Neuropsychological Profiles of Children Diagnosed as Specific Language Impaired With and Without Hyperlexia

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This study compared the neuropsychological profiles of 46 children with Specific Language Impairment (SLI) and 16 children with SLI and Hyperlexia (SLI + H). The results indicated that the essential feature of Hyperlexia is Specific Language Impairment and not reading disability. Thus, Hyperlexia would be best conceptualized as a subgroup of Developmental Language Disorder rather than as a subgroup of Developmental Dyslexia. Further, the SLI + H group exhibited significantly better developed visual/spatial memory which, along with average visual perceptual skills, appears to be the major contributing factor to their elevated word recognition and spelling ability. Finally, it should be noted that both groups of children exhibited decreasing performance on tasks of immediate auditory/verbal memory as the language/semantic demands of the memory task increased. This finding appears to be the result of a limited capacity for immediate verbal processing and not the result of a deficit in verbal learning and recall. © 1997 National Academy of Neuropsychology

INTRODUCTION

Atypical reading ability has been described as early as the 1940s among children with pervasive developmental delay (Eisenberg & Kanner, 1956). However, it was not until 1967 that Silberberg and Silberberg provided the first analysis of children who demonstrated word recognition skills far superior to either their reading comprehension or verbal functioning levels. The authors proposed the term Hyperlexia for this type of reading behavior and defined it as the ability to recognize words at an advanced level relative to intellectual
potential. Language deficits were considered essential to the diagnosis (Silberberg & Silberberg, 1967, 1971).

Later on, the Child Neurology Society Task Force (Child Neurology Society, 1981) published the Nosology of Disorders of Higher Cerebral Function. In the nosology, Hyperlexia is defined as the ability of an individual to recognize words at a level superior to that which would be predicted by their measured intellectual potential. Further, Hyperlexia is regarded as a variant of the language disorder subtype of Developmental Dyslexia. The essential features of Hyperlexia as listed in the nosology are: fluent oral reading, defective reading comprehension, superior verbal memory, and adequate to superior visual perceptual skills. Variable features include: decreased verbal IQ, echolalia, autistic like behavior, and preoccupation with numbers.

However, research and case study reports (Cobrink, 1974; Cohen, Campbell, & Gelardo, 1987; Goldberg & Rothermel, 1984; Healy, Aram, Horowitz, & Kessler, 1982; Huttenlocher & Huttenlocher, 1973; Mehegan & Dreifuss, 1972; Richman & Kittell, 1981; Seymour & Evans, 1992; Temple, 1990), have indicated that one of the essential features, if not the essential feature, of Hyperlexia is language disorder. As a result, Cohen et al. (1987) proposed that Hyperlexia should be considered a variant of Specific Language Disorder, rather than as a variant of Developmental Dyslexia.

The present study was undertaken in order to compare the neuropsychological profiles of children with borderline to average intelligence, diagnosed as Specific Language Impaired (SLI) with and without Hyperlexia.

METHOD

Subjects

Neuropsychological profiles of 46 children with Specific Language Impairment (SLI) and 16 children with SLI and Hyperlexia (SLI + H) were retrospectively analyzed. Children were consecutive referrals to the pediatric neuropsychology service at the Medical College of Georgia, a tertiary health care facility. In the vast majority of cases, the primary referral question centered around ruling out global mental handicap, pervasive developmental disorder, or SLI. All children receiving the diagnosis of SLI presented with a clinical history of significant language delay as evidenced by marked delays in the attainment of language milestones (e.g., first words, two word phrases, and sentences) contrasted by normal motor milestone development. In addition, each child exhibited borderline to average nonverbal intelligence as measured by the performance IQ of the WISC-R (Wechsler, 1974) or by the Leiter International Performance Scale (Leiter, 1969), deficient performance on tests of receptive and or expressive language, and borderline to average performance on tests of visual spatial perception/construction. In order to receive a co-diagnosis of Hyperlexia the child had to demonstrate word recognition skills on the Wide Range Achievement Test-Revised (WRAT-R), that were at least 15 standard score points above the highest estimate of nonverbal intelligence, and exhibit evidence of word recognition skills before 6 years of age (the start of first grade). In the few cases involving children of preschool age, the School Readiness Composite Section of the Bracken Basic Concept Scale (Bracken, 1984) was substituted for the WRAT-R. Children who met DSM-III-R (APA, 1987) criterion for pervasive developmental disorder and/or demonstrated global intellectual handicaps as well as those children with identifiable neurological involvement resulting from epilepsy, brain tumor, stroke, or head injury, etc. were excluded. Further, all subjects demonstrated normal peripheral hearing and normal visual acuity (with corrective lenses if necessary).
The 46 children with SLI had a mean age of 6.45 years (±1.97), and included 31 males (67%) and 15 females (33%). The mean reported family income ranged from $30-40,000. The 16 children with SLI + H had a mean age of 6.43 years (±1.78), and included 11 males (69%) and 5 (31%) females. The mean reported family income for this group ranged from $20-30,000. Chi-square and independent t-test analyses indicated that the groups did not significantly differ (p > .05) on the variables of age, gender, race, or reported family income.

Procedure

A comprehensive neuropsychological assessment was administered to all subjects. Measures of intellectual ability included The Wechsler Intelligence Scale for Children - Revised; VIQ: Verbal IQ; PIQ: Performance IQ; PPVT-R: Peabody Picture Vocabulary Test - Revised; WPPSI-R: Wechsler Preschool and Primary Scale of Intelligence - Revised; BNT: Boston Naming Test; EOWPVT-R: Expressive One Word Picture Vocabulary Test-Revised; VMI: Developmental Test of Visual Motor Integration; TVPS: Test of Visual Perceptual Skills; K-ABC: Kaufman Assessment Battery for Children; DTLA-2: Detroit Tests of Learning Ability-2; WRAT-R: Wide Range Achievement Test-Revised.

Notes.


* p < .05; ** p < .01; *** p < .001.

TABLE 1
Means (SD) of Neuropsychological Measures

<table>
<thead>
<tr>
<th></th>
<th>SLI</th>
<th>SLI + H</th>
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<tbody>
<tr>
<td><strong>Intelligence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leiter</td>
<td>85.06 (14.55)</td>
<td>92.13 (14.01)</td>
</tr>
<tr>
<td>WISC-R VIQ</td>
<td>73.05 (13.40)</td>
<td>68.50 (8.17)</td>
</tr>
<tr>
<td>WISC-R PIQ</td>
<td>83.14 (16.22)</td>
<td>82.00 (16.76)</td>
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<tr>
<td><strong>Language</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PPVT-R</td>
<td>64.42 (15.33)</td>
<td>58.81 (13.37)</td>
</tr>
<tr>
<td>WISC-R/WPPSI-R Vocabulary</td>
<td>77.43 (14.97)</td>
<td>72.00 (13.78)</td>
</tr>
<tr>
<td>BNT/EOWPVT-R</td>
<td>62.58 (12.81)</td>
<td>67.53 (14.43)</td>
</tr>
<tr>
<td><strong>Visual/Spatial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VMI</td>
<td>86.70 (12.66)</td>
<td>90.44 (11.56)</td>
</tr>
<tr>
<td>TVPS Visual Discrimination</td>
<td>102.14 (21.01)</td>
<td>111.00 (17.29)</td>
</tr>
<tr>
<td>K-ABC Gestalt Closure</td>
<td>91.11 (18.99)</td>
<td>80.63 (19.54)</td>
</tr>
<tr>
<td><strong>Auditory/Verbal Memory</strong></td>
<td></td>
<td></td>
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<tr>
<td>K-ABC Number Recall</td>
<td>84.20 (11.15)</td>
<td>88.45 (18.12)</td>
</tr>
<tr>
<td>DTLA-2 Word Sequences</td>
<td>78.00 (11.11)</td>
<td>77.14 (15.77)</td>
</tr>
<tr>
<td>DTLA-2 Sentence Imitation</td>
<td>74.57 (10.65)</td>
<td>70.93 (8.67)</td>
</tr>
<tr>
<td><strong>Visual/Spatial Memory</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TVPS Visual Memory</td>
<td>91.48 (12.00)</td>
<td>101.54 (12.65)*</td>
</tr>
<tr>
<td>K-ABC Spatial Memory</td>
<td>86.00 (10.89)</td>
<td>85.00 (23.18)</td>
</tr>
<tr>
<td>K-ABC Hand Movements</td>
<td>85.25 (10.45)</td>
<td>98.75 (9.54)**</td>
</tr>
<tr>
<td><strong>Achievement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WRAT-R Word Recognition</td>
<td>75.39 (16.24)</td>
<td>111.33 (19.41)*****</td>
</tr>
<tr>
<td>WRAT-R Spelling</td>
<td>77.92 (14.90)</td>
<td>115.00 (17.25)*****</td>
</tr>
<tr>
<td>WRAT-R Arithmetic</td>
<td>71.85 (17.68)</td>
<td>91.79 (11.50)*****</td>
</tr>
</tbody>
</table>

The mean age of 6.45 years (±1.97), and included 31 males (67%) and 15 females (33%). The mean reported family income ranged from $30-40,000. The 16 children with SLI + H had a mean age of 6.43 years (±1.78), and included 11 males (69%) and 5 (31%) females. The mean reported family income for this group ranged from $20-30,000. Chi-square and independent t-test analyses indicated that the groups did not significantly differ (p > .05) on the variables of age, gender, race, or reported family income.
Buffer (1988). Employing a Z-score transformation, raw scores were converted into standard scores ($M = 100$, $SD = 15$). In order to evaluate visual-motor/constructional ability and visual spatial perception, The Developmental Test of Visual Motor Integration (VMI: Beery, 1989), the Visual Discrimination subtest from The Test of Visual Perceptual Skills (TVPS: Gardner, 1988) and the Gestalt Closer subtest from The Kaufman Assessment Battery For Children (KABC: Kaufman & Kaufman, 1983) were administered. Assessment of immediate auditory/verbal memory was conducted using the Number Recall subtest from The Kaufman Assessment Battery For Children (KABC: Kaufman & Kaufman, 1983), and The Word Sequences and Sentence Imitation subtests from the Detroit Test of Learning Aptitude-2 (DTLA-2: Hammill, 1985). In the case of preschool children, the Sentences subtest from the WPPSI-R (Wechsler, 1989) was substituted. Immediate visual/nonverbal memory was evaluated using the Visual Memory subtest from The Test of Visual Perceptual Skills (TVPS: Gardner, 1988), and the Hand Movements and Spatial Memory subtests from The Kaufman Assessment Battery For Children (KABC: Kaufman & Kaufman, 1983). As previously stated, academic achievement was assessed using The Wide Range Achievement Test-Revised (WRAT-R: Jastak & Wilkinson, 1984). In the few cases involving children of preschool age, the School Readiness Composite Section of the Bracken Basic Concept Scale (Bracken, 1984) was substituted for the WRAT-R.

In the case of preschoolers, there were a few instances when the directions for some of the neuropsychological measures attempted were found to be beyond the comprehension of the child, making them invalid. When this occurred the results of the test in question were not included in the analysis. All scores were reported in standard score format ($M = 100$, $SD = 15$) for ease of comparison across measures. Means and standard deviations were computed for all measures of interest for each group and are presented in Table 1.

**RESULTS**

Qualitative analysis of the mean performance patterns across the neurocognitive measures presented in Table 1 indicates that both groups tended to demonstrate normal nonverbal intelligence on the Leiter. Further, independent t-test analysis indicated no significant ($p > .05$) between group differences. In addition, for those children who were able to successfully attempt the WISC-R (SLI = 21; SLI + H = 6), both groups exhibited a pattern of verbal-performance discrepancy favoring PIQ. T-test analysis demonstrated that for the children with SLI this discrepancy was significant ($p = .002$). However, the discrepancy for the children in the SLI + H group was not significant ($p > .05$) due to the small sample size.

As expected, by definition, t-test analysis indicated that the SLI + H group, demonstrated word recognition and spelling skills that were significantly ($p < .001$) greater than those obtained by the SLI group, and well above what would be expected based upon nonverbal IQ. In addition, arithmetic skills were found to be significantly ($p < .001$) elevated in the SLI + H group. In order to determine if the apparent deficits noted in linguistic functioning as compared with visual/spatial abilities was statistically significant and differed by group, a two way repeated measures analysis of variance was carried out comparing the mean scores for a derived verbal language quotient versus a visual-spatial quotient across each group. The verbal language quotient was obtained for each child by averaging the standard scores for the receptive and expressive vocabulary subtests and the test of confrontational picture naming. The visual-spatial quotient was obtained for each child by averaging standard scores for the visual-spatial and visual-motor/constructional tests. A similar analysis was conducted comparing a derived immediate auditory/verbal memory quotient with an immediate visual/nonverbal memory quotient. It was felt that utilizing quotients for comparison purposes would control for chance occurrences of significant differences in single test scores.
Results of this analysis indicated that the mean language quotients for the children with SLI (68.24 ± 11.94) and children with SLI + H (67.32 ± 9.47) were significantly (p < .001) lower than the mean visual-spatial quotients for the SLI (90.85 ± 13.02) and SLI + H (94.06 ± 10.90) groups. Further, there were no significant group (p = .696) or interaction (p = .291) effects.

Comparison of the mean immediate auditory/verbal memory quotients for the SLI (79.52 ± 8.78) and SLI + H (78.35 ± 10.64) groups with the mean immediate visual/nonverbal memory quotients for the SLI (87.7 ± 9.28) and SLI + H (97.76 ± 11.30) groups indicated that the mean immediate auditory/verbal memory quotients were significantly (p < .001) lower than the mean immediate visual/nonverbal memory quotients with a significant (t9 = .003) interaction effect also evident. Specifically, the mean immediate visual/nonverbal memory quotient was found to be higher for the SLI + H as opposed to the SLI group. Post hoc independent t-test analysis indicated that the SLI + H group mean performance was significantly higher on the TVPS Visual Memory subtest (p = .025) and the K-ABC Hand Movements subtests (p = .005) than for the SLI group.

Finally, it should be noted that both groups of children demonstrated a progressive decline in their performance on auditory/verbal memory assessment as the linguistic/semantic load of the stimulus material to be recalled increased (e.g., digits, words, sentences). In order to determine if this clinical observation was statistically significant, a repeated measures analysis of variance was conducted across the three immediate auditory/verbal memory tasks by group. Results indicated that there was a significant test effect (p = .01), with no significant group (p = .06) or interaction (p = .43) effects. Post-hoc analysis utilizing Fischer’s Modified LSD procedure indicated that both groups demonstrated significantly (p < .05) lower group mean performance on the Word Sequences and Sentence Imitation subtests as compared with the group mean performance on the Number Recall subtest. The group mean performance was not significantly (p > .05) different between the Word Sequences and Sentence Imitation subtests.

DISCUSSION

The results of this study appear to indicate that as in previous studies (Cobrink, 1974; Cohen et al., 1989; Goldberg & Rothermal, 1984; Huttenlocher & Huttenlocher, 1973; Mehegan & Dreifuss, 1972; Richman & Kitchell, 1981; Silberberg & Silberberg, 1967) the primary and essential cognitive feature of Hyperlexia is Specific Language Impairment involving a severe inability to process, organize, integrate, and comprehend language, rather than a primary reading disability as alluded to by the Child Neurology Society Task Force (1981). The reported reading comprehension deficit that these children exhibit appears to be a function of the core deficits in expressive and receptive language and not a secondary manifestation of poor word recognition skills since these are elevated beyond IQ expectancy. Children with hyperlexia exhibit difficulty comprehending spoken as well as written language, where as children with developmental dyslexia may exhibit difficulty with the comprehension of written language only. Thus, Hyperlexia would be best conceptualized as a subgroup or variant of Specific Language Impairment (SLI), rather than as a variant of the language disorder subtype of developmental dyslexia.

Further, based upon the results of this study, the significantly elevated word recognition, spelling and arithmetic ability demonstrated by these children appears to be the result of significantly elevated immediate visual/nonverbal memory skills in conjunction with average to above average visual perceptual skills, and not a result of superior auditory/verbal memory as proposed by the Child Neurology Society Task Force (1981). In fact, the only significant
difference between the SLI and SLI + H groups was the elevated performance on measures of immediate visual/nonverbal memory by the SLI + H group. However, given the relatively small sample size of the SLI + H group employed in this study, replication of this finding with a larger sample is certainly warranted.

The performance of both groups of children on tests of immediate auditory/verbal memory also deserves comment. Analysis indicated that both groups performed very poorly on immediate auditory/verbal memory assessment. Further, it should be noted that both groups of children exhibited decreasing performance as the linguistic/semantic demands of the memory task increased. This finding has recently been reported by Cohen & Riccio (1994) in a larger sample of children with SLI. Based upon these findings, it is not immediately clear as to whether or not these children have a decreased immediate auditory/verbal memory capacity, or simply give the appearance of having a decreased immediate auditor/verbal memory capacity as a secondary manifestation of their language disorder. Recently, Records, Tomblin, and Buckwalter (1995) reported the results of a study investigating verbal learning and memory in adults with a history of SLI which indicated that although these individuals exhibited difficulty with immediate auditory/verbal memory span, they demonstrated a normal learning curve and normal immediate recall after presentation of a distractor word list. These results, taken together with the work of Kirchner and Klatsky (1985) who also reported a diminished immediate auditory/verbal memory capacity in children with SLI, would lead one to conclude that the findings reported in this study were the result of a limited capacity for immediate verbal processing and not the result of a deficit in verbal learning and recall. Stated another way, it appears that children with SLI exhibit a deficit in verbal working memory (Baddeley & Hitch, 1974, 1994). However, further investigation is certainly warranted in this area employing a cross-sectional or longitudinal research design so that the effects of development can be adequately explored.

REFERENCES


