Factors Associated with Arithmetic-and-Reading Disability and Specific Arithmetic Disability

David L. Share, Terrie E. Moffitt, and Phil A. Silva

Factors associated with arithmetic-and-reading disability and specific arithmetic disability were investigated in a large sample of representative New Zealand children. Evidence was sought for Rourke's hypothesis (Rourke & Finlayson, 1978; Rourke & Strang, 1978, 1983) that these two types of arithmetic disability show reverse patterns of strengths and weaknesses with regard to verbal and nonverbal skills. This "crossover" effect was clearly evident for boys but noticeably absent for girls. When compared to a nondisabled control group, arithmetic-and-reading disabled boys showed deficits primarily, but not exclusively, on verbal tasks. Girls with arithmetic-and-reading disability were best characterized as showing a general (verbal and nonverbal) deficit. In specific arithmetic disabled boys there was evidence of predominantly nonverbal but also verbal deficits while girls with specific arithmetic disability did not differ from the control group on any of the measures included in this study.

A number of studies have reported data suggesting that poor achievement in arithmetic may be largely attributable to the same language-based deficits that underlie poor reading achievement (e.g., Chansky, Czernik, Duffy, & Finnell, 1980; Perry, Guidubaldi, & Kehle, 1979; Pullman, 1981; Rourke & Finlayson, 1978; Satz, Taylor, Friel, & Fletcher, 1978; Stevenson, Parker, Wilkinson, Hegion, & Fish, 1976). Consistent with this view is the observation that children with poor arithmetic achievement also tend to be poor readers (Satz et al., 1978; Share, Silva, & Adler, in press; Yule, 1973). Studies investigating the factors associated with reading and arithmetic achievement have consistently reported a high degree of commonality between these two areas of achievement (Colligan, 1979; Fotheringham & Creal, 1980; Perry et al., 1979; Stevenson et al., 1976). For example, letter recognition in kindergarten correlates equally well with later reading and arithmetic achievement (Chansky et al., 1980; Perry et al., 1979). Moreover, the ability to count dots in kindergarten also correlates equally strongly with both reading and arithmetic achievement (Perry et al., 1979). Early cognitive and neuropsychological predictors of reading and arithmetic achievement are striking in their similarity (Bryant & Bradley, 1985; Stevenson et al., 1976). Some investigators have suggested that poor arithmetic achievement in many children may be attributable to poor reading skills per se (Muth, 1984; Pullman, 1981). For example, Muth (1984) experimentally manipulated the computational and reading demands of a series of arithmetic problems. She concluded that of the 54% of variance explained, 14% was uniquely attributable to reading skills, 8% to computational skills, and 32% to joint variance.

A further line of evidence suggesting that common verbal factors may underlie both arithmetic and reading is the nature of the difficulties experienced by children with both poor arithmetic and poor reading achievement. Rourke and Strang (1983) have argued that the difficulties these children have memorizing tables and memorizing procedural steps in problem solving are reflections of verbal impairments.

From the evidence outlined above, it seems clear that poor arithmetic achievement in many children may be attributable to deficits in verbal factors common to both reading and arithmetic and/or to poor reading skills per se. However, there appears to be a subgroup of children who have relatively specific difficulties in arithmetic despite normal levels of reading ability (Benson & Geshwind, 1970; Kinsbourne & Warrington, 1963; Rourke & Finlayson, 1978; Rourke & Strang, 1978).

Rourke and his associates (Rourke & Finlayson, 1978; Rourke & Strang, 1978, 1983) reported that a group of learning disabled children with above-average reading ability but below-average arithmetic achievement showed a qualitatively different pattern of neuropsychological strengths and weaknesses when compared to a learning disabled group with low achievement in both arithmetic and reading. The group with specific arithmetic difficulties showed poor nonverbal skills (visuo-spatial and tactile-perceptual) relative to verbal skills (verbal and auditory-perceptual). In a classic crossover interaction (see Rourke & Finlayson, 1978, Figure 1, p. 127), children with both arithmetic and reading difficulties showed the reverse pattern. Their performance on the nonverbal tasks was superior to their performance on verbal tasks. Rourke and Finlayson suggested these patterns of deficit reflect right hemisphere dysfunction in the case of specific arithmetic disabled children, in contrast to left hemisphere dysfunction in arithmetic-and-reading disabled children. Although normative data were presented, this study did not include any control groups. Demonstrating different patterns of performance *within* learning disabled populations does not imply that such differences explain differences in achievement *between* learning disabled and nondisabled populations. To attribute specific arithmetic difficulties solely to nonverbal deficits (as Rourke and his associates do), it is first necessary to show that these children have significantly poorer visuo-spatial and tactile-perceptual skills but similar verbal skills when compared to controls of the same age and reading ability. If nondisabled children, for example, were found to perform significantly better than disabled children on both verbal and nonverbal tasks, quite a different interpretation would be needed. Nolan, Hammeke, and Barkley (1983) compared a group of specific arithmetic impaired children to a group of nondisabled children with similar levels of reading achievement and found no significant differences on any verbal or nonverbal tasks in the Luria-Nebraska neuropsychological test battery. One weakness in this study that may have contributed to the null finding was the fact that members of the disabled group were on average 10 months older than the control subjects. A second weakness in both the Nolan et al. study and the studies reported by Rourke and colleagues was the exclusive use of subjects from referred populations. Such samples are likely to be atypical of the general population from which they are drawn (McGee, Williams, & Silva, 1984; Rutter, 1981).

The present study sought evidence of the "crossover effect" reported by Rourke and his colleagues using data obtained longitudinally from a large unselected sample that was also homogeneous with respect to age. On the basis of achievement tests administered at age 11, children were divided into three groups: arithmetic-and-reading disabled, specific arithmetic disabled, and the remaining children, who were designated "nondisabled controls." Following the methodology discussed by Bryant and Bradley (1985), groups were matched as closely as possible on achievement levels. That is, the level of reading achievement in the specific arithmetic disabled group was similar to the nondisabled controls, while their arithmetic achievement was similar to the group with both low arithmetic and reading achievement. In addition, the arithmetic-and-reading disabled group had similar levels of reading and arithmetic achievement.

These selection criteria were applied to boys and girls separately since it has been shown that combining boys and girls may either obscure gender-related differences or distort within-gender results (Share, Williams, & Silva, 1987). Both the Rourke and Nolan et al. studies used groups that were almost exclusively male. It was therefore of interest to examine possible gender differences.

The availability of a wide range of measures obtained from this sample at ages 9, 11, and 13 made it possible to form broad composite measures of verbal and nonverbal skills for an initial overall test of between-group differences. This overall test was followed up by more detailed examination of performance on the individual tests that made up these composite measures.

METHOD

Sample

The sample consisted of those children followed from birth by the Dunedin Multidisciplinary Health and Development Research Unit. The sample has so far been studied from birth to age 13, with most of the children tested within one month of their birthdays every second year since age 3. The study and sample have been described in detail by McGee and Silva (1982). In summary, these children were part of a cohort born between April 1972 and March 1973 at Queen Mary Hospital in Dunedin. The children were first traced at age 3 (1975), when a total of 1,139 lived in the Dunedin metropolitan area of the Otago province and were, thus, eligible for inclusion in the study. Of the 1,139 children, 1,037 were assessed within one month of their third birthdays (1975–1976). The remaining children were not assessed because of parental refusal or because they were traced too late for inclusion at this age. Subsequent assessments have occurred every two years, with 991 assessed at age 5, 954 at age 7, 955 at age 9, 925 at age 11, and 850 at age 13 (1985–1986).

When compared to all New Zealand children, the Dunedin sample is slightly skewed, with more children being represented in the upper socioeconomic status (SES) levels and fewer in the lower SES levels, according to the Elley and Irving (1972) index. In addition, the sample is mainly of European origin, with only 2% of Maori and Polynesian background compared with about 10% for the country as a whole (Department of Statistics, 1976).

Identification of Groups

The classification of children into groups was based on (a) data obtained at the Research Unit on the complete sample of children (n=925 at age 11) and (b) the results of standardized tests of mathematics and reading comprehension administered in school at age 11 to approximately 2,600 Dunedin children (Silva, 1984) attending intermediate schools in Dunedin. The standardized achievement tests were Progressive Achievement Tests (PAT) of Reading Comprehension (Elley & Reid, 1969) and Mathematics (Reid & Hughes, 1974). Of the 2,600 Dunedin children tested on the PAT, 625 children were part of the Health and Development study. These 625 children were tested between March and April, 1984, at which time their ages ranged from 11:0 to 12:0 with a mean of 11:6. Since Silva (1984) found no significant differences between the achievement of the 625 children from the Health and Development Study and the remaining Dunedin children of the same age tested on the PAT (approximately 2,000), it appears reasonable to assume that the sample of 625 is representative of Dunedin children in general.

Prior to the application of the achievement criteria discussed above, all children with evidence of social disadvantage, hearing and vision abnormalities, and psychiatric disturbance were excluded in accordance with the conventional exclusion criteria for learning disabilities. The following exclusion criteria were applied based on data obtained directly at the Research Unit on the complete sample of children in the Health and Development Study.

Social Disadvantage. At age 11 a measure of the adversity of a child's home background was obtained, based on Rutter's adversity index (Rutter, 1978). The index, described in McGee, Williams, and Silva (1985), was based on low paternal social class, large family size, low maternal intelligence score, single parent status, poor maternal mental health, and a relatively poor score on a measure of family social environment. All children with disadvantage scores of 7 or more (57 children, approximately the lowest 10% of the complete 11-year-old sample, $n=925$, seen at the Research Unit) were excluded.

Psychiatric Disturbance. Behavioral ratings obtained independently from parents, teachers, and children were used to exclude 64 11-year-old children for whom two of the three sources agreed on the presence of a behavioral disorder meeting DSM III criteria (Anderson, Williams, McGee, & Silva, in press).

IQ. Subjects who satisfied the achievement criteria (see below) for learning disability but with IQs below 90 ($n=55$) were excluded from the learning disabled groups. IQs were obtained from administration of the Weschler Intelligence Scale for Children-Revised (WISC-R) (Weschler, 1974) at age 11 at the Research Unit.

Hearing and Vision Abnormalities. Data obtained at age 11 from examination of refractive error were used to exclude 44 children with 4/6 visual acuity or near visual acuity equivalent to N8 or worse in one or both eyes. Pure tone audiometry led to the exclusion of 42 children with hearing losses of greater than 15 dB in either ear at each of four frequencies (.5, 1, 2, and 4 kHz).

Group Assignment. PAT achievement test results were used to define groups of children according to the achievement criteria discussed above. For the designation of arithmetic-and-reading disabled children the cutoff level of achievement was set at the 30th percentile in both arithmetic and reading. For the designation of specific arithmetic disabled groups, the same cutoff (at or below the 30th percentile) was used for arithmetic achievement. It was found that using the same reading cutoff for girls and boys left too few girls ($n=9$) in the specific arithmetic disabled group; therefore the reading score cutoff for girls was relaxed by 5 percentile points to include two additional girls. For reading, the cutoff for girls with specific arithmetic disability was set at achievement at or above the 35th percentile, and for boys with specific arithmetic disability at or above the 40th percentile. These selection criteria yielded 27 arithmetic-and-reading disabled boys, 19 specific arithmetic disabled boys, and 190 nondisabled control boys. There were 12 girls in the arithmetic-and-reading disabled group, 11 in the specific arithmetic disabled group, and 200 nondisabled control girls.

Measures

Data from a number of general measures of speech, language, intelligence, and motor development were collected when the children were seen at the Research Unit at ages 9, 11, and 13.

Language and Speech Development. At age 9 the Verbal Comprehension (Auditory Reception) and Verbal Expression subscales of the Illinois Test of Psycholinguistic Abilities were administered (Kirk, McCarthy, & Kirk, 1968). Speech articulation was assessed at age 9 with the Dunedin Articulation Check (Justin, Lawn, & Silva, 1983). At age 11, listening comprehension was assessed with the PAT Listening Comprehension Test.

Intelligence. The WISC-R was administered at age 13. Only eight subtests were given in order to reduce testing time: Information, Similarities, Arithmetic, Vocabulary, Picture Completion, Block Design, Object Assembly, and Coding. Verbal, Performance, and Full Scale IQs were prorated using the method described in the test manual.

Motor Development. At age 9, children were administered the Basic Motor Abilities Test (Arnheim & Sinclair, 1974). This test was comprised of nine subtests: long jump, agility run, target throwing, push-ups, face-down to standing, tapping, balance, bead stringing, and hamstring stretch. At age 11, tests of flexibility, curl-ups, and bead stringing were administered.

Neuropsychological Measures. Neuropsychological measures in this study may be divided into tasks that require the subject to use language (language-based tests) and tasks that allow performance without reliance upon language skills (non-language-based tests). Among the language-based tests were the following: (1) the Rey Auditory Verbal Learning Test (Rey, 1964; Taylor, 1959), which consisted of four presentation trials with immediate recall of a 15-word list, presentation of an interference list, and a sixth recall trial after 15 minutes' delay; (2) a shortened version of the Controlled Oral Word Association Test (Benton & Hamsher, 1978), in which the child was asked to say as many words as possible beginning with the letter *A* (and then *S*) in 1 minute; (3) the Trail-Making Test, Forms A and B (Lewisohn, 1973; Reitan, 1958). For this last test the child drew lines to connect a sequence of numbered circles on a sheet (A) and then to connect numbered and lettered circles in alternative sequence (B).

Non-language-based tests included (1) The Grooved Pegboard (Klove, 1963; Knights & Moule, 1968), consisting of a small board containing slotted holes angled in varying directions. The subject was timed while inserting notched pegs into the board, with separate trials for each hand. (2) WISC-R Mazes, in which the subject drew the way out of a series of increasingly difficult mazes. (3) The Rey-Osterreith Complex Figure (Osterreith, 1944; Waber & Holmes, 1985), which required the child to copy a complex figure, and then after 3 minutes of interpolated activity (the Grooved Pegboard Test), the child was asked to reproduce the figure from memory.

Each of the tests yielded several scores for quantitative aspects (e.g., numbers of errors), qualitative aspects (e.g., types of errors), and for timed aspects of task performance. All scores were coded so that larger scores reflected better performance, consistent with the WISC-R. All scores were transformed to z-scores separately for boys and girls, so that each gender cohort formed its own normative standards.

Composite Measures. To test the major hypothesis that children with specific arithmetic disabilities showed the reverse pattern of strengths and weaknesses (low nonverbal relative to verbal) compared to children with arithmetic-and-reading disability (low verbal relative to nonverbal), all available measures were collapsed into two broad composite measures of language-based and non-language-based measures as follows. All individual scores were recoded for consistent directionality and transformed to z-scores for equivalent scaling. The z-scores for each subject were then averaged to yield composite z-scores for language-based and non-language-based measures.

The composite language-based measure included ITPA Comprehension and Expression, speech articulation, PAT Listening Comprehension, and Rey Auditory-Verbal Learning and Verbal Fluency.[1] The composite non-language-based measure consisted of all the motor tests administered at ages 9 and 11, the Grooved Pegboard Test, Rey-Osterreith copying and recall, and Mazes. A comparison of Verbal and Performance IQs enabled a second independent overall test of the crossover effect.

Table 1
Group Means and Standard Deviations for Descriptive Variables

Variable[a]	Group 1 (Non-disabled)	Group 2 (Arithmetic-and-reading disabled)	Group 3 (Specific arithmetic disabled)
Boys	n = 190	n = 27	n = 19
PAT Reading Percentile*,***			
M	60.94	15.25	55.47
SD	26.20	8.80	11.84
PAT Mathematics Percentile*,**			
M	58.06	20.25	20.21
SD	24.27	8.67	7.08
WISC-R Full Scale IQ*			
M	113.44	103.62	107.10
SD	15.01	9.14	8.78
Family Disadvantage Index			
M	1.70	2.15	2.15
SD	1.51	1.56	1.95
Girls	n = 200	n = 12	n = 11
PAT Reading Percentile*,***			
M	56.78	14.25	53.72
SD	26.25	6.94	15.17
PAT Mathematics Percentile*,**			
M	52.79	14.33	17.36
SD	23.15	8.53	8.54
WISC-R Full Scale IQ*			
M	108.94	100.58	104.63
SD	15.15	8.41	9.18
Family Disadvantage Index			
M	1.80	2.09	2.09
SD	1.57	2.25	1.51

[a]PAT = Progressive Achievement Tests; WISC-R = Wechsler Intelligence Scale for Children-Revised.
*Comparison between nondisabled and arithmetic-and-reading disabled yields $p < .05$.
**Comparison between nondisabled and specific arithmetic disabled yields $p < .05$.
***Comparison between arithmetic-and-reading disabled and specific arithmetic disabled yields $p < .05$.

RESULTS AND DISCUSSION

Group means and standard deviations for arithmetic and reading achievement, Full Scale IQ, and an index of family disadvantage appear in Table 1. One-way analyses of variance followed by Tukey's HSD test were used to test differences between groups. The analyses of variance indicated that the selection procedure had successfully selected arithmetic-and-reading disabled children with comparably low achievement in both arithmetic and reading. Furthermore, the specific arithmetic disabled groups had equally low arithmetic achievement when compared to the arithmetic-and-reading disabled groups but similar achievement in reading compared to the nondisabled controls. Although the arithmetic-and-reading disabled groups had lower Full Scale IQs, there were no significant differences on the disadvantage index.

Results from Composite Measures

Group means on Verbal and Performance IQ and on the composite

[1]The Trails test was included in the language-based composite measure in an earlier version of this manuscript. However, several reviewers were unhappy with this decision. Comparison of this test's correlations with the language-based and non-language-based composite measures failed to clarify where Trails belonged. Trails correlated equally strongly with both language (.49 girls, .40 boys) and nonlanguage (.42 girls, and .38 boys) measures. It was finally decided to exclude this test entirely from both composite measures. Happily, this did not change the pattern of differences between groups.

language-based and non-language-based measures are depicted in Figure 1. For ease of comparison, all scores are plotted as z scores. On both independent sets of measures the crossover effect was clearly evident for boys but notably absent for girls. Arithmetic-and-reading disabled boys scored significantly lower than controls on the composite language-based measure but were not significantly different on the non-language-based measure. On the non-language-based tasks the difference between groups just failed to reach significance ($p=.06$). However, the Performance IQs of both arithmetic-and-reading disabled boys and specific arithmetic disabled boys were significantly below those of controls. On Verbal IQ, only arithmetic-and-reading disabled boys were significantly below controls.

The present results therefore replicated Rourke's crossover effect, with one additional piece of evidence. Specific arithmetic disabled boys not only showed a reverse pattern of strengths and weaknesses compared to arithmetic-and-reading disabled boys, but the "specific" group's nonverbal skills were significantly below those of boys of the same age and reading ability but who had normal levels of arithmetic achievement (the nondisabled controls).

Girls with arithmetic-and-reading disability showed a similar pattern of results to the arithmetic-and-reading disabled boys. Significant differences from controls were found on both Verbal and Performance IQs and on the language-based composite. Unlike boys, however, girls with specific arithmetic disability did not differ significantly from controls nor was there any evidence of a crossover effect.

Although these data are consistent with the hypothesis that nonverbal deficits may have a causal role in specific arithmetic disability in boys, factors other than those measured in the present study may be responsible for specific arithmetic disabilities in girls. It was also apparent that deficits in the language area alone may not be sufficient to explain arithmetic difficulties that are accompanied by reading problems. Both girls and boys with arithmetic-and-reading disabilities had significantly lower Performance IQs than controls.

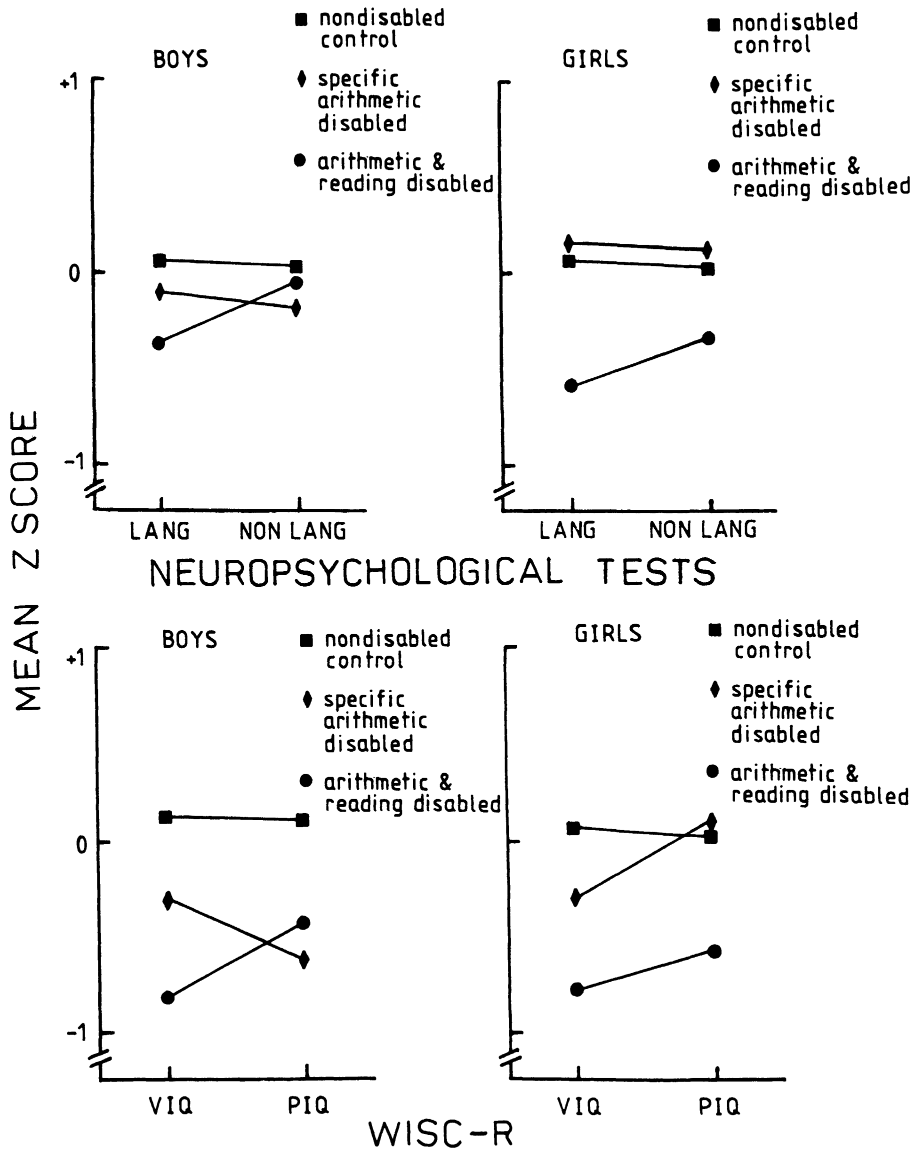

Figure 1. Performance of disabled and nondisabled children on language-based (LANG) and non-language-based (NONLANG) measures.

Results from Individual Tests

Group performance on individual tests was examined to determine whether deficits were evident in any discrete area of verbal and nonverbal functioning. Rourke and Strang (1978) found no significant differences between arithmetic-and-reading disabled and specific arithmetic disabled children on two tasks of general motor skills (grip strength and finger tapping) but significant differences on the Mazes and Grooved Pegboard Test (labeled "psychomotor") and also on the Reitan Davidson Tactual Performance Test. With the inclusion of the Mazes and Grooved Pegboard tasks in the present study as well as a number of other motor tasks, it was possible to test the hypothesis that specific arithmetic disabled children have a specific psychomotor deficit.

To avoid inflating the Type I error rate with the large number of significance tests being carried out, alpha was set at .01 for the overall analysis of differences between groups on individual measures. A significant overall test was followed by post hoc comparisons between groups using Tukey's HSD test (Winer, 1962).

Boys. Consistent with the finding that arithmetic-and-reading disabled boys showed poor performance on the composite language-based measure, significant differences between this group and nondisabled controls were also found on most individual language-based measures (including ITPA Comprehension, speech articulation, PAT Listening Comprehension, WISC-R Information, WISC-R Arithmetic, and WISC-R Vocabulary). Among the neuropsychological measures only the time taken to complete Trails B showed a significant difference. This pattern of results failed to suggest that any particular aspect of language may be responsible for the overall verbal decrement. Arithmetic-and-reading disabled boys also had significantly lower scores on WISC-R Block Design but were significantly better than controls at push-ups. Specific arithmetic disabled boys were significantly below controls on only three measures apart from WISC-R Arithmetic. These were Block Design (psychomotor), push-ups (motor), and ITPA Comprehension.

It appears that although specific arithmetic disabled boys had weak nonverbal skills relative to verbal skills (see also Figure 1), it does not follow that their deficits are exclusively nonverbal. It can be seen in Figure 1 that this group's scores on the language-based composite and Verbal IQ fell approximately midway between nondisabled controls and the arithmetic-and-reading disabled group. Because both disabled groups had similar levels of arithmetic achievement, it is reasonable to conclude that verbal deficits may play a relatively greater role in the arithmetic difficulties experienced by arithmetic-and-reading disabled boys. However, a more secondary role for verbal deficits was evident in the performance of specific arithmetic disabled boys.

Girls. For arithmetic-and-reading disabled girls, significant deficits were found on several neuropsychological measures, including Rey Auditory-Verbal Learning, Mazes, and the Rey-Osterreith copying/recall task. Both verbal and nonverbal deficits (relative to controls) were apparent in this group—perhaps to a greater degree than for the boys. (Boys with arithmetic-and-reading disability tended to show a predominantly verbal pattern of deficits.) Apart from WISC-R Arithmetic, specific arithmetic disabled girls showed no significant performance decrement on any of the tests examined when compared to controls of similar reading levels.

CONCLUSIONS

Results obtained in the present unselected sample of boys for the most part replicated the crossover effect reported by Rourke and his associates (Rourke & Finlayson, 1978; Rourke & Strang, 1978). Of course, the use of slightly different tests and selection techniques makes exact comparisons with the Rourke et al. studies impossible. On the other hand, replication of the basic crossover effect in boys, in spite of these procedural variations, can only serve to strengthen confidence in the robustness of this effect.

Rourke concluded that children with arithmetic-and-reading disability are characterized by verbal deficits while children with specific arithmetic difficulties are characterized by nonverbal deficits. The inclusion of a nondisabled control group in the present study revealed that even the "strengths" of the disabled groups appeared to be below the performance levels of nondisabled students and may therefore also have contributed to the disorder. Arithmetic-and-reading disabled children (both girls and boys) showed a pattern of predominantly verbal deficits but also showed evidence of some nonverbal deficits. When compared to controls, arithmetic-and-reading disabled girls showed a pattern of deficits best characterized as general rather than predominantly verbal.

These findings indicate some of the potential pitfalls in (a) confining investigations to differences *within* learning disabled populations in the absence of non-learning-disabled controls and (b) generalizing across gender from results obtained with predominantly male samples. The present study found no evidence of the crossover effect in girls, nor any evidence of deficits in the nonverbal domain in girls with specific arithmetic disability. If these findings are replicated, they may suggest that the explanation for specific arithmetic difficulties in girls may be found in factors other than their cognitive or neuropsychological abilities. One possibility may be motivational; some girls may see mathematics as a "male" domain.

It seems highly unlikely that these gender differences can be attributed to the use of different selection criteria for specific arithmetic disabled girls versus boys. The need to relax the lower percentile bound for normal reading achievement from 40 to 35 in specific arithmetic disabled girls simply attests to the closer association between reading and arithmetic in girls. Only nine specific arithmetic disabled girls satisfied the 40th percentile cutoff. The lower cutoff added only two further girls. The gender differences reported here dramatically reinforce arguments presented elsewhere (Share et al., 1987) that girls and boys differ both quantitatively and qualitatively and should therefore be considered separately.

The present study failed to find clearcut evidence on the nature of the nonverbal deficits in specific arithmetic disabled boys. This group was significantly below controls on both the WISC-R Block design and on a motor task (push-ups). There was therefore insufficient evidence to support Rourke and Strang's (1978) conjecture that children with specific arithmetic difficulties have a specific psychomotor deficit as opposed to a general motor deficit. However, low power resulting from relatively small sample sizes may well have obscured some of the analyses on individual tests.

The use of different tests at different ages suggests caution regarding the possibility of experimental and developmental confounds. Unfortunately, the logistics of the present study did not make it possible to administer all the tests to all the children at the same time. The question of confounding can only be settled empirically. Perhaps the most serious doubt concerns the stability of group classification across testing ages. Fortunately, data reported elsewhere on the long-term stability of reading disabled group classification (Share & Silva, 1986) suggest that unstable classification is unlikely to be a problem.

An important issue that it was not possible to address in the present study was the type of arithmetic difficulties experienced by disabled children. Comprehensive diagnostic testing together with careful task analysis is needed in order to pinpoint the nature of these difficulties. The Rourke studies appear to be one of the few attempts to link these children's difficulties with patterns of deficits. This is an important avenue for future research for at least two reasons. First, demonstrating the presence of a particular cognitive or neuropsychological deficit does not imply causation (the familiar "correlation equals causation" fallacy). For example, there is evidence that some language deficits in reading disabled children (who are probably also arithmetic disabled) may be partly the consequence of the learning difficulty itself (Bishop & Butterworth, 1980; Share & Silva, in press). A theory that links patterns of neuropsychological deficits with the particular difficulties experienced by children during the learning process provides a stronger case for causal attributions. A second advantage to be gained by linking neuropsychological deficits to the nature of the arithmetic difficulties is in the development of theory-based prescriptions for remediation. Too often, consideration of cognitive/neuropsychological deficits in isolation provides few or no guidelines for treatment.

ABOUT THE AUTHORS

David L. Share *received his PhD from Deakin University in 1985. He is currently a Neil Hamilton Fairley Fellow (National Health & Medical Research Council of Australia). His research interests include early literacy acquisition and learning disabilities.* **Terrie E. Moffitt** *received her PhD from the University of California, Los Angeles, in 1984. She is now an assistant professor of clinical psychology at the University of Wisconsin at Madison. Her research interests are in the neuropsychological correlates of psychopathology, especially juvenile delinquency.* **Phil A. Silva** *received his PhD from Otago University in 1975. He is now Director of the Dunedin Multidisciplinary Health and Development Research Unit, University of Otago Medical School, Dunedin, New Zealand, and a Medical Research Council of New Zealand Career Fellow. His research interests include multidisciplinary aspects of human health and development. Address: David L. Share, Department of Psychology, University of Queensland, St. Lucia QLD 4067, Australia.*

ACKNOWLEDGMENTS

1. The Dunedin Multidisciplinary Health and Development Research Unit is supported by the Medical Research Council of New Zealand, the Departments of Education and Health, and involves several departments of the University of Otago.

2. The authors are indebted to the many people whose contributions make this ongoing study possible. Dr. Share is the recipient of a Neil Hamilton Fairley Fellowship (National Health and Medical Research Council of Australia). Dr. Moffitt is supported by USPHS Grant 1-R23-MH-39994-01 from the Antisocial and Violent Behaviour Branch of the United States National Institute of Mental Health; and Dr. Silva is a Medical Research Council of New Zealand Career Fellow.

REFERENCES

Anderson, J.C., Williams, S., McGee, R.D., & Silva, P.A. (in press). The prevalence of DSM III disorders in a large sample of preadolescent children from the general population. Archives of General Psychiatry.

Arnheim, D.D., & Sinclair, W.A. (1974). The clumsy child. St. Louis: C.V. Mosby.

Benson, D.F., & Geshwind, N. (1970). Developmental Gerstmann syndrome. Neurology, 20, 293-298.

Benton, A.L., & Hamsher, K. deS. (1978). Multilingual aphasia examination manual. Iowa City: University of Iowa.

Bishop, D.V.M., & Butterworth, G.E. (1980). Verbal-performance discrepancies: Relationship to birth risk and specific reading retardation. Cortex, 16, 375-389.

Bryant, P., & Bradley, L. (1985). Children's reading problems. Oxford, England: Basil Blackwell.

Chansky, N.M., Czernik, J., Duffy, J., & Finnell, L. (1980). Sex differences and initial reading performance. Psychological Reports, 46, 523-526.

Colligan, R.C. (1979). Predictive utility of the Myklebust Pupil Rating Scale: A two-year follow-up. Journal of Learning Disabilities, 12, 59-62.

Department of Statistics. (1976). New Zealand Yearbook. Wellington: Government Printer.

Elley, W.B., & Irving, J.C. (1972). A socio-economic index for New Zealand based on levels of education and income from the 1966 census. New Zealand Journal of Educational Studies, 7, 155-167.

Elley, W.B., & Reid, N.A. (1969). Progressive achievement tests. Teacher's manual. Reading comprehension. Reading vocabulary. Wellington: New Zealand Council for Educational Research.

Fotheringham, J.B., & Creal, D. (1980). Family socioeconomic and educational-emotional characteristics as predictors of school achievement. Journal of Educational Research, 73, 311–317.

Justin, C., Lawn, L., & Silva, P.A. (1983). The Dunedin articulation check (DAC). A clinical instrument from the Dunedin Multidisciplinary Health and Development Research Unit. Dunedin, New Zealand: Otago Speech Therapy Association.

Kinsbourne, M., & Warrington, E.K. (1963). The developmental Gerstmann syndrome. Archives of Neurology, 8, 490-501.

Kirk, S.A., McCarthy, J.J., & Kirk, W.D. (1968). The Illinois test of psycholinguistic abilities (rev ed.). Urbana: University of Illinois Press.

Klove, J. (1963). Clinical neuropsychology. In F.M. Forster (Ed.), The medical clinics of North America (pp. 1647-1658). New York: Saunders.

Knights, R.M., & Moule, A.D. (1968). Normative data on the motor steadiness battery for children. Perceptual and Motor Skills, 26, 643-650.

Lewisohn, P.M. (1973). Psychological assessment of patients with brain injury. Unpublished manuscript. Eugene: University of Oregon.

McGee, R., & Silva, P.A. (1982). A thousand New Zealand children: Their health development from birth to seven. Special Report No. 8. Auckland: Medical Research Council of New Zealand.

McGee, R., Williams, S.M., & Silva, P.A. (1984). Behavioural and developmental characteristics of aggressive, hyperactive, and aggressive-hyperactive boys. Journal of the American Academy of Child Psychiatry, 23, 270-279.

McGee, R., Williams, S.M., & Silva, P.A. (1985). The factor structure and correlates of ratings of inattention, hyperactivity, and antisocial behavior in a large sample of nine-year-old children from the general population. Journal of Consulting and Clinical Psychology, 53, 480-490.

Muth, K.D. (1984). Solving arithmetic word problems: Role of reading and computational skills. Journal of Educational Psychology, 76, 205-210.

Nolan, D.R., Hammeke, T.A., & Barkley, R.A. (1983). A comparison of the patterns of the neuropsychological performance in two groups of learning disabled children. Journal of Clinical Child Psychology, 12, 22-27.

Osterreith, P.A. (1944). Le test de copie d'une figure complex. Archives de Psychologie, 30, 206-356.

Perry, J.D., Guidubaldi, J., & Kehle, T.J. (1979). Kindergarten competencies as predictors of third-grade classroom behaviour and achievement. Journal of Educational Psychology, 71, 443-450.

Pullman, H.W. (1981). The relationship of the structure of language to performance in mathematics. Journal of Psycholinguistic Research, 10, 327-338.

Reid, N.A., & Hughes, D.C. (1974). Progressive achievement tests, teacher's manual. Mathematics. Wellington: New Zealand Council for

Educational Research.
Reitan, R.M. (1958). Validity of the trail making test as an indication of organic brain damage. Perceptual and Motor Skills, 8, 271-276.
Rey, A. (1964). L'examen clinique en psychologie. Paris: Presses Universitaires de France.
Rourke, B.P., & Finlayson, M.A.J. (1978). Neuropsychological significance of variations in patterns of academic performance: Verbal and visual-spatial abilities. Journal of Abnormal Child Psychology, 6, 121-123.
Rourke, B.P., & Strang, J.D. (1978). Neuropsychological significance of variations in patterns of academic performance: Motor, psychomotor, and tactile-perceptual abilities. Journal of Pediatric Psychology, 3, 62-66.
Rourke, B.P., & Strang, J.D. (1983). Subtypes of reading and arithmetic disabilities: A neuropsychological analysis. In M. Rutter (Ed.), Developmental neuropsychiatry (pp. 473-488). New York: Guilford Press.
Rutter, M. (1978). Family, area and school influences in the genesis of conduct disorders. In L.A. Hersov, M. Berger, & D. Schaffer (Eds.), Aggression and anti-social behaviour in childhood and adolescence. Oxford, England: Pergamon Press.
Rutter, M. (1981). Epidemiological/longitudinal strategies and causal research in child psychiatry. Journal of the American Academy of Child Psychiatry, 20, 513-544.
Satz, P., Taylor, H.G., Friel, J., & Fletcher, J.M. (1978). Some developmental and predictive precursors of reading disabilities: A six year follow-up. In A.L. Benton & D. Pearl (Eds.), Dyslexia (pp. 313-347). New York: Oxford University Press.
Share, D.L., & Silva, P.A. (1986). The stability and classification of specific reading retardation: A longitudinal study from age 7 to 11. British Journal of Educational Psychology, 56, 32-39.
Share, D.L., & Silva, P.A. (in press). Language deficits and specific reading retardation: Cause or effect? British Journal of Disorders of Communication.
Share, D.L., Silva, P.A., & Adler, C.J. (1987). Factors associated with reading-plus-spelling retardation and specific spelling retardation. Developmental Medicine and Child Neurology, 29, 64-71.
Share, D.L., Williams, S., & Silva, P.A. (1987). Specific reading retardation: Girls versus boys. Manuscript submitted for publication.
Silva, P.A. (1984). The educational attainment of 2,600 Dunedin children: A report on the Dunedin intermediate schools' collaborative testing project 1984: The NZCER tests. Dunedin: The Dunedin Multidisciplinary Health & Development Research Unit.
Stevenson, H.W., Parker, T., Wilkinson, A., Hegion, A., & Fish, E. (1976). Longitudinal study of individual differences in cognitive development and scholastic achievement. Journal of Educational Psychology, 68, 377-400.
Taylor, E.M. (1959). The appraisal of children with cerebral deficits. Cambridge, MA: Harvard University Press.
Waber, D.P., & Holmes, J.M. (1985). Assessing children's copy productions of the Rey-Osterreith complex figure. Journal of Clinical and Experimental Psychology, 7, 264-280.
Wechsler, D. (1974). Manual of the Wechsler intelligence scale for children-Revised. New York: Psychological Corp.
Winer, B.J. (1962). Statistical principles in experimental design. New York: McGraw-Hill.
Yule, W. (1973). Differential prognosis of reading backwardness and specific reading retardation. British Journal of Educational Psychology, 43, 244-248.

NATIONAL ASSOCIATION CONVENTION CALENDAR

May 1-2, 1988 • Washington, DC • **Society for Behavioral Pediatrics,** 241 E. Gravers Ln., Philadelphia, PA 19118; 215/248-9168

May 4-7, 1988 • Banff, Canada • **Canadian Association of Speech-Language Pathologists and Audiologists,** 5599 Fenwick St., Halifax, N.S. B3H 1R2; 403/240-4762

May 7-13, 1988 • Montreal, Canada • **American Psychiatric Association,** 1400 K St., N.W., Washington, DC 20005; 202/682-6193

May 21-23, 1988 • Kansas City, Missouri • **Neuro-Developmental Treatment Association,** PO Box 2110, Glen Ellyn, IL 60138; 312/717-1710

May 26-30, 1988 • Philadelphia, Pennsylvania • **Association for Behavior Analysis,** Western Michigan University, Kalamazoo, MI 49008; 616/383-1629

May 29-June 2, 1988 • Washington, DC • **American Association on Mental Deficiency,** 1710 Kalorama Rd., NW, Washington, DC 20009; 202/387-1968

June 12-15, 1988 • Cleveland, Ohio • **Association for the Care of Children's Health,** 3615 Wisconsin Ave. N.W., Washington, DC 20016; 202/244-1801

August 17-19, 1988 • Fort Worth, Texas • **Texas School for the Deaf,** 1102 S. Congress Ave., PO Box 3538, Austin, TX 78764; 512/442-7821

October 13-15, 1988 • Louisville, Kentucky • **Council for Learning Disabilities,** PO Box 40303, Overland Park, KS 66204: 913/492-8755

October 21-22, 1988 • Indianapolis, Indiana • **Indiana Association for Children and Adults with Learning Disabilities,** PO Box 20584, Indianapolis, IN 46220: 317/266-4001

November 5-8, 1988 • Melbourne, Australia • **Spastic Society of Victoria,** 135 Inkerman St., PO Box 381, St. Kilda, Victoria, Austrailia, 3182; 03/537-2611

November 9-12, 1988 • Philadelphia, Pennsylvania • **National Association of Social Workers,** 7981 Eastern Ave., Silver Spring, MD 20910; 301/565-0333

December 8-9, 1988 • Washington, DC • **The Association for Persons with Severe Handicaps,** 7010 Roosevelt Way N.E., Seattle, WA 98115; 206/523-8446