrieve visual/non-verbal material from long-term storage. Thus, the working memory system associated with the storage and retrieval of visual/non-verbal material (e.g., the visuospatial sketchpad of Baddeley's model) appears to be intact in children with SLI. It is not possible, based on these data, to determine if the differences on auditory/verbal memory tasks reflect a deficient phonological loop, or if deficient auditory/verbal processing impairs the encoding onto the phonological loop. Regardless, these finding would appear to indicate that intervention planning and programs that link verbal short-term memory with visual/non-verbal information may be useful with these children.

Taken together, these results provide support for the clinical usefulness of the CMS in the assessment of children with SLI. These finding clearly suggest that the CMS differentiates between children with SLI and normal functioning children providing useful clinical insights that can be incorporated into recommendations for remedial interventions at the classroom level for this population. In light of the risk for reading difficulties and below average academic achievement for children with SLI (Lewis et al., 2000; Swanson, 2000), future studies should consider using the CMS to identify possible memory deficits in young children with phonological awareness difficulties. Early identification of memory and language deficits should serve to expedite the development and implementation of appropriate remediation and possibly divert later academic difficulty or failure.

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