A Comparison of Neuropsychological Test Profiles of Children with Attention Deficit–Hyperactivity Disorder and/or Learning Disorder

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The study compared 8-year-old children with pure attention deficit–hyperactivity disorder (ADHD) (n = 21), specific learning disorder (LD) (n = 12), and both (ADHD + LD) (n = 27) on a comprehensive set of neuropsychological measures. The tests were mainly derived from a new neuropsychological instrument, the Neuropsychological Assessment of Children. The children with ADHD were specifically impaired in the control and inhibition of impulses; the children with LD were impaired in phonological awareness, verbal memory span, and storytelling, as well as in verbal IQ. Children with both showed all of these deficiencies; they also had more pervasive attention problems and more visual–motor problems than the two other groups. All groups exhibited impaired performance in tasks of visual–motor precision and name retrieval. The latter finding may involve two different mechanisms, one related to linguistic impairment and possibly contributing to reading and spelling problems, and the other related to attentional problems.

In the research on attention deficit–hyperactivity disorder (ADHD) and on learning disability (LD), a special problem is presented by the high degree to which these disorders overlap. Due to methodological variability, however, a reliable estimate of the comorbidity of the disorders is difficult to obtain.

The reported estimates of LD in children with ADHD have ranged from 10% (August & Holmes, 1984; Halperin, Klein, & Rudel, 1984) to above 80% (McGee & Share, 1988; Silver, 1981). According to some recent studies in which comparable criteria for LD were applied, the incidence is around 20% to 40%. Barkley (1990) found the incidence to be 41% when LD was defined as learning achievement scores of at least 15 standard score points below the Full-Scale IQ. When achievement scores below the 7th percentile were considered as the criterion for LD, the incidence was 21%. Similarly, Semrud-Clikeman et al. (1992) found an incidence of reading disability (RD) of 38% when applying a criterion of at least 10 standard score points below the Full-Scale IQ. When the criterion for RD was set at 20 standard score points below Full-Scale IQ, the incidence was 23%.

The incidence of ADHD among children primarily diagnosed as LD has been less extensively studied. Cantwell and Baker (1991) followed up on 600 young children with speech/language impairments and found an increased prevalence of both ADHD and LD, and a strong relationship between the two conditions. When 300 of the children reached school age, 30.3% were found to have LD. Of these children, 53% also had ADHD. In a sample of 27 twins, both monozygotic and dizygotic, Gilger, Pennington, and DeFries (1992) found that in twin pairs having at least one member with a reading disability, 39% of those individuals also had an attention deficit. Thus, on the whole, the overlap of the two types of disorders is considerable enough to warrant attention, both in the context of research attempting to specify the characteristics and underlying mechanisms of the disorders, and in the context of clinical assessment.

The comorbidity of the disorders complicates the clarification of their distinct natures and underlying deficiencies. If unspecified groups of children with ADHD and LD are compared to only nondisabled controls, some deficiencies thought to be causally related to one disorder may actually be related to the other. The risk of contamination should be recognized by specifying to what extent both disorders occur in a given group of subjects. Ideally, subjects with pure ADHD and pure LD should be examined separately or compared with each other.

In studies in which children with ADHD and those with SLD have been compared, some variant of the Continuous Performance Test (CPT) has frequently been utilized. Van der Meere, van Baal, and Sergeant (1989) found that children with LD were im-

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paired in memory search and decision processes, whereas children with hyperactivity were impaired in motor-decision processes. In a follow-up study, Kupietz (1990) found no initial difference between children with RD and children with ADHD + RD in number of correct detections and number of commission errors. However, the former group improved more than the latter with increasing age. Richards, Samuels, Turnure, and Ysseldyke (1990) found that students with both LD and ADHD were more affected by letter distractors adjacent to the target letters than were students with LD only.

Other studies have applied memory and language tests, as well as attention scales. Impaired verbal memory and susceptibility to interference effects in verbal memory tasks (Benezra & Douglas, 1988; Siegel & Ryan, 1989; Tarnowski, Prinz, & Nay, 1986), as well as impairment on measures of naming and phonological awareness (August & Garfinkel, 1990; Felton & Wood, 1989), have been found to discriminate children with LD from children with ADHD. Douglas and Benezra (1990) found that children with ADHD were characterized by deficits on memory tasks requiring organized, deliberate rehearsal strategies, whereas children with RD showed a more generalized verbal-memory deficit. Robins (1992), however, did not find short-term verbal memory and verbal learning over trials to discriminate between children diagnosed as having ADHD and those with LD, nor did the groups differ with respect to sustained attention; but both groups performed more poorly than nondisabled children. The children with ADHD were specifically characterized by impulsive behavior, impaired accuracy when speed of responding was required, and behavioral characteristics such as aggressivity and poor ability to function in the classroom or work independently.

Although there is much concordance in the findings of deficiencies characterizing children with ADHD and those with LD, the reviewed studies also showed considerable methodological variability. Most studies have been restricted to a few specific aspects of attention or learning. There has been no systematic comparison of children with ADHD and children with specific LD on a comprehensive set of tests relating to all or most aspects of functioning that have been found relevant for attention and learning. Such a comparison would shed light not only on interindividual but also on intraindividual differences by analyzing test patterns or profiles. If specific test patterns were characteristic of different disorders, this finding would provide a firmer basis for diagnostic decisions than would data from only a few separate tests.

A new neuropsychological instrument, the Neuropsychological Assessment of Children (NEPSY) (Korkman, 1988a), provided an opportunity to compare children with ADHD and children with LD on a wide range of performances. NEPSY consists of 36 tests that tap various aspects of attention, language, motor, sensory, and visual-spatial functions, and memory and learning. From this comprehensive test collection, tests may be selected in accordance with the clinical or research problems in question. As the tests are simultaneously standardized, the results may be expressed as test profiles. The method is, as yet, available only in Finnish (Korkman, 1988a) and Swedish (Korkman 1990a), but detailed descriptions are available in English (Korkman, 1988b, 1988c, 1990b). An American adaptation is in press (Korkman, Kirk, & Kemp, in press); therefore, the present study may be of interest internationally.

The aim of this study was to compare the test profiles of children with ADHD and children with specific LD. The test profiles include the main components considered relevant for attention and for reading and spelling acquisition. Of specific interest were differences that emerged as double dissociations—children with ADHD, but not children with LD, having impairments in some tests, and children with LD, but not children with ADHD, having impairments in others. In addition to being clinically useful, such double dissociations may also provide firmer evidence of the causality of deficiencies associated with the disorders than does a comparison of the differences between nondisabled controls and children with ADHD or LD.

Method

Subjects

Sixty children considered to have ADHD and/or specific LD participated in the study. The children were 8-year-old second-grade students from general education classes (45 boys and 15 girls). The children fulfilled the criteria of having (a) either ADHD or specific LD or both, according to specified criteria; (b) average nonverbal or verbal IQ; and (c) no significant emotional or conduct problems.

ADHD was assessed with the aid of a Finnish translation of the *Diagnostic and Statistical Manual of Mental Disorders* (third edition) (DSM-III) (American Psychiatric Association, 1980), with the criterion being that the children should be evaluated to have attention deficit (i.e., 4 or 5 points on a 5-point scale) on more than 6 of the 12 items. Although the DSM-III was used, the term *ADHD* from the DSM-III-R (American Psychiatric Association, 1987) was applied to designate the deficit, as this is the term now generally used.

Specific LD was diagnosed with the aid of a Finnish spelling test (Helsingin kouluvirasto, 1988) that corresponds to the Spelling subtest of the Wide Range Achievement Test–Revised (WRAT-R) (Jastak & Wilkinson, 1984). Children with error scores ≥ 12, which corresponded to the 6th percentile of the population, were considered to have a learning disorder. The diagnosis of LD was thus based on achievement level rather than on a discrepancy score. But as the 6% level corresponds roughly to a *z* score of −1.89, and an IQ of 90 to a *z* score of −0.67, all children had a discrepancy of at least 1.22 between IQ and spelling achievement.

All children had an IQ of at least 90 on either the Verbal or the Performance scale of the Wechsler Intelligence Scale for Children–Revised (WISC-R) (Wechsler, 1974). Children with significant emotional problems or conduct disorders were not included. These behaviors were evaluated by the child's school psychologist, in the context of individual contact, classroom observations, and conferences with teachers.

The 60 children were divided into three groups, as follows: ADHD only: $n = 21$; LD only: $n = 12$; ADHD+LD: $n = 27$. A control group was not considered necessary, as the neuropsychological tests used in the study had been standardized on the same norm sample (Korkman, 1988b, 1988c).

The results of the three groups on the DSM-III attention scale and on the spelling test, as well as the distributions on the background variables of age, gender, and verbal and performance IQs are shown in Table 1. Although the IQ values are included among the background variables, it should be pointed out that they may also be considered as dependent neuropsychological variables, as they may be affected by the disorders.

As may be seen in Table 1, there was no difference in age between the three groups. However, the groups seemed to differ with respect to gender distribution, with the proportion of girls being larger in the LD group (50%) and smaller in the ADHD+LD group (11.1%) than in the total group (25%). The difference, however, did not reach significance on a chi-square analysis of differences between observed and expected frequencies.

The groups differed significantly with respect to verbal IQ but not with respect to performance IQ. The poorer verbal IQ in the LD and ADHD+LD groups probably reflects a tendency toward specific language deficiencies in children with spelling disability, as children with language disorders form a high-risk group with respect to reading and spelling problems (Bishop & Adams, 1990; Cantwell & Baker, 1991; Paul, Cohen, & Caparulo, 1983; Scarborough, 1990). Therefore, an equalization of the groups with respect to verbal IQ, or a computational elimination of its effect, would be likely to distort true conditions.

TABLE 1
ADHD Scale and Spelling Test Results and Demographic Variables

Tests and variables	ADHD	LD	ADHD+LD	*F* ratio (*df* = 2, 57)
ADHD ratings				
M	43.6	25.6	44.8	42.3**
SD	7.2	3.0	6.6	
Spelling test				
M	5.1	25.8	24.1	21.0**
SD	3.4	14.6	10.9	
Age (years-months)				
M	8-9	8-8	8-8	*ns*
Gender (girls, boys)				
n	6, 15	6, 6	3, 24	*ns*
Verbal IQ				
M	97.8	89.2	90.6	4.21*
SD	10.1	5.7	10.9	
Performance IQ				
M	102.0	98.3	93.5	*ns*
SD	17.4	15.2	12.0	

*$p < .05$. **$p < .001$.

Classifying Tests

Teachers' Ratings of ADHD. For the purpose of verifying ADHD in the children, the DSM-III diagnostic criteria for ADD with Hyperactivity (categories A, B, and C) were utilized. Four of the items were omitted (items A5, C1, C4, and C5) because they were considered difficult to evaluate in a classroom context. The applied items were as follows:

1. Does the child often fail to finish things he or she starts?
2. Does the child often seem to not listen?
3. Is the child easily distracted?
4. Does the child often have difficulty concentrating on schoolwork or other tasks requiring sustained attention?
5. Does the child often act before thinking?
6. Does the child shift excessively from one activity to another?
7. Does the child have difficulty organizing work (this not being due to cognitive impairment)?
8. Does the child need a lot of supervision?
9. Does the child frequently call out in class?
10. Does the child have difficulty awaiting turns in games or group situations?
11. Does the child fidget excessively or have difficulty sitting still?
12. Does the child have difficulty staying seated?

Each of the observational items was evaluated on a 5-point scale that indicated the extent of the observed behavior (1 = *not at all*, 5 = *very much*). No attempt was made to distinguish between children with or without hyperactivity, as this distinction has been questioned (American Psychiatric Association, 1987; Rutter, 1984).

Spelling Test. Spelling was assessed with the aid of the Finnish standardized group spelling test, which is comparable to the Spelling subtest of the WRAT-R. Children are to write on dictation 20 progressively more difficult words, the easiest one being *teddy* (in Finnish, *nalle*) and the most difficult, *chrystal* (*kristalli*). The score was an error score formed by giving 1 point for each separate error, 2 points for a missing syllable or part of a word, and 3 points for hard-to-recognize or missing words.

Although a more comprehensive assessment of reading and spelling would have been desirable, using only a test of spelling corresponds to common practice in Finland, and to the specific characteristics of the Finnish language. Finnish words are long and rich in vowels, and the spelling is phonetic. The vowels form an abundance of easily recognized phonological characteristics, which facilitate word recognition in reading. This redundancy is not of help in spelling, where frequent double vowels and consonants cause problems. Therefore, in the early stages of reading and spelling acquisition, the spelling test is more sensitive in detecting dyslexia than is a reading test.

Dependent Measures: Neuropsychological Tests

The primary aim of the neuropsychological assessment was to evaluate the functions and abilities that are thought to be involved in the complex processes of attention, reading, and spelling. Therefore, a number of attention and language tests were chosen that would tap the various subcomponents of these processes. In addition, some sensory-motor, visual-spatial, and memory tests were employed to yield a more comprehensive neuropsychological assessment. Most tests were drawn from the Finnish NEPSY version, which has been standardized on children ages 3 years 6 months to 8 years 6 months. It should be noted that the children in this study were somewhat older than the standardization sample, but when the scoring was performed according to the oldest age level, the tests were still sensitive enough to demonstrate intraindividual and interindividual differences. The applied NEPSY tests have adequate reliabilities (.68 to .88), as measured by the Kuder-Richardson test of homogeneity (Korkman, 1988b, 1988c).

The applied neuropsychological tests are described below. To elucidate test content, the partial test intercorrelations from part of the norm sample (N = 74 to 108), after the effect of age was eliminated, are also given (Korkman, 1988b).

1. *Inhibition and Control* (NEPSY). This test consists of five subtests that require inhibition of impulses to respond automatically to various stimuli. For example, the child must keep his or her eyes closed in spite of sounds made by the examiner, knock on the table when the examiner taps, tap when the examiner knocks, and so on. In nondisabled children, this test had significant partial intercorrelations with the Evaluation of Attention (.36) and with the Token Test (DeRenzi & Faglioni, 1978) (.43).

2. *Selective Auditory Attention* (NEPSY). A long series of isolated words is read to the child. The child reacts whenever he or she hears the target word *red* by putting a red peg in a pegboard. The test puts demands on selective, sustained attention. The intercorrelations for this test were not obtained, as it was added later than the other NEPSY tests and thus simultaneous data were not available.

3. *Evaluation of Attention.* The examiner's overall evaluation of the child's ability to stay on task during the testing sessions was expressed on a 4-point scale (−2 to +1). The scale is not a psychometrically elaborated test but may be regarded as a situational test. A slightly different but equivalent version of this test (Sustained Concentration; NEPSY) had significant partial intercorrelations for nondisabled children with Inhibition and Control (.36) and Digit Span (.52).

4. *Auditory Analysis of Speech* (NEPSY). The first language test is one of phonological awareness. The child points to the one picture out of three alternatives that corresponds to a word fragment presented orally by the examiner (e.g., the child points to a mushroom when the stimulus is *ush*). In nondisabled children, this test had significant partial intercorrelations with the Token Test (.33); Speeded Naming (.31); and the Motor-Free Visual Perception Test (MVPT) (Colarusso & Hammill, 1992) (.36).

5. *The Token Test.* The test used in this study was the shortened version of the Token Test, which measures the comprehension of complex instructions. Aside from being a receptive-language test, it may also gauge attention in children, as it is a long test in which instructions cannot be repeated. This test had significant partial intercorrelations with a large number of tests: Inhibition and Control (.43), Auditory Analysis of Speech (.33), Speeded Naming (.56), Visuomotor Precision (.43), Relative Concepts (.68), and the MVPT (.59).

6. *Relative Concepts* (NEPSY). The child's comprehension of concepts such as "between," "opposite of," and so forth is assessed. This test also had numerous significant partial intercorrelations: Inhibition and Control (.36); the Token Test (.68); Speeded Naming (.63); the MVPT (.63); the Developmental Test of Visual-Motor Integration (VMI) (Beery, 1983) (.39); and the Delayed Recall of Story (.43).

7. *Storytelling* (NEPSY). A story is read to the child, who then is asked to retell it. Test intercorrelations for Storytelling were not obtained, as norms on this test were collected only for children ages 7 and 8 years.

8. *Speeded Naming, Errors* (NEPSY). For this test, the child names the size, color, and shape of the tokens from the Token Test as quickly as possible; then naming errors are counted. This test

had significant partial intercorrelations with Inhibition and Control (.49), Auditory Analysis of Speech (.31), the Token Test (.56), Relative Concepts (.63), the MVPT (.47), and the VMI (.34).

9. *Speeded Naming, Time* (NEPSY). The performance time in the test above forms the score. Test intercorrelations were not calculated for this test score.

10. *Handedness* (NEPSY). Six tasks of handedness (such as erasing, throwing a ball, etc.) are presented. This test did not have significant partial intercorrelations with any of the other tests.

11. *Tactile Finger Discrimination* (NEPSY). In this test, the child discriminates, without seeing, which finger was touched. This test also did not have significant partial intercorrelations with any of the other tests.

12. *Visuomotor Precision* (NEPSY). The child has to draw lines along fine, curvilinear routes. This test had a significant partial intercorrelation only with the Token Test (.43).

13. *Developmental Test of Visual–Motor Integration.* This test consists of copying designs. In nondisabled children, the VMI had significant partial intercorrelations with Relative Concepts (.39), Speeded Naming (.34), and the MVPT (.39).

14. *Motor-Free Visual Perception Test.* This test includes nonmotor visual-matching tasks, visual-memory tasks, and figure-ground tasks. Because the tasks are easy for 8-year-olds, only the eight most difficult tasks were presented. In nondisabled children, this test had significant partial intercorrelations with many language tests: Auditory Analysis of Speech (.36), the Token Test (.59), Relative Concepts Test (.63), Speeded Naming (.47), and Delayed Recall of Story (.34). The correlations with language tests were probably due to the complexity of the instructions, which taxed the younger children's performance. However, the test did have a significant intercorrelation with two nonlanguage tests—the VMI (.39) and Discrimination of Slopes (.52) (not applied in this study).

15. *Block Design* (WISC-R). This subtest was chosen as a visual-constructional assessment. The intercorrelations of this test and the NEPSY tests have not been calculated.

16. *Object Assembly* (WISC-R). This test was also employed as a visual-constructional test. The intercorrelations of this test and the NEPSY tests have not been calculated.

17. *Digit Span* (NEPSY). The child is asked to repeat digit series; in nondisabled children, this test had significant partial intercorrelations with the Evaluation of Attention equivalent (Sustained Concentration) (.52) and Delayed Recall of Story (.71).

18. *Name Learning* (NEPSY). The examiner presents seven names of children depicted in photographs to the child, three times each. After each presentation, the child's retrieval of the names is tested. The test is thus one of intentional name learning. The test did not have significant partial intercorrelations with any of the applied tests, but it had a partial intercorrelation with a NEPSY test of color naming, Naming Colors (.57) (not applied in this study).

19. *Delayed Recall of Story* (NEPSY). Thirty minutes after the initial presentation of a story, the child's long-term retention of the story is assessed with the aid of eight questions. In nondisabled children, this test had significant partial intercorrelations with Relative Concepts (.43), the MVPT (.34), and Digit Span (.73).

The neuropsychological test results are expressed in standard scores, corresponding to the means and standard deviations of the norm group at different age levels. The scores vary from −3 to +1. All tests except the General Evaluation of Attention, Selective Auditory Attention, and the WISC-R Block Design and Picture Arrangement subtests have been standardized on the same norm sample, and the results for these tests are thus directly comparable. The two WISC-R subtests have been standardized on a separate, but comparable, Finnish norm sample. The scores on these tests were converted to a corresponding scale.

Procedure

The children were recruited from second-grade classes in an area of Helsinki of around 250,000 inhabitants. Classroom teachers, special educators, and school psychologists selected candidates for the study among children who had been referred for psychological assessments or consultations, or to special education. Candidates were children who, according to the teachers and psychologists, were the least ambiguous cases of pure ADHD or pure LD. The school psychologists administered the WISC-R if it had not been recently administered and evaluated the children's behavior. In these preliminary evaluations, 30 children were proposed to have pure ADHD and 30 to have pure LD.

The 60 children were then assessed via more formal procedures. Classroom teachers completed the DSM-III rating scale and conducted the spelling test. On the basis of these tests, the children were redivided into groups having ADHD, LD, or ADHD+LD. The neuropsychological assessments were performed by one of the authors in the children's schools.

The tests were performed in the order in which they were described previously, with the exception of the two WISC-R subtests, which were performed in the context of the intelligence assessment. The neuropsychological tests, which took approximately 1½ hours to complete, were not presented blindly, as they are objective, standardized measures.

Results

The test profiles of the ADHD, LD, and ADHD+LD groups are shown in Figure 1. Due to the tendency toward unequal gender distribution, the group differences were analyzed by using a two-way ANOVA (3 × 2), where gender was the second source of variation. In tests in which the variance differed between the groups, according to the Levene test for equality

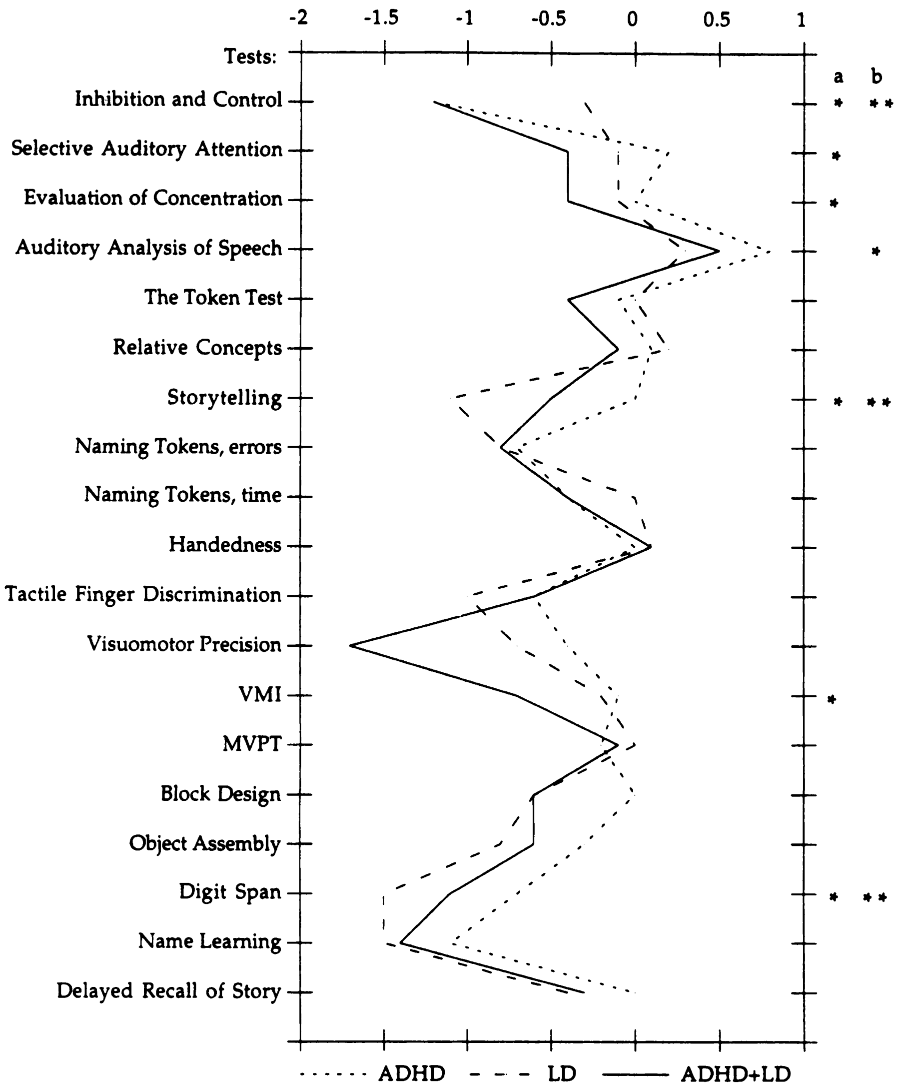

FIGURE 1. Test profiles of children with ADHD (n = 21), LD (n = 12), and ADHD + LD (n = 27). Results show (a) significant differences among the three groups, as compared by ANOVA (df = 2, 54), and (b) significant differences between the ADHD and SLD groups, as compared by t test (df = 58) (see also Table 2); $^{*}p \leq 0.05$. $^{**}p \leq .01$.

of variance, the Welch formula of ANOVA was used.

As can be seen in Figure 1, significant differences emerged in 6 of the 19 tests. No significant gender effect or interaction between group and gender emerged.

As some differences may emerge more clearly when contrasting only the ADHD and LD groups, the differences between the test means of these groups were also analyzed separately through a t-test comparison. Significant differences emerged in four tests (see Figure 1); the test results that differed significantly between the groups are shown in greater detail in Table 2. The observed differences were all in the expected direction, which excludes the possibility that they could have occurred by chance.

To further test the degree to which the test profiles differed, the seven tests included in Table 2 were subject to an additional repeated-measures ANOVA. A repeated-measures ANOVA was chosen instead of a MANOVA due to the small number of observations (n = 12) in the smallest group (Tabachnick & Fidell, 1989). When comparing the test profiles of all three groups, an interaction F ratio (which expresses the degree to which the test profiles differ) of 3.75 (df = 14, 399) was obtained (p = .02), when a Huynh-Feldt adjustment of the degrees of freedom was applied (Tabachnick & Fidell, 1989). The corresponding value when comparing only the ADHD and LD groups was F = 6.55 (df = 7, 217, p = .01, with a Huyhn-Feldt adjustment of df).

Discussion

The first noteworthy result of the study was the high degree of comorbidity of ADHD and LD, which corresponded to the earlier findings reviewed above. Although the children admitted to the formal assessments were preselected from a large population as being the purest cases of ADHD and LD, only 12 (20%) of the children actually scored below the cutoff score in the spelling test only, whereas 21 (35%) scored below the cutoff score in the attention scale only. As many as 27 (45%) of the children with supposedly pure ADHD or LD had both types of disorders, according to the criterion measures. Dykman and Ackerman (1991) also reported difficulties in finding children with RD but without any ADD symptomatology.

A more precise estimation of the co-occurrence of the disorders was not obtained, as the teachers were not prompted to report every pupil suspected of having LD and/or ADHD.

The basic findings of the study were the double dissociations in the test findings of the ADHD and LD groups. The children with ADHD had a relatively good overall performance level, but they showed specific impairment on Inhibition and Control. The performance of the children with specific LD approached the normal mean on that test, but this group displayed poor results on Auditory Analysis of Speech, Digit Span, and Storytelling.

The results thus support the earlier finding that poor impulse control is one of the main characteristics of children with ADHD (Barkley, 1988; Douglas, 1984; Korkman & Peltomaa, 1991) and phonological, linguistic problems are the main deficiencies underlying reading and spelling disorders (Benezra & Douglas, 1988; Bradley & Bryant, 1985; Felton & Wood, 1989; Vellutino & Scanlon, 1989; Wagner & Torgesen, 1987).

It may be noted that the results on Auditory Analysis of Speech were above zero even for the LD group, which is explained by the fact that the children were somewhat older than the norm group. The test puts demands on phonological awareness and is probably affected by the frequent training of this ability in the context of reading and spelling education at this age.

The finding of poor digit span and storytelling ability in the LD but not in the ADHD group requires some consideration. An impaired rote memory result in the LD group is consistent with the finding of poor auditory–phonological processing found in earlier studies (Benezra & Douglas, 1988; Siegel & Ryan, 1989). Less self-evident was the finding that the LD group but not the ADHD group was impaired in the ability to tell a story that they just heard. In Douglas and Benezra's (1990) study, it was the children with ADHD who performed more poorly on a memory task requiring organized and deliberate effort and executive function. In Robins's (1992) study, verbal performance did not differentiate between children with LD and those with ADHD. The reason for the present finding may be that the children with LD, due to a subtle, generalized linguistic impairment, were affected by the demands on extensive verbal formulations. When questioned about the details of the story half an hour later, the children with LD performed normally, which confirms that this finding was one of language impairment rather than memory deficiency. The language impairment was also manifest in a poor verbal IQ. The children with ADHD did not experience difficulties because the task—listening to and retelling a colorful story—was enjoyable and did not put demands on deliberate, controlled attention.

In addition to the differences between the groups, some test results were poor in all three groups. The most profound impairment across groups was seen in performance on Name Learning. A related but less pronounced impairment was seen in the number of errors on Speeded Naming. The total mean for the former test was −1.3 (*SD* = 1.2) and for the latter test, −0.7 (*SD* = 1.0). These tests are thought to be sensitive to impairment in name storage and retrieval. Both tests demand more active and deliberate learning and memory search than traditional naming tests (e.g., Denckla & Rudel, 1976). The results suggest that poor name learning and retrieval occurs not only in children with LD—which has been clearly established (August & Garfinkel, 1990; Denckla & Rudel, 1976; Felton & Wood, 1989; Korhonen, 1991; Wiig, Semel, & Nystrom, 1982; Wolf, 1986)—but also, when more active forms of name memorization and retrieval are required, in children with ADHD. This finding corresponds to earlier findings of poor application of rehearsal strategies when learning other types of verbal material by children with ADHD (Douglas & Benezra, 1990; Robins, 1992). Thus, name-retrieval deficiencies may be caused by two different mechanisms: one related to linguistic impairment and possibly contributing to reading and spelling problems, and the other related to attention problems and poor active memorization and evidently not causally related to specific reading and spelling problems.

TABLE 2
Tests Discriminating Among Children with ADHD, LD, and ADHD + LD (*F* Ratios), and Children with ADHD and LD (*t* Values)

Tests	ADHD	LD	ADHD+LD	*F* ratio	*t* value
Inhibition and Control					
M	−1.2	−0.3	−1.2	3.27[a]	2.9[d]
SD	1.3	0.6	1.3	(*p* = .03)	(*p* = .007)
Selective Auditory Attention					
M	0.2	−0.1	−0.4	3.46[b]	0.7[d]
SD	1.0	1.2	1.5	(*p* = .04)	(*ns*)
Evaluation of Attention					
M	0.0	−0.1	−0.4	3.75[b]	0.1[d]
SD	1.1	0.8	1.3	(*p* = .03)	(*ns*)
Auditory Analysis of Speech					
M	0.8	0.3	0.5	0.50[c]	2.4[d]
SD	0.5	0.9	1.1	(*ns*)	(*p* = .04)
Storytelling					
M	0.0	−1.1	−0.5	3.46[b]	2.7[d]
SD	0.9	1.3	1.4	(*p* = .04)	(*p* = .01)
VMI					
M	−0.1	−0.2	−0.7	3.23[b]	0.2[d]
SD	0.9	0.8	0.9	(*p* = .05)	(*ns*)
Digit Span					
M	−0.7	−1.5	−1.1	3.90[b]	2.6[d]
SD	0.9	0.7	0.7	(*p* = .03)	(*p* = .01)

Note. VMI = Developmental Test of Visual–Motor Integration.
[a]*df* = 5, 18 (Welch adjustment for inequal variances). [b]*df* = 2, 54. [c]*df* = 5, 22 (Welch adjustment for inequal variances). [d]*df* = 58.

A second type of impairment that appeared across groups was poor performance in Visuomotor Precision ($M = -1.0$; $SD = 1.3$), indicating a tendency toward problems with manual motor coordination. The impairment was most accentuated in the ADHD + LD group, but due to great interindividual variability, the group difference was not significant.

The children with ADHD + LD exhibited the same types of impairment as did both the ADHD and the LD groups. This result is logical and seems to verify that the ADHD + LD children were affected by both specific disorders. However, they also showed some unique impairments that were not seen in the other two groups. Performance was specifically impaired on Selective Auditory Attention, Evaluation of Attention, and the VMI. The two former results may be interpreted as evidence of poor ability to stay on task and to pay attention to a long array of monotonous verbal stimuli. Thus, it seems that the ADHD + LD group had more pervasive attention deficits than did the pure ADHD group. This finding corresponds to Tarnowski et al.'s (1986) finding of more pervasive attention problems in children with ADHD + LD than in children with ADHD only. Furthermore, Boudreault et al. (1988) found reading disability and poor verbal IQ in connection with pervasive ADHD but not with situational ADHD. In the absence of other evidence of perceptual deficiency, the visual-motor integration difficulty, in turn, may be seen as evidence of a relatively severe motor-coordination deficiency of the same type as indicated by Visuomotor Precision. These children thus had quite widespread neuropsychological dysfunction. The results may be seen as confirming the tendency for developmental disorders to cluster in the same individuals.

The approach applied in the present study is comparable to the stage approach proposed by Sternberg (1969) and advocated by, for example, Sergeant and van der Meere (1990); van der Meere et al. (1989); and Klorman, Brumaghim, Fitzpatrick, and Borgstedt (1991). These authors have divided performance into successive stages of encoding, search, decision, and motor organization. By varying the task parameters representing the various stages, interactions between groups and deficiencies may be seen. The NEPSY does not consist of a single task, the stage parameters of which may be manipulated. Instead, the separate NEPSY tests are constructed to represent the various, successive components of several types of complex processes (such as reading and spelling) and attention. In addition to representing the encoding, search, selection, and executive stages, the tests also differ with respect to modality. For example, the children with LD were found to be specifically impaired in phonological and linguistic encoding, but they were not impaired in the encoding of visual stimuli, as indicated by their normal results on the MVPT test.

Applying stage approach terminology, we can interpret the present findings in children with specific LD as problems in the initial phonological encoding, whereas the children with ADHD had problems in motor-decision processes, as evident in their poor control of motor responses on the Inhibition and Control Test. Both groups had some problems in linguistic rehearsal and search, as evident in their poor results on Name Learning. They also demonstrated some difficulties with motor execution, as evident in the Visuomotor Precision Test, although this deficiency is probably not decisive for either spelling achievement or attention.

One interesting side finding of the study was the large percentage of misdiagnosed cases when the children were evaluated only by informal procedures. Out of the 30 children whom the teachers and school psychologists originally selected as having only ADHD, 15 were actually confirmed to have pure ADHD, whereas 14 also had LD and one had only LD. Of the 30 children originally proposed as having only LD, 11 actually had pure LD, 13 had both ADHD and LD, and 6 had only ADHD. Thus, only 26 (43.3%) of the 60 preliminary evaluations of ADHD or LD were confirmed on the formal assessment. Classroom teachers may tend to interpret the academic failures of children with dyslexia as being due to attention problems because children who cannot follow the teacher become restless and distractible. Special educators may tend to miss signs of poor attention skills in their pupils, as attention problems may not be as evident when these children are instructed individually or in small groups. The failure of informal assessments constitutes a serious problem in practice, as children who are assessed in such a way may be referred to inappropriate treatment programs or special classes. The importance of formal and comprehensive assessments of children with specific developmental disorders should, therefore, be emphasized.

Finally, some limitations of the study need to be pointed out. The generalizability of the results suffers from the small number of observations in the three groups of children. The small number of observations also prohibited a discriminant function analysis, which could have provided a means to further investigate the ability of the NEPSY tests to discriminate between the three groups. In addition, the small sample size did not permit an adequate subdivision of the disabilities. Although the groups may be seen as relatively homogeneous, the LD group, in particular, is probably composed of children with different types of LD. In future studies, effort should be paid to finding larger groups of children having pure ADHD and LD, in order to detect possible variations in the test patterns within the groups, and to further clarify the diagnostic validity of the NEPSY.

In conclusion, earlier findings of impaired control and inhibition of impulses as the main characteristic of ADHD, and of phonological and linguistic problems as primary deficiencies of children with LD, were confirmed by this study. These findings did indeed appear as double dissociations (specific impairment in one group but not in the other). In contrast, a double dissociation did not appear in the name-retrieval tasks, as both the LD and the ADHD groups were impaired in these tasks. Children with ADHD may be impaired with respect to the active-memorization aspects of the tasks. This form of learning disorder is not, according to the present findings, directly related to specific disorders of reading and spelling. Children with LD may be impaired in the semantic and verbal memory aspects of the tasks, and these deficiencies may be causally related to specific reading and spelling problems. The children with ADHD+LD showed all the above-mentioned deficiencies but were also further affected by more pervasive attention problems and visual-motor deficiencies, indicating widespread neuropsychological dysfunction. The generalizability of the results, however, suffers from the small number of children included in the study.

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