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NEUROPSYCHOLOGICAL SIGNIFICANCE OF VARIATIONS IN
PATTERNS OF ACADEMIC PERFORMANCE: MOTOR, PSYCHOMOTOR,
AND TACTILE-PERCEPTUAL ABILITIES

by

John Douglas Strang

B. A. York University, 1974

A Thesis

Submitted to the Faculty of Graduate Studies
through the Department of Psychology
in Partial Fulfillment of the
Requirements for the Degree
of Master of Arts at the
University of Windsor

Windsor, Ontario, Canada

1977



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ABSTRACT

Forty-five 9- to 14-year-old children with learning disabilities who fell within the WISC Full Scale IQ range of 86-114 were divided into three groups on the basis of their patterns of reading, spelling, and arithmetic achievement. Group 1 was composed of children who were uniformly deficient in reading, spelling, and arithmetic; children in Group 2 were relatively adept at arithmetic as compared to their performance in reading and spelling; Group 3 was composed of children whose reading and spelling performances were average or above, but whose arithmetic performance was relatively deficient. The performances of these children were compared on 19 dependent measures.

The performances of Groups 1 and 2 were superior to that of Group 3 on the psychomotor and composite tactile-perceptual measures. In general, the results with regard to expectations of differences in right- and left-hand performances within and among groups were not as profound, although all differences were in the expected direction. Group 1 exhibited no differences in right- and left-hand performances on the motor, psychomotor, and tactile-perceptual tasks. Group 2 exhibited a superior left-hand performance on the most complex psychomotor task as well as on a relatively simple motor task. Group 3 exhibited a superior right-hand performance on the most complex psychomotor task as well as on the tactile-perceptual tests. No other differences in right- and left-hand performances within either group were in evidence, although Group 2 was superior to Groups 1 and 3 in left-hand performance on the most complex psychomotor task.

The results are discussed in terms of the relationships between varying patterns of academic abilities and patterns of brain-related behaviours, and the nature of the neuropsychological abilities which may facilitate or limit performance on arithmetic calculation tasks.

This thesis is dedicated to
the "older" people in my family:
my grandmothers, Dorothy and Margaret
and, her husband Walter; my great aunts,
Lillian and Mary and; my great uncle, Fred.
They are a lesson to all of us in that they're
always interested and, always care.

There are a number of people to which I am indebted for assistance in the completion of this thesis. First, however, I would like to take this opportunity to extend my sincere thanks to Dr. Byron Rourke, not only for introducing me to this project, but also for his friendship, guidance and concern throughout these past two years.

I would like to express my appreciation to Dr. Ann McCabe for travelling far to provide instructive comments and to Dr. James Duthie also for his helpful comments on this thesis. A hearty "thank you" is due Marilyn Frederick for her very able ~~typing~~ assistance. Last, but not least, I would like to thank the other members of the Neuropsychology Unit staff for their invaluable and timely help during the various stages of research and writing.

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CHAPTER I

INTRODUCTION

A significant problem facing educators of learning disabled children is how best to group the individual children for purposes of educational remediation. For this and other reasons that are more directly related to actual programme planning, several investigators (e.g., Ackerman, Dykman, & Peters, 1976; Doehring & Hoschko, 1976; Mattis, French, & Rapin, 1975; Nelson & Warrington, 1976; Rourke, 1975, 1976a, 1978) have stressed the need for more exact specification of the abilities and deficits exhibited by differing types of learning disabled children.

The purpose of this study is to provide further information concerning the neuropsychological characteristics of groups of learning disabled children (see Rourke [1975] for an extended treatment of this mode of approach) wherein significant variations in pattern of performance on reading, spelling, and arithmetic tasks are exhibited. The performance of these three groups had recently been compared on several verbal and visual-spatial variables (Rourke & Finlayson, 1976) which had been shown in previous research (e.g., Boll, 1974; Rourke, 1975) to be sensitive to the relative integrity of the two cerebral hemispheres (especially with respect to "higher cortical functions") in children. In the present study, the motor, psychomotor, and tactile-perceptual performances on the two sides of the body were compared in an attempt to clarify some of the issues relating to assertions made in the Rourke and Finlayson (1978) study regarding the relative integrity of the cerebral hemispheres for the groups of children in question. It was anticipated that significant differences between Groups 1 and 2, absent in the Rourke and Finlayson study (1978) would emerge.

Before discussing the Rourke and Finlayson (1978) study, it is necessary to review the results of some relevant work from two areas of research; the

neuropsychological abilities of children with learning disabilities; and the neuropsychological abilities of adults with well-documented cerebral lesions.

The results of some previous studies which have focussed on the neuropsychological abilities of children who exhibit learning disabilities have been reviewed elsewhere (Rourke, 1975). Of these studies, there are two of particular interest within the present context. In one of these (Rourke & Telegdy, 1971), older (9 to 14 years) children with learning disabilities were divided into three groups on the basis of their Verbal IQ and Performance IQ scores on the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1949). The performance of these subjects on 25 measures indicated clear superiority of the Low Verbal IQ - High Performance IQ group on a number of measures of complex motor and psychomotor abilities. The results of this study in conjunction with that of Rourke, Young, and Flewelling (1971) were considered consistent with the view that WISC Verbal IQ - Performance IQ discrepancies reflect the differential integrity of the two cerebral hemispheres in older children with learning disabilities. Specifically, it was hypothesized that the Low Verbal IQ - High Performance IQ subjects may have a more intact right than left cerebral hemisphere, whereas the exact opposite may be the case for the High Verbal IQ - Low Performance IQ subjects.

With these results as background, the next investigation in this series (Rourke, Yanni, MacDonald, & Young, 1973) was concerned with the patterns of psychological test performances of older children with learning disabilities who had been distributed into groups on the basis of the presence or absence of lateralized psychomotor deficits as indicated by performance on the Grooved Pegboard Test. In this investigation, the patterns of performance exhibited by the four groups so composed were found to be strikingly similar to those exhibited by adults with well-documented lateralized and non-lateralized

cerebral lesions as described in previous research (e.g., Reed & Reitan, 1963; Reitan, 1955). Of particular concern within the context of the present investigation is the fact that the group composed of subjects with normal right-hand and impaired left-hand performance on the Grooved Pegboard Test (who also had a higher Verbal IQ than Performance IQ) exhibited a pattern of High WRAT Reading and Spelling and relatively low Arithmetic, whereas among the subjects with impaired right-hand and normal left-hand Grooved Pegboard Test performance (who also had a lower Verbal IQ than Performance IQ) there was some tendency for their WRAT Arithmetic performance to be better than their performances on the WRAT Reading and Spelling subtests. Furthermore, the two groups with no lateralized deficits on the Grooved Pegboard Test performed at a level intermediate to that of the other two groups on verbal tests, regardless of the fact that one group had right- and left-hand Grooved Pegboard Test performances that were within normal limits while the other group was composed of subjects whose right- and left-hand performances were impaired. This latter group (which had virtually identical Verbal and Performance IQs) displayed a pattern of performance on the WRAT in which there was no appreciable differences among any of the three subtests.

The aforementioned studies with learning disabled children acquire added significance when viewed in the light of the results of some studies that have employed adult humans with known cerebral lesions as subjects. Reitan, (1958) compared the performance of groups of subjects with known cerebral lesions on the Tactual Performance Test. He found that subjects with lesions confined principally to the left cerebral hemisphere required more time to complete the task with the right hand than with the left hand, and that subjects with right cerebral lesions required more time to complete the task with the left hand than with the right hand. In addition, on a finger-tapping test, it was found that subjects with left cerebral lesions showed

some impairment in finger-tapping speed with the right hand, whereas subjects with right cerebral lesions exhibited deficits in finger-tapping speed with the left hand.

In a related study, Reed and Reitan (1963) compared the performances of brain-damaged subjects suffering from lateralized motor deficits (hemiplegia and hemiparesis), brain-damaged subjects with no lateralized motor deficits, and hospitalized control subjects with no detectable brain damage. The Wechsler-Bellevue was administered to all subjects. The performance of the normal controls was superior to that of all of the brain-damaged groups on all subtests of the Wechsler-Bellevue. The performance of groups with left-sided motor deficits was superior to that of the groups with right-sided motor deficits on all of the Verbal measures, with the reverse being the case for the Performance measures. The brain-damaged group with no lateralized motor deficits performed at a level intermediate to that of the other brain-damaged groups on the Verbal tests, and generally somewhat superior to these groups on the Performance measures.

Thus, it has been established that: (1) brain-damaged adults with lateralized motor deficits exhibit particular patterns of Wechsler-Bellevue Verbal IQ-Performance IQ discrepancies (Reed & Reitan, 1963); (2) adults with lesions confined to either the right or left cerebral hemisphere exhibit lateralized deficits on complex motor and psychomotor tasks (Reitan, 1958); (3) particular patterns of WISC Verbal IQ - Performance IQ discrepancies may reflect the differential integrity of the two cerebral hemispheres (Rourke & Telegdy, 1971; Rourke et. al., 1971) of children with learning disabilities; (4) lateralized deficits on a psychomotor task are related to consistent WISC Verbal IQ - Performance IQ discrepancies in such children and, possibly, to (a) variations in patterns of WRAT Reading, Spelling and Arithmetic performance;

and, (b) differential hemispheric integrity (Rourke et. al. 1973).

With these studies as background, Rourke and Finlayson (1978) formed three groups for study, as follows: Group 1 was composed of children who were relatively deficient, as compared to their age-mates, in reading, spelling, and arithmetic; Group 2 was composed of children who were relatively deficient in reading and spelling as compared to their performance in arithmetic; and, Group 3 was composed of children whose level of arithmetic achievement was poor relative to their performance in reading and spelling. The dependent measures were chosen so as to reflect a fairly broad spectrum of verbal, auditory-perceptual, visual-perceptual, and visual-spatial skills similar to those employed in the Rourke, et. al. (1971) study.

In general, it was found that the performance of Group 1 was quite similar to that of Group 2 (e.g., all subjects in both Groups had a lower Verbal IQ than Performance IQ except for one subject in Group 2 who had equivalent Verbal IQ and Performance IQ scores). For the most part, the performance of Group 2 was significantly inferior to that of Group 3 on measures of verbal and auditory-perceptual abilities, and significantly superior to that of Group 3 on most of the measures of visual-perceptual and visual-spatial abilities. All subjects in Group 3 had a higher Verbal IQ than Performance IQ.

If there is reason to believe that WISC Verbal IQ - Performance IQ discrepancies may be associated with or reflect the differential integrity of the two cerebral hemispheres in older children with learning disabilities, it would appear that the basis upon which the groups were chosen in the Rourke and Finlayson (1978) study may also reflect this difference. Specifically, the subjects in this study who were relatively adept at arithmetic as compared to their performance in reading and spelling (Group 2) performed in a fashion consistent with that which would be expected were they to have a relatively dysfunctional left cerebral hemisphere and a relatively intact right cerebral

hemisphere. The exact opposite state of affairs obtained in the case of those subjects who were relatively deficient in arithmetic as compared to their performance in reading and spelling. (Group 3). A reference to the abilities and deficits exhibited by those with Turner's syndrome as well as findings concerning the neurological characteristics of those who are impaired in their arithmetic abilities, may shed further light upon this issue.

Turner's syndrome is produced by a chromosomal abnormality in females that, unless treated at an early age, results in profound mental retardation. These girls are born with female sexual characteristics, but fail to develop secondary sexual characteristics. Dwarfed in size, the webbed neck and epicanthal folds over the eyes as well as other peculiar physical characteristics resemble those individuals affected by other kinds of developmental disorders of the central nervous system.

Money (1973) studied a sample of Turner's syndrome patients which ranged in age from 10 to 24 years (mean: 15 years). He found that these people were retarded in arithmetic abilities, and exhibited a consistent pattern of a higher Verbal IQ than Performance IQ on the WISC and WAIS: that is, a pattern of performance quite similar to that exhibited by the children in Group 3 of the Rourke and Finlayson (1978) study.

Black (1973) classified 25 children with demonstrable neurological dysfunction as showing either (1) primarily right-sided impairment, (2) primarily left-sided impairment, or (3) bilateral impairment. The division was made on the basis of E.E.G. and neurological examination findings, without reference to psychometric test performance. Comparisons made between the first two groups showed that the right-impaired subjects performed relatively more poorly on the WRAT Arithmetic subtest, WISC Performance Scale IQ, and WISC Full Scale IQ, with the differences on the Performance Scale IQ reaching significance. The

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left impaired subjects performed relatively more poorly on the WRAT Reading subtest, WRAT Spelling subtest and the WISC Verbal Scale IQ - with the differences on Verbal IQ, WRAT Reading, and WRAT Spelling being statistically significant.

These findings would be consistent with the view that impairment of functioning of the right cerebral hemisphere can be a limiting factor with respect to calculation performance, as measured with the WRAT. The results of the following studies are also of interest with respect to the neuropsychological significance of deficiencies in arithmetic calculation.

Ingram, Blackburn, and Mason (1970) divided 82 reading disabled children into two groups on the basis of their performance in school subjects other than reading, particularly mechanical arithmetic. The "specific dyslexics" included retarded readers who were able to perform in a satisfactory manner in arithmetic, whereas the "general dyslexics" included those who performed poorly in reading, spelling, and arithmetic. They compared these two groups with respect to the likelihood that they had sustained brain damage or cerebral dysfunction. This was assessed through information gathered from birth history, developmental history, clinical examination, and E.E.G. tracings. They found that the group of specific dyslexics had significantly less evidence of brain damage or dysfunction than did the general dyslexics. The results of this study would suggest that learning disabled children are more likely to exhibit positive signs of neurological dysfunction if an arithmetic disability is present.

Black (1976) compared the cognitive, academic, and behavioural performance of two matched samples of children as follows: (a) one with documented neurological dysfunction; and, (b) one with neurological dysfunction suspected on the basis of clinical findings commonly ascribed as concomitants of neuro-

logical dysfunction, but without objective evidence of such dysfunction. He found that the pattern of cognitive impairment in the two samples was consistent in that both groups were relatively more impaired in their WRAT Arithmetic performance as compared to their performance in WRAT Reading and Spelling, -- a pattern of academic achievement very similar to that exhibited by Group 3 in the present study. These results might suggest that learning disabled children exhibiting this particular pattern of academic impairment would be more likely to show signs that could be associated with neurological dysfunction than would children exhibiting other kinds of academic ability patterns.

Hypotheses

With the foregoing results as background, the following hypotheses regarding performances on the motor, psychomotor, and composite tactile-perceptual measure were formulated.

- (1) Group 3 was expected to perform at a level inferior to that of Group 1 and Group 2.
- (2) Group 3 was expected to exhibit a pattern of relatively deficient performance with the left hand as compared to that with the right hand.
- (3) Group 2 was expected to exhibit a pattern of relatively deficient performance with the right hand as compared to that with the left hand.
- (4) No differences between right-hand and left-hand performances over and above those anticipated on the basis of hand dominance were expected for Group 1.
- (5) The left-hand performance of Group 1 was expected to be inferior to that of Group 2.

In the case of the expectations regarding differences in the patterns of performance between and within Groups on the motor and psychomotor tasks, it was expected that these differences would be more marked on the latter than on the former.

CHAPTER II

METHOD

Subjects

The 45 subjects were the same as those employed by Rourke and Finlayson (1978). These subjects were selected from over 2000 children who had received an extensive battery of neuropsychological tests administered in the recommended standardized manner (see Rourke, 1976a) by technicians trained specifically for that purpose. In all cases, the subjects had been referred for neuropsychological assessment because of a "learning" and/or a "perceptual" problem to which it was thought that cerebral dysfunction might be a contributing factor. All subjects exhibited poor performance in a particular school subject or general academic underachievement. The subjects chosen were 9- to 14-year-old, right-handed children who fell within the WISC Full Scale IQ range of 86-114. All subjects had attended school regularly since the age of six years. On the basis of information derived from their social and medical histories and the school records available for each subject, none of the subjects were (a) judged to be in need of psychiatric treatment for an emotional disorder, (b) considered to be "culturally deprived", or (c) hampered by defective vision or hearing. In a word, these subjects could be classified as "learning disabled" children in terms of the working definition adopted for this series of investigations (see Rourke, 1975).

Group 1 was composed of 15 subjects whose grade-equivalent scores on the WRAT Reading, Spelling, and Arithmetic subtests were at least 2.0 years below their expected grade placement. In no case did the WRAT Reading, Spelling, and Arithmetic centile scores for subjects in Group 1 exceed 18, nor was there more than a 0.9 year grade-equivalent discrepancy between any two of

the three WRAT subtests for subjects in this group. Group 2 was composed of 15 subjects whose WRAT Reading and Spelling grade-equivalent scores were at least 1.8 years below their WRAT Arithmetic grade-equivalent scores. In no case did the WRAT Reading and Spelling centile scores exceed 14 for subjects in Group 1. Group 3 was composed of 15 subjects whose WRAT Reading and Spelling grade-equivalent scores exceeded their WRAT Arithmetic grade-equivalent scores by at least 2.0 years. The three groups were equated for age and Full Scale IQ on the WISC.

In Group 1 there were two girls and 13 boys; all subjects in Group 2 were boys; there were four girls and 11 boys in Group 3. The unequal sex distribution in the three groups was not considered to pose any particular difficulties because normative data collected for these dependent variables (see Knights & Moule, 1967; 1968) did not reveal any sex differences in performance. Furthermore, the results of a recent study (Canning, Orr, & Rourke, Reference Note 1) would suggest that no sex differences for children with learning disabilities should be expected on dependent variables such as those employed in this study. In any event, the data for males were analyzed independently, and there were no deviations from the overall results in evidence.

Measures

The Wide Range Achievement Test (WRAT; Jastak & Jastak, 1965) contains three subtests. The Reading subtest is a standardized test of oral reading performance. The task requires the child to associate printed letters with the spoken word. The score is based on the total number of words correctly read aloud and is expressed in centiles as well as grade-equivalent levels. The Spelling subtest is a standardized test of written spelling achievement.

The task requires the child to produce the written counterpart of the spoken word. Scoring is based on the total number of words correctly spelled and is expressed in centiles as well as grade-equivalent levels. The Arithmetic subtest is a standardized test of written arithmetic achievement. The task requires the child to solve progressively more difficult arithmetic problems that he reads, and to write the answer in the appropriate form on the test blank. Scoring is based on the total number of correct solutions and is expressed in centiles as well as grade-equivalent levels.

It should be noted that the WRAT Reading subtest has been criticized for tapping only a very limited spectrum of the behaviours which would ordinarily be thought to comprise "reading". In spite of this consideration, data from a four-year-longitudinal study (Rourke, 1976b; Rourke & Orr, 1977) demonstrated clearly that the WRAT Reading subtest is as powerful a discriminator of normal and retarded readers as are the Reading, Word Knowledge, and Word Discrimination subtests of the Metropolitan Achievement Test. This being the case, the WRAT Reading measure was considered to be quite suitable for the purposes of the present study.

The dependent measures used in this study can be divided into three main categories, namely, (a) motor, (b) psychomotor, and (c) those for tactile-perceptual disturbances.

The following is a description of the motor tests employed.

Finger Tapping (Reitan & Davison, 1974). For this test, the child used alternately the index finger of the dominant hand and of the nondominant hand. Four 10-sec. trails were given for each hand. The score for finger tapping was the average number of taps of the best three out of four trials.

Strength of Grip (Reitan & Davison, 1974). The Smedley Dynamometer was used to measure strength of grip. The child was required to squeeze the

dynamometer three times with his dominant hand and three times with his non-dominant hand, alternating hands on each trial. The mean pressure which he exerted on the three trials was recorded (in kgs.) for each hand.

The following is a description of the psychomotor tests employed.

Maze Test (Kløve, 1963; Knights & Moule, 1968). The child was required to run a stylus through a maze which had the blind alleys filled and was placed at a 70° angle (on the Tactual Performance Test stand). A score was obtained for the number of contacts made with the sides of the maze, as well as one for the total amount of time during which the stylus was in contact with the side of the maze. These were electrically recorded. The scores used were the total of two trials with the right hand and two trials with the left hand.

Grooved Pegboard Test (Kløve, 1963; Knights & Moule, 1968; Rourke et al., 1973). The child was required to fit keyhole-shaped pegs into similarly shaped holes on a 4-in. x 4-in. board beginning at the left side with the right hand and at the right side with the left hand. The children were urged to fit all 25 pegs in as rapidly as possible. One trial was performed with the dominant hand, followed by one trial with the nondominant hand. The score obtained was the length of time required to complete the task with each hand.

Tactual Performance Test (TPT; Reitan & Davison, 1974). This test involves tactile- and kinesthetic-perceptual abilities to a considerable degree, in addition to psychomotor skills. The TPT is Reitan's modification for children of the test developed by Halstead (1947). Halstead's test was based, in turn, upon a modification of the Sequin-Goddard formboard. The child was blindfolded and not permitted to see the formboard or blocks at any time. The formboard was placed in a vertical disposition at an angle of

70° on a stand situated on a table immediately in front of the child. He was to fit six blocks into the proper spaces with the dominant hand, then with the nondominant hand, and a third time using both hands. The scores obtained were the amounts of time taken to fit the six blocks into their proper spaces for each of these three conditions. (There are also total time, memory, and location components of the TPT as commonly used for clinical purposes. However, these measures were not appropriate for this study).

The following is a description of the tests for tactile-perceptual disturbances that were employed.

Tactile Perception (Reitan & Davison, 1974). The child was required to identify correctly (without the aid of vision) the hand or face (left or right) which received tactile stimulation. The stimulus was produced by a light touch. Following this determination of the child's ability to perceive unilateral stimulation, simultaneous bilateral hand stimulation and contralateral hand-face stimulation were interspersed with the unilateral stimulation. There were four trials for each condition, and the score obtained was the number of errors for each hand and each side of the face under all conditions.

Finger Agnosia (Reitan & Davison, 1974). The child was required to identify (without the aid of vision) the finger which had been touched. Each of the five fingers was stimulated four times in a random order. First the right hand and then the left hand was stimulated. The score obtained was the number of errors made with each finger for each hand.

Finger-Tip Number-Writing Perception (Reitan & Davison, 1974). The child was required to verbalize (without the aid of vision) which of the numbers 3, 4, 5, or 6 had been written on his fingertips. A different finger

of the right hand was used for each trial until four trials had been given for each finger. The procedure was then repeated for the left hand. The score was the number of errors made with each finger for each hand.

Coin Recognition (Adrian & Davison, 1974). The child was required to identify (without the aid of vision) through tactile perception, 1-, 5-, and 10-cent pieces placed in random order: separately in each hand for three trials; then, simultaneously in both hands for three trials. The score was the number of errors made with each hand under each condition.

A summary score that included all errors on these tests for tactile-perceptual disturbances for each hand was considered to be most meaningful for the purposes of this study.

CHAPTER III

RESULTS

The Statistical Analysis System designed by Barr, Goodnight, Sall, and Helwig (1976) was utilized for data analyses, employing the IBM-360-65 Computer (Model IH with LCS). The means and standard deviations for each of the control and dependent variables are presented in Table 1.

Two-factor analyses of variance, with repeated measures on the last factor (right- and left-hand performance on each dependent measure, except for TPT in which performance with both hands was included as a repeated measure), were utilized to analyze (1) differences between groups and, (2) differences between right- and left-hand performances within groups. The cell entries for these analyses were the raw scores on the individual variables for subjects in each of the three groups.

It should be noted that: (a) the groups did not differ significantly in age or WISC Full Scale IQ; (b) the mean WRAT Reading and Spelling grade-equivalent scores for Groups 1 and 2 did not differ significantly; (c) the mean Arithmetic grade-equivalent scores in Groups 1 and 2 were significantly different; and (d) Groups 2 and 3 did not differ in this respect; (e) an analysis was carried out with just 11 boys in each group and there were no deviations from the overall pattern of results in evidence.

In order to provide meaningful comparisons, all data for all of the dependent measures were converted into T scores. Figure 1 is a graphic representation of the T score means for each test for each of the three groups. The T Scores have been adjusted so that good performance is represented in one direction (above 50) and poor performance is represented in the opposite direction (below 50).

In view of the fact that specific hypotheses were entertained prior to data analyses, the apriori "planned comparisons" technique (Winer, 1962) was

Means and Standard Deviations for Control and Dependent Variables,
and the Knights Norms

Variable	Group (n = 15 for each)			Norms
	1	2	3	
Age (in months)				
M	140.20	143.67	140.93	
SD	15.42	18.52	18.53	
WRAT Reading (grade-equivalent score)				
M	3.22	2.34	8.47	
SD	1.18	0.42	1.90	
WRAT Spelling (grade-equivalent score)				
M	2.97	2.51	7.74	
SD	1.05	0.39	1.92	
WRAT Arithmetic (grade-equivalent score)				
M	3.45	4.86	4.25	
SD	1.01	0.70	1.08	
WISC Full Scale IQ				
M	97.73	99.20	95.00	
SD	7.52	7.31	5.74	
RH Dynamometer (kgs.)				
M	19.72	19.16	18.49	
SD	4.54	8.16	6.98	
LH Dynamometer (kgs.)				
M	17.53	17.21	17.06	
SD	4.30	6.74	7.49	

TABLE I
(cont'd)

RH Finger Tapping (number of taps)

M	37.55	34.77	36.89	39.60
SD	6.00	6.67	8.27	4.50

LH Finger Tapping (number of taps)

M	34.62	32.27	33.30	35.49
SD	4.80	5.18	6.31	5.47

RH Grooved Pegboard Test (time in secs.)

M	68.00	68.06	80.00	68.59
SD	9.34	7.03	24.17	7.7

LH Grooved Pegboard Test (time in secs.)

M	75.20	76.80	84.40	74.5
SD	9.08	11.52	22.51	7.96

RH Maze Test (time in secs.)

M	1.60	1.58	3.79	1.76
SD	1.23	1.25	3.84	1.36

LH Maze Test (time in secs.)

M	5.52	4.07	6.95	3.96
SD	3.10	2.24	5.06	2.16

RH Tactual Performance Test (time in secs.)

M	3.03	3.79	3.24	3.63
SD	0.95	2.12	1.84	1.95

LH Tactual Performance Test (time in secs.)

M	3.18	1.52	3.29	2.13
SD	2.31	0.81	2.15	1.16

BH Tactual Performance Test (time in secs.)

M	1.07	0.89	1.95	0.80
SD	0.38	0.44	2.26	.38

TABLE I
(cont'd)

RH Tactile-Perception Measures (no. errors)

M	5.86	6.20	9.06	4.09
SD	5.81	4.36	6.40	3.72

LH Tactile-Perception Measures (no. errors)

M	5.86	6.40	10.20	4.25
SD	3.81	4.80	6.15	2.96

Abbreviations: RH = Right Hand; LH = Left Hand; BH = Both Hands

4

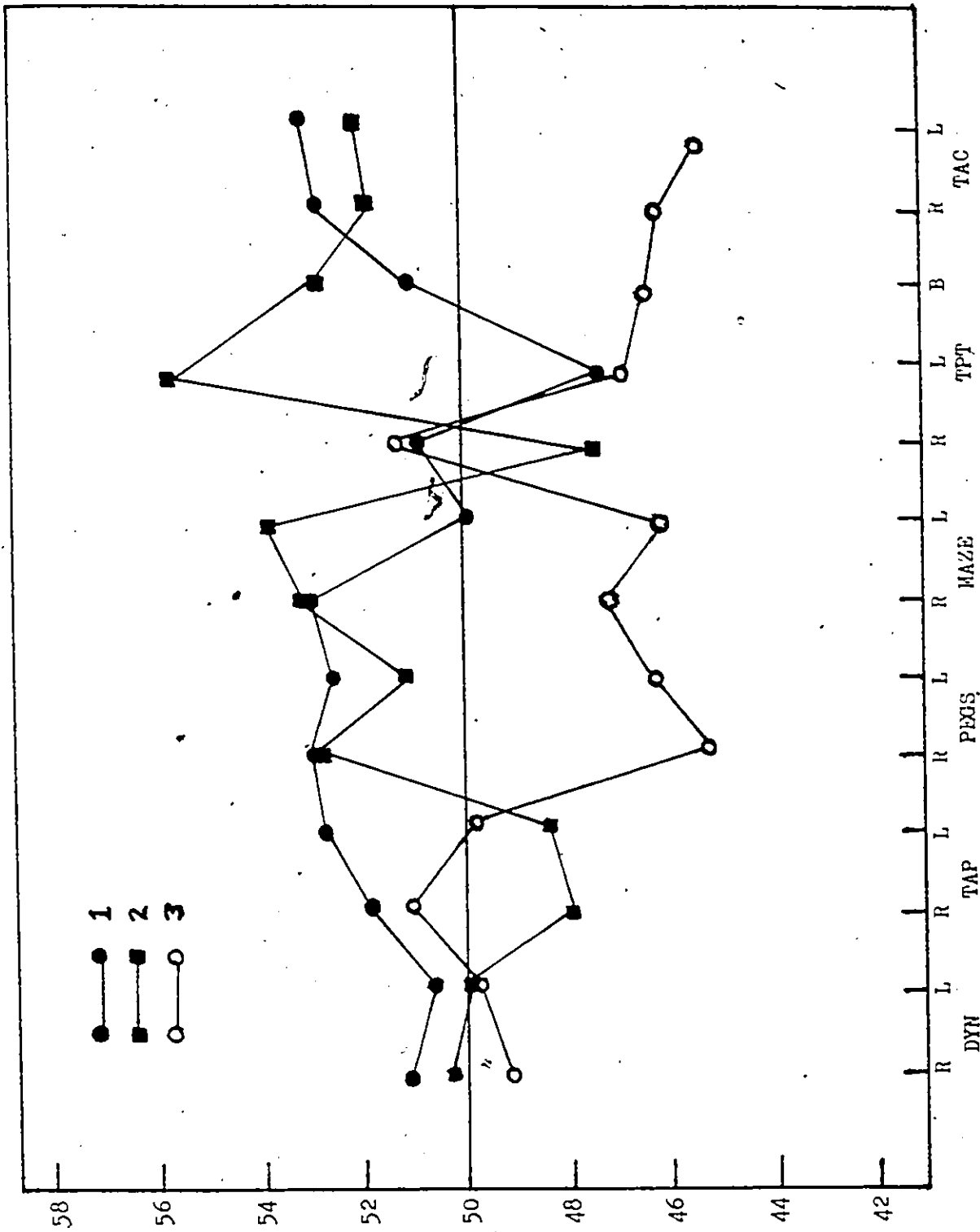


Figure 1. Mean \bar{T} scores for Group 1, Group 2, and Group 3. (High score = good performance)
Note. Abbreviated: R = Right hand; L = Left hand; B = Both hands; DYN = Dynamometer; TAP = Finger Tapping; PEJS = Grooved Pegboard Test; MAZE = Maze Test (time); TAC = Tactile-Perceptual Tests.

employed to compare mean scores between and within the Groups for each analysis. (In the case of comparisons between right-hand and left-hand performances on the Dynamometer, Finger Tapping, and Maze measures, it was necessary to carry out three comparisons rather than two. Due to the very robust F ratios for the main effect for right- vs. left-hand performance in all three of these instances, this procedure was deemed to introduce no appreciable degree of distortion. The following is a summary of the results of these comparisons.

Motor Measures

Strength of Grip (dynamometer) Comparisons favouring right-hand performance over left-hand performance yielded the following: (a) $F(1,42) = 19.26$, $p < .01$ for Group 1; (b) $F(1,42) = 15.44$, $p < .01$ for Group 2; and (c) $F(1,42) = 8.26$, $p < .01$ for Group 3.

Finger Tapping Test Comparisons favouring right-hand performance over left-hand performance yielded the following: (a) $F(1,42) = 9.66$, $p < .01$ for Group 1; (b) $F(1,42) = 6.83$, $p < .05$ for Group 2; and (c) $F(1,42) = 14.55$, $p < .01$ for Group 3.

Psychomotor Measures

Grooved Pegboard Test Comparisons favouring the combined performance of Groups 1 and 2 over that of Group 3 yielded the following: (a) $F(1,42) = 5.95$, $p < .05$ for the right hand, and (b) $F(1,42) = 2.93$, $p < .10$ for the left hand. Comparisons favouring right-hand performance over left-hand performance yielded the following: (a) $F(1,42) = 4.96$, $p < .05$ for Group 1, and (b) $F(1,42) = 7.30$, $p < .01$ for Group 2.

Maze Test Comparisons favouring the combined performance of Groups 1 and 2 over that of Group 3 yielded the following: (a) $F(1,42) = 5.00$,

$p < .05$ for the right hand, and (b) $F(1,42) = 6.40$, $p < .05$ for the left hand. Comparisons favouring right-hand performance over left-hand performance yielded the following: (a) $F(1,42) = 32.71$, $p < .01$ for Group 1; (b) $F(1,42) = 13.22$, $p < .01$ for Group 2, and (c) $F(1,42) = 21.24$, $p < .01$ for Group 3.

Tactual Performance Test Comparisons favouring the left-hand performance of Group 2 yielded the following: (a) $F(1,36) = 7.38$, $p < .01$, over that of Group 3, and (b) $F(1,36) = 5.59$, $p < .05$ over that of Group 1. Comparisons favouring left-hand performance over right-hand performance yielded the following: $F(1,72) = 27.71$, $p < .01$, for Group 2. Comparisons favouring the both-hands performance of Groups 1 and 2 over that of Group 3 yielded the following: $F(1,36) = 2.92$, $p < .10$.

Tactile-Perceptual Measures (composite score from the tests for tactile-perceptual disturbance) Comparisons favouring the combined performance of Groups 1 and 2 over that of Group 3 yielded the following: (a) $F(1,42) = 5.85$, $p < .05$, for the left hand, and (b) $F(1,42) = 3.25$, $p < .10$ for the right hand. Comparison favouring right-hand performance over left-hand performance yielded the following: $F(1,42) = 3.51$, $p < .10$ for Group 3.

CHAPTER IV

DISCUSSION

In this section, the results which have bearing upon each of the five hypotheses will be discussed within the context of four interpretive strategies, viz.: (a) the level of performance approach; (b) the pathognomic sign approach; (c) the differential score or configurational analysis approach; and (d) comparisons of performance of the two sides of the body. The level of performance comparisons for group mean scores were made with Knights' (1968) norm scores for children of this age. The Knights scores include combined mean scores for groups of boys and girls for each of the dependent measures used in this study. These children were functioning in an age-appropriate fashion in the Ontario schools system.

Hypothesis 1. The expected superiority of performance of Groups 1 and 2 was in evidence on the Grooved Pegboard Test, the Maze Test, the composite tactile-perceptual measure and, on the "both hands" component of the Tactual Performance Test. It was not in evidence on the Strength of Grip or Finger Tapping tests. For the most part, these findings are in line with the results of the Rourke and Telegdy (1971) study in which no significant differences in favour of a WISC High Performance IQ - Low Verbal IQ Group were found on the relatively simple Strength of Grip and Finger Tapping tests, while such differences were in evidence on the more complex Maze and Grooved Pegboard Tests.

In comparing levels of performance for each of the three groups with Knights' (1968) norm scores, it was found that Group 3 exhibited right- and left-hand performances on the Grooved Pegboard and Maze Tests that were, in all cases, at least one standard deviation above the expected mean. (In this instance, these time scores indicate poor performance for Group 3.) Right- and left-hand performances for Groups 1 and 2 on these same measures yielded mean scores that were within one standard deviation of the Knights' norm mean

score, indicating that these performances were "within normal limits". This "level of performance" strategy of comparison further establishes the superiority of Groups 1 and 2 over that of Group 3 on complex psychomotor tasks.

Additional evidence of the superiority of Groups 1 and 2 over that of Group 3 was in evidence on the "both hands" component of the Tactual Performance Test. It was found that there was a trend towards a difference in favour of Groups 1 and 2 over that of Group 3 in the statistical analysis. Furthermore, the level of performance for each of the groups on this task shows that the score for Group 3 was in excess of three standard deviations above the mean of the Knights' norms, while scores for Groups 1 and 2 were within normal limits (i.e., within one standard deviation of the mean). This comparison indicates a significant degree of impairment for Group 3 on this task.

The tests for tactile imperception, finger agnosia, and other deficits which are included in the composite tactile-perceptual measure are commonly carried out as part of a physical neurological examination. These and other "signs" of brain pathology form the basis of the neurological diagnosis. That there were (a) significant differences in favour of Group 1 and 2 over that of Group 3 on this measure and, (b) scores in excess of one standard deviation above the mean for Knights' norms with both right and left hands for Group 3 as contrasted with scores that were within normal limits for Group 1 and 2, would be consistent with the view that cerebral dysfunction plays a role in the adaptive deficits exhibited by children in Group 3. From an academic performance point of view, the deficit seems to be confined exclusively to arithmetic calculation. Considered in the light of neuropsychological measures, there is fairly clear evidence of visual-spatial complex psychomotor, and tactile-perceptual deficiencies, all of which may be attri-

butable to a relatively dysfunctional right cerebral hemisphere in Group 3 children.

Hypothesis 2. The expectation of a relatively deficient performance with the left hand as compared with right hand for Group 3 was in evidence, to some extent, on the Tactual Performance Test and on the composite tactile-perceptual measure. It was not in evidence on the Finger Tapping, Grooved Pegboard, or Maze Tests.

On the Tactual Performance Test Group 3 exhibited a left-hand performance that was one standard deviation above the mean of the Knights' norms, while the right-hand score was within one standard deviation of the mean. This indicates a poor left-hand performance and essentially a "normal" right-hand performance for Group 3. The same pattern of results was found on the composite tactile-perceptual measure. On these tests, there was a trend towards a statistical difference in favour of the right-hand performance over the left-hand performance for Group 3. In addition, the left-hand score for Group 3 was almost two standard deviations above the mean of Knights' norms, while the right-hand score was closer to one standard deviation above the mean. On the other hand, the right- and left-hand performances for Groups 1 and 2 were within one standard deviation of the mean of Knights' norms. This comparison indicates that Group 3 children were relatively more impaired with their left hand than with their right hand. The pattern of performance for Group 3 on the composite tactile-perceptual measure, in particular, is consistent with Black's (1976) findings concerning the pattern of academic abilities in children with documented and suspected right-sided brain impairment.

Taken as a whole, these findings would suggest that the right cerebral hemisphere rather than the left cerebral hemisphere is maximally involved

in the hypothesized brain dysfunction that is contributing to the difficulty in calculation performance for children in Group 3. At the very least, it would appear that functions thought to be subserved by the right cerebral hemisphere (e.g., visual-spatial organization and integration), when impaired, may be limiting features with respect to adequate performance in arithmetic calculation.

Hypothesis 3. The expectation of relatively deficient performance with the right hand as compared to the left hand for Group 2 was in evidence on the Tactual Performance Test and the Finger Tapping Test. It was not in evidence on the Strength of Grip, Grooved Pegboard or Maze Tests, or the combined tactile-perceptual measure.

The significant difference in favour of left over right-hand performance on the Tactual Performance Test might be construed as evidence in support of the view that the left hemisphere is relatively compromised for children in Group 2 (Rourke & Finlayson, 1978). However, this was the only test in which significant statistical differences were found in favour of the left-hand over the right-hand performance for Group 2. This makes it difficult to draw any definite conclusions concerning the functional integrity of the left cerebral hemispheres for children in Group 2 although the Finger Tapping Test results are consistent with the Tactual Performance Test findings. The right-hand performance of Group 2 was one standard deviation below Knights' norm score, while the left-hand performance was within one standard deviation of Knights' norm score indicating a poor right-hand performance for Group 2 in this case. On the basis of these and the Rourke and Finlayson (1978) results, it might be suggested that the areas of maximal involvement for the hypothesized left cerebral hemisphere dys-

function is more anterior than posterior in terms of brain localization. Studies of adults with documented cerebral lesions have shown that patients with impaired Finger Tapping abilities usually have lesions confined to the anterior quadrants of the brain (Reitan & Davison, 1974).

Hypothesis 4. The expectation of no differences between right- and left-hand performances on all dependent measures for Group 1 was supported in all cases, both in terms of pattern of performance for right and left hands and in terms of level of performance.

In this connection, it should be noted that the groups with no lateralized motor deficits in the Reed & Reitan (1963) and Rourke, Yanni, MacDonald, and Young (1973) studies displayed a pattern of Low Verbal IQ - High Performance IQ on the Wechsler scales. From the neuropsychological standpoint, the hypothesized cerebral dysfunction in this instance is difficult to localize to one hemisphere or the other solely on the evidence provided by performance on motor, psychomotor, or tactile-perceptual tests. It might be the case that Group 1 contains a number of subgroups. In any event it is clear that this overall pattern of performance for Group 1 differs from that of Group 2. A discussion of hypothesis 5 will shed further light upon this issue.

Hypothesis 5. The expected superiority of left-hand performance for Group 2 over that of Group 1 was in evidence on the Tactual Performance Test. It was not in evidence on the Strength of Grip, Finger Tapping, Grooved Pegboard or Maze Tests or on the composite measure for tactile-perceptual disturbances.

This significant difference in favour of the left-hand performance of Group 2 over that of Group 1 on the Tactual Performance Test was the only

one in evidence on any of the dependent measures. It may be of importance, in this connection, to note that the subject is blindfolded during the Tactual Performance Test, thus preventing visual input. The way in which this task requirement might contribute to the inferior performance of Group 1 relative to that of Group 2 is not understood at this point, although it may be the case that the added degree of complexity is crucial. In any event, the Tactual Performance Test results are suggestive of more intact functioning of the right cerebral hemisphere for children in Group 2 than for those in Group 1 on the basis of results obtained by Reitan (1958) on adults with documented cerebral lesions. It follows, that relatively good WRAT Arithmetic performance (as compared to very deficient WRAT Reading and Spelling performance) is dependent upon an intact right cerebral hemisphere.

It should be noted that the clearest separation of groups and particularly of right- and left-hand performances within groups came on more complex psychomotor tests. Generally, in the present study, the more simple the motor skills, the less likely it was that performance of the three groups could be differentiated. In children with recently imposed and/or actively debilitating cerebral lesions differences may occur on the relatively simple motor tasks. But, even in the examination of older children and adults suspected of having sustained damage to the brain, relatively heterogeneous, complex tests are valuable, even preferable (Reitan, 1966).

CHAPTER V

SUMMARY AND CONCLUSIONS

As early as 1938, Strauss & Werner became interested in the relationship between arithmetic disability and finger localization difficulties in children. Their conclusion at that time was that there was an obvious relationship between the ability to appreciate the finger schema and arithmetic disability in children. Although the methodology of this early study was later criticized by Benton, Hutcheon, & Scymour (1951), the association between arithmetic disability and neurological dysfunction could not be dismissed.

The results of the present study offer some support for the relationship between what might be termed "specific arithmetic disability" and tactile-perceptual deficits in that Group 3 exhibited a significant number of signs of such deficits. In addition, the performance of Group 3 was particularly deficient on measures of psychomotor abilities. These findings carry some implications for at least two very important and current issues within the field of learning disabilities: (1) referral priorities, and (2) differentiation between specific arithmetic disability and difficulties in reading and spelling for remediation and/or intervention purposes.

Both of these latter issues were addressed in a recent factor analysis study by Goodstein & Kahn (1974), in which they found that an arithmetic disability can exist independently of a reading or spelling disability. However, they note that, in general, schools are not prepared to recognize this issue. Therefore, they describe the school situation as being one in which referral to diagnostic and intervention services for arithmetic disability is given very low priority in relation to the more commonly recognized reading and spelling disabilities. This is of particular concern, in view of the fact that the results of the current study would seem to indicate

that a specific arithmetic disability may be reflective of more serious brain-related difficulties than are disabilities in reading and spelling.

From an etiological point of view, children who exhibit outstanding difficulties in arithmetic and intact reading and spelling skills would certainly seem to exhibit many characteristics which would be expected were they to have a relatively dysfunctional right cerebral hemisphere.

The differences between Groups 1 and 2 that emerged in favour of the left-hand performance of Group 2 over that of Group 1 are consistent with the hypothesis of Rourke & Finlayson (1978) that subjects in Group 2 may have a relatively intact right cerebral hemisphere. However, the issue in this regard is far from clear because of the large number of similarities in performance between Groups 1 and 2.

It may be the case that the limitations in arithmetic experienced by subjects in Group 2 are almost exclusively in those skills thought to be subserved principally by the left cerebral hemisphere. But there is still not sufficient evidence to state with a great deal of confidence that the subjects in Group 1 have, in addition to problems associated with a relatively dysfunctional left cerebral hemisphere, deficits arising from dysfunction of the right cerebral hemisphere.

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