

PHONETIC SKILLS IN NORMAL,
SLOW, AND DYSLEXIC READERS

by

BARBARA JANICE BURNSIDE
B.A., University of Victoria, 1980

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

ACCEPTED
FACULTY OF GRADUATE STUDIES

In the Department
of
Psychology

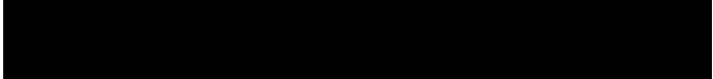


DATE 23 Dec 1982 DEAN

We accept this thesis as conforming
to the required standard



Dr. O. Spreen



Dr. G.A. Milton



Dr. P.M. Baker



Dr. W.H. MacGinitie

© BARBARA JANICE BURNSIDE, 1982
UNIVERSITY OF VICTORIA
May 1982

All rights reserved. This thesis may not be reproduced
in whole or in part, by mimeograph or other means,
without the permission of the author.

Supervisor: Professor Otfried Spreen

ABSTRACT

Normal, slow, and dyslexic readers at grade two reading level were compared on a series of four tasks requiring phonetic skills. A same-different comparison of pairs of three- and four-letter nonsense words was presented auditorially, visually, and cross-modally. There were no differences in group performance for auditory-auditory comparison (A-A), visual-visual comparison (V-V), or for the cross-modal comparison in which the auditory stimulus was given first and the visual stimulus second (A-V condition). The groups did differ in cross-modal performance when the initial stimulus was visual and the second was auditory (V-A condition). Dyslexic readers performed more poorly than normal and slow readers; the latter two groups did not differ from each other in V-A performance.

Post hoc analysis showed that dyslexic readers made more errors than the slow or normal readers of the same level, whether the stimulus pairs differed in the initial, central, or final letters of the nonsense word pair.

Dyslexic readers are more impaired in the phonetic skills used in visual-auditory comparison of nonsense words than

*dyslexic group block design
mean = 20%ile. Group
may therefore be mostly perceptually
handicapped ("dysorthic") thus
accounting for poor visual &
auditory performance.*

normal or slow readers of the same reading level.

Examiners:

[REDACTED]
Dr. O. Spreen

[REDACTED]
Dr. G.A. Milton

[REDACTED]

Dr. P.M. Baker

[REDACTED]
Dr. W.H. MacGinitie

CONTENTS

TITLE PAGE	i
ABSTRACT	ii
TABLE OF CONTENTS	iv
LIST OF TABLES	vi
LIST OF FIGURES	vii
ACKNOWLEDGEMENTS	viii

<u>Chapter</u>	<u>page</u>
I. INTRODUCTION	1
Definitions of Dyslexia	2
Research on factors which might contribute to dyslexia	6
Cross-Modal Sensory Integration	6
Specific Deficits	23
Memory	26
Cross-modal Comparison in a Reading Task	31
II. HYPOTHESES	39
III. METHOD	43
Subjects	43
Stimulus Selection	46
Procedure	48
IV. RESULTS AND DISCUSSION	53
Scores	53
Multivariate Cross-modal Deficit Hypothesis	57
Perceptual Deficit Hypothesis	57
Post Hoc Analysis Based on Perceptual Deficit Hypothesis	58
Perceptual Impairments vs. General Cognitive Deficit	59
Dyslexic V-A Deficit	61

Post Hoc Error Analysis	62
Interpretation: Some Reservations	66
Ipsi-medal Controls	66
What IS a 'Grapheme-Phoneme Route'?	67
Other Factors: Memory, General Cognitive Deficit, and Experience.	70
Conclusion	71
Future Research	71
 REFERENCE NOTE	 75
 REFERENCE LIST	 76
 <u>Appendix</u>	 Page
A. VICTORIA NORMS: RAW SCORES. FROM MCALLISTER, 1981.	81
B. WORD PAIR MASTER LIST	82
C. STIMULUS LIST FOR AUDITORY-AUDITORY CONDITION	83
D. STIMULUS LIST FOR VISUAL-VISUAL CONDITION	84
E. STIMULUS LIST FOR AUDITORY-VISUAL CONDITION	85
F. STIMULUS LIST FOR VISUAL-AUDITORY CONDITION	86
G. PERCENT CORRECT: GROUP BY EXPERIMENTAL CONDITION	87
H. PEARSON CORRELATIONS BETWEEN EXPERIMENTAL CONDITIONS	88

LIST OF TABLES

<u>Table</u>	<u>page</u>
1. Group Defining Measures: Ages, Test Scores and Difference Scores	45
2. Analyses of Variance: Percent Correct by Group for Each Experimental Condition	56
3. Post Hoc Analysis: Performance by Three Groups on Four Types of Differing Word Pairs	65

LIST OF FIGURES

<u>Figure</u>	<u>page</u>
1. Graphic Representation of Hypotheses 2, 3, and 4 . .	42
2. Percent Correct: Group by Experimental Condition . .	54
3. Post Hcc Analysis: Location of Difference	64

ACKNOWLEDGEMENTS

The author gratefully acknowledges the help of the School Board of Greater Victoria School District 61. Special thanks to the principals, teachers, parents, and students whose participation made this study possible.

Chapter I

INTRODUCTION

Learning to read is a complex process requiring that we associate meaningful spoken language with a graphic symbol system. The symbols are arbitrarily though more or less consistently assigned to sounds, not words; and the code for translating from letters to meaningful words is a complex one.

Some children have unusual difficulty learning this code. Those children whose problems in learning to read seem to be disproportionate to their capabilities in other academic areas are considered to have a specific reading problem: dyslexia.

The study described here examined the performance of three groups of children who differed in the amount of difficulty they had in reaching the level of reading competence appropriate to grade two. The three groups were designated as normal, slow, or dyslexic readers; they were measured on a set of tasks using phonics skills.

There are three areas of study which are relevant to this paper, and each will be reviewed in turn. The first deals with definitions of dyslexia; the second, with factors which

may contribute to dyslexia; and the third, with research addressing characteristics of the reading process.

1.1 DEFINITIONS OF DYSLEXIA

It has generally been agreed that it is important to distinguish poor readers who are specifically and disproportionately disabled in reading as compared to other academic skills, from those who are generally slower in all their school subjects. The two groups may differ in intelligence, neurological status and a host of other variables. In any case, it is assumed by many authors that the two groups are not part of the same population.

The World Federation of Neurology defines specific developmental dyslexia as

a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and sociocultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin (Critchley, 1970).

While this is an improvement over definitions based solely on a difference between chronological age and reading age, several questions are raised by this definition. What is the degree of severity meant by 'difficulty'? What is 'conventional' reading instruction, 'adequate' intelligence, or 'sociocultural opportunity'?

Myklebust (1967) suggested a definition of disability based on objective measures of achievement and intelligence. He suggested calculating a 'Learning Quotient' (LQ) for reading or any other academic ability. In the case of reading this was done by calculating the ratio between a child's observed reading level and 'Expectancy Age'. Myklebust recommended using the full scale IQ score from the Wechsler Intelligence Scale for Children (WISC; Wechsler, 1949) as the measure of mental age. Chronological age, grade age, and mental age were then averaged to calculate 'Expectancy Age'. Thus,

$$LQ = \text{Reading Age} / \text{Expectancy Age}.$$

The use of a ratio, however, presents a statistical problem: the 'regression effect' (Thorndike, 1963). When the measures used to define the ratio are less than perfectly correlated, the children who receive extreme scores on one measure are likely to receive less extreme scores on the other. The 'Learning Quotient' is most likely to take the value of unity in the center of the score distribution. Children of average intelligence and reading ability would be most likely to have a 'Learning Quotient' which would accurately reflect their achievement-potential ratio. The 'LQ' would classify as under-achievers too many children of high IQ and too few of low IQ. The solution to this problem is to derive a regression equation to describe the

relationship of scores in the population being studied (Yule, Rutter, Berger & Thompson; 1974).

Yule (1967) did use such an equation to define specific reading disability. He used normative data from a large number of school children from the Isle of Wight to derive a regression equation which used age and score on the short form of the WISC to predict reading as measured by Neale's Analysis of Reading Ability. By comparing each child's predicted and obtained reading score, a difference score was obtained. This score was used to separate generally backward readers from those who had a specific reading disability disproportionate to their other observed intellectual capacities.

Yule and Rutter (1976) subdivided a large group of severely retarded readers by measuring the difference between their predicted and observed reading levels. One group was disabled in several cognitive areas; the other had a disability which was specific to reading. One of the purposes of the Yule and Rutter (1976) study was to investigate prognoses for severely retarded readers. Thus it was essential to match the two groups for degree of reading retardation.

A similar definition was used in the present study. Here, the term 'dyslexic' readers refers to those with widely discrepant obtained and predicted reading scores, and

the term 'slow' readers refers to the group whose predicted and obtained scores were relatively congruent. Specific defining criteria are given in the 'Methods' section below. In the current study the groups differed in the severity of reading retardation.

Before a definition such as Yule's may be applied, normative data on intelligence measures and reading tests must be available. Differences had been observed between U.S. national norms and Canadian local norms gathered by the University of Victoria. It was assumed that national norms gathered in the U.S. for the WISC or any of the widely used reading tests, would not necessarily be applicable in Victoria. In any case their relationships to each other would not be known.

McAllister (Note 1) collected normative data in greater Victoria schools for the Wide Range Achievement Test (WRAT; Jastak, Bijou, & Jastak, 1978), which contains subtests for reading, spelling, and arithmetic. McAllister also administered the Peabody Picture Vocabulary Test (PPVT; Dunn, 1959) and the Block Design subtest of the Wechsler Intelligence Scale for Children - Revised (WISC-R; Wechsler, 1974). McAllister's norms are given in Appendix A. McAllister's data were used in the present study to derive a regression equation predicting scores on the reading subtest of the WRAT from each child's age, PPVT and Block Design

scores. Differences between obtained and predicted reading scores were then used to assign the subjects of the present study to the slow, normal, or dyslexic groups.

1.2 RESEARCH ON FACTORS WHICH MIGHT CONTRIBUTE TO DYSLEXIA

Even in an oversimplified account of the reading process, several possible areas of reading difficulties should be mentioned: children may have trouble with the perception of sounds, with the separation of the sounds that make up each word, with visual perception of the letter symbols, with the translation of information from one sense modality to another, with associating meaning to the read words, and with organizing larger units of read material for comprehension.

The present study examined the process of translating information from one sense modality to another. This study most closely resembles earlier studies of 'cross-modal sensory integration'; these earlier studies will be reviewed first. Studies examining specific perceptual deficits and memory will also be reviewed.

1.2.1 Cross-Modal Sensory Integration

In 1964, Birch and Belmont published a study in which they proposed that a critical component of the reading task was the ability to equate auditory stimuli with

corresponding visual ones. They used the term 'cross-modal sensory integration' to describe this process. Assuming that cross-modal sensory integration deficits would cause problems at an early stage of information processing, Birch and Belmont proposed a task using simple sensory stimuli to test their hypothesis. They presented a series of taps (by a pencil on a table) and asked their subjects to choose a visual representation of the sequence they had just heard from an array of three visual patterns of dots resembling Morse Code. They referred to this as the A-V task. They found that poor readers were consistently poorer at this task and concluded that this demonstrated a deficiency in cross-modal sensory integration.

Subjects were all boys; the retarded readers were the 150 children with the lowest 10% of scores on the reading tests given all school children in Aberdeen, Scotland. Fifty control subjects were matched by age from the remaining school population. Reading score means and standard deviations showed the two groups to be significantly different. However, the two groups were also very different in IQ. Mean IQ for the retarded readers was 96.7; for the normal readers it was 110.8 ($p < .001$).

Birch and Belmont attempted to control for the IQ difference after the study was completed by eliminating the subjects from both groups whose IQ's were less than 100.

Then they compared the mean A-V scores of the resulting two groups. A one-tailed t-test showed them to be different on A-V scores ($p < .01$), but only 53 of the retarded readers and 35 of the normal readers remained in the new groups, and Birch and Belmont did not report the mean IQ scores of the two new groups.

The possibility that perceptual difficulties might have contributed to the group differences was recognized by Birch and Belmont; they considered that gross sensory screening was sufficient to control for this possibility. None of the children had a significant degree of hearing loss or a significant uncorrected visual disturbance. The contribution of auditory memory was assumed to be controlled by the results of the WISC Digit Span subtest. Digit Span scores were compared between high and low A-V scorers, rather than between the original experimental groups of subjects.

The results of this study indicated that poorer readers did more poorly on the A-V task than the good readers did. However, the conclusion that this demonstrated a deficit in cross-modal sensory integration was not justified for several reasons.

First, the auditory stimulus as presented in the original experiment included visual elements: the pencil tapping was done in full view of the child. Second, IQ measures should have been matched from the beginning.

Other problems were pointed out by Bryant in his 1975 review. It is invalid to claim demonstration of a cross-modal sensory integrative deficit when competence in comparable within-modal tasks has not been demonstrated. Further, the task presented by Birch and Belmont also required a temporal-to-spatial transformation. While these authors had good reason to claim that their task discriminated between the two groups, they did not test whether it did so by its auditory-visual demands, its temporal-spatial ones or because it was related to IQ in its predictive ability. Without testing for within-modal matching they could not attribute the task's discriminative ability to an integrative function between sensory modalities.

Finally, the procedure Birch and Belmont (1964) used to control for memory differences could have capitalized on the regression effect. The children receiving the highest and lowest A-V scores would be less likely to receive extreme scores on the WISC digit span subtest.

The remainder of this section will review studies which used a cross-modal sensory integration paradigm to study reading, with special attention paid to the alternative hypotheses which grew out of attempts to replicate or extend Birch and Belmont's 1964 study. Each of the studies reviewed below addresses a different area of weakness in the original work.

The first extension of the study to be discussed is Birch and Belmont's own (1965). They examined the relation of IQ and reading to their A-V task in normal children of several ages. Subjects were 220 children, about 30 from each grade, kindergarten through grade six. Findings in this study were that the mean number of correct A-V judgements increased with age. Secondly, product-moment correlations between IQ and A-V score were highest in the lower grades, as were the correlations between A-V score and reading. IQ remained highly correlated with reading throughout the age range of the sample.

The authors suggested that there was a curvilinear relationship between the A-V task and reading; that is, the cross-modal matching skill was more important in the early stages of reading than in the later ones. An alternative suggestion was that there was a ceiling effect for the older children. This suggestion was borne out in a later study (Kahn & Birch, 1968), in which task difficulty was increased for the older children. While this removed the ceiling effect, it increased the intercorrelation between reading, IQ, and the auditory-visual matching task, making it even less clear how the A-V task is related to reading.

The Birch and Belmont (1965) study was directed at the relationship between IQ, A-V task performance and reading in normal readers. Beery (1967) studied these three factors in

retarded readers, using a careful selection of subjects as well as a refined administration of the A-V task. She compared 30 retarded readers with 15 normal readers matched for age, IQ, and sex. Retarded readers were two years or more below grade level in their reading skills. She also chose all the subjects from the files of school psychologists, so that while the normal readers had not had reading problems, they did have similar histories of troubles with school.

Beery expanded the test battery from Birch and Belmont's original 10 items to 20, with the first 10 the same as Birch and Belmont's. She also included a 20-item visual-to-auditory matching task. Auditory stimuli were presented from a speaker, without visual cues.

Beery found that all three forms of the A-V test discriminated between the two groups of subjects, and were equivalent to each other in their ability to discriminate between the good and poor readers.

Temporal-spatial elements in matching task performance were examined by Blank and her colleagues (Blank & Bridger, 1966; Blank, Weider & Bridger, 1968). The 1966 study used 26 fourth graders, 13 normal readers and 13 poor readers, matched for IQ. One stimulus was visual-temporal--a light flashing between long or short pauses. The other was a visual-spatial dot pattern. The first task was to match the

visual-temporal (VT) standard to a visual-spatial (VS) comparison. The second required matching a VS pattern to another VS pattern; the third task was to give a verbal description of the visual-temporal patterns. Blank and Bridger found that both groups performed at ceiling on the VS-VS matching task, but that the poorer readers were deficient on the VT-VS task and on the verbal description task.

The authors did not test auditory stimuli at all in this study, nor did they use a task matching two visual-temporal stimuli. The conclusions drawn were that the poor readers' problems were a result of being unable to code the visual sequences verbally, but that the visual-spatial patterns did not require the same extent of coding. As Bryant (1975) pointed out, this conclusion was unjustified without testing the children's ability to match VT with VT stimuli. Blank and Bridger (1966) argued that such a control task is not really valid either, because of the different memory demands in successive presentation of three temporal comparison stimuli as opposed to simultaneous presentation of the three visual-spatial dot pattern choices.

One of the questions raised by Blank and Bridger is whether these results are the cause of reading problems or the result of them. Normal readers would have had more practice in visual sequential tasks than poor readers, and

the differences in temporal tasks may have been greater after several years of reading. To test this hypothesis Blank and her colleagues conducted the second study with younger subjects.

The Blank, Weider and Bridger study (1968) also elaborated the tasks used. Testing children at the end of grade one, Blank, et al. found that younger children could not comprehend the required transformations from temporal to spatial presentation unless the stimuli were presented in a series. The first stimulus was a bank of lights with some lit and some unlit in a spatial pattern like the visual spatial dots. The next task would use groups of lights going on one group at a time. Finally the children would see just one light flashing on and off with different time intervals between, corresponding to the VT stimulus of the Blank and Bridger (1966) study.

The study also used a task of matching VS dots with VS dots, and one in which the children imitated clapped rhythms. Finally the subjects were asked to describe a visual-temporal light series, and again the findings given most emphasis by Blank, et al. were these verbal reports. They found again that the poorer readers made more mistakes in telling about the sequences than the normal readers did. They found in both studies that all the children used verbal coding of some kind to remember the sequential stimuli, but that the poorer readers used it less efficiently.

A weakness of the Blank, et al. studies is that they have very few subjects for the number of measures used. The observations on efficiency of verbal coding are more clinical impressions than experimental data, but they are probably worth examining further.

Sterritt and Rudnick published two studies using multiple regression to examine the value of auditory-visual tasks in predicting reading (Sterritt & Rudnick, 1966; Rudnick, Sterritt & Flax, 1967). They used samples of normal readers who were in the high normal range on IQ and reading achievement tests. In these studies three types of temporal stimuli were matched to visual-spatial dot patterns. One task used a visual-temporal standard similar to Blank's flashing light stimulus; thus a temporal-to-spatial transformation within the visual modality was required. Another stimulus consisted of auditory tone patterns as the standard. This required an auditory-temporal to visual-spatial transformation. The Birch and Belmont auditory task--a pencil tapped on the table in view of the subject--was also used. Regression equations were derived to see if any of the auditory tasks added significantly to the amount of variance accounted for by IQ.

The 1966 study was done with grade four boys; the 1967 study with grade three boys. Both studies found that the Birch and Belmont task did not predict reading when IQ was held constant. For the fourth graders, only the auditory

task added a significant contribution to the reading score when IQ was held constant; for the third graders both the auditory and the visual task accounted for significant variance. Sterritt et al. interpreted these results as indicating that the auditory-temporal to visual-spatial transformation was probably the critical predictor of reading success, beside IQ. For the 1966 study of fourth grade readers the authors concluded that the spatial-temporal shift within the spatial modality was not an important predictor of reading. For the third grade readers in the 1967 study the task requiring the spatial-temporal shift was a significant predictor of reading ability. The authors interpreted this as evidence of changing importance of different subskills at different levels of reading skill.

In 1968 Kahn and Birch published a study directed at three issues which had come up in the research since 1964. The first was Sterritt and Rudnick's finding that the Birch and Belmont task did not significantly predict reading performance when IQ was held constant though a variant of the Birch and Belmont task did. The second issue was that raised by Blank et al., of the importance of verbal mediation in the A-V task performance. The third was the possibility that Birch and Belmont's own 1965 results had demonstrated a ceiling effect rather than the decreasing importance of the A-V measure with increasing reading level.

Some incidental refinements were included in the design. The auditory stimulus was produced behind a screen to reduce visual confounding of the auditory task. To ensure that the groups did not differ in auditory memory, the WISC digit span subtest was given to all subjects. Product-moment correlations between digit span and A-V scores were low for children of all ages.

Presumably, Kahn and Birch's choice to give the digit span subtest to all subjects in the 1968 study was intended as an improvement over the Birch and Belmont (1964) procedure. However, Kahn and Birch (1968) controlled for deficits in ipsi-modal performance using the same logic Birch and Belmont (1964) had used to address auditory memory. In their 1968 study Kahn and Birch administered ipsi-modal versions of the A-V task to the subjects with the 10 lowest and 10 highest scores on the A-V task. The low and high scorers did not differ on the ipsi-modal tasks. Once again, the regression effect would help to conceal a correlation if there were one. A second problem with this procedure is that by testing only the highest and lowest A-V scorers, Kahn and Birch tested ipsi-modal performance as it was related to cross-modal performance, not as it was related to reading. The extreme A-V scores could have come from either reading group.

Kahn and Birch predicted that among normal readers, their form of A-V matching task would be related to reading even when IQ was held constant. They also predicted that verbal mediation was not as significant in matching task performance as Blank et al. had claimed; and they expected more difficult A-V matching tasks to continue to discriminate between good and poor readers in the higher grades.

The Kahn and Birch 1968 study supported its authors' predictions. However, Kahn and Birch say they statistically held constant the variance from IQ, but they neither give the scores nor their variance nor explain what procedure they used to hold the variance constant.

Kahn and Birch used different criteria from those used by Blank et al. to define strategies as verbal or non-verbal. Blank and her colleagues described all strategies as verbal; Kahn and Birch categorized them as verbal, visual, feeling, or 'don't know'. Blank et al. (1968) analysed errors to compare the efficiency with which each reading group used a strategy; Kahn and Birch regrouped the subjects according to the strategy used and compared the results of each group. They did not examine the efficiency with which different reading groups used their chosen strategies.

The ceiling effect question did seem to be clearly resolved; by increasing the difficulty of the A-V matching

tasks, the relationship between reading scores and A-V scores continued at the same strength throughout the age range tested.

Two studies by Vande Voort and his colleagues addressed the temporal-spatial confound. Vande Voort and Senf's study (1973) was published second but completed first; the study by Vande Voort, Senf and Benton (1972) addressed some of the puzzling results of the 1973 study.

Vande Voort and Senf (1973) examined the cross-modal matching paradigm for the effects of the temporal-spatial dimension. In addition to the AT-VS matching task, they presented AT-AT, VS-VS, and VT-VT matching tasks. They reasoned that if it is cross-modal integration which is particularly troublesome for retarded readers, their performance should be significantly different on the AT-VS task only; if there are other variables involved, their performance should be depressed on all tasks.

One factor Vande Voort and Senf thought would be important was short-term memory; to control for this they modified the interstimulus interval (ISI), providing the longest interval between the VS-VS tasks.

Testing 16 male good readers and 16 male poor readers, matched for IQ, Vande Voort and Senf found that their results did not replicate Birch and Belmont's (1964) results, but neither were the results what the experimenters

had expected. Scores of the retarded readers were lower on all the tasks, but the difference was significant only on the VS-VS task. Correlating error scores and reading scores for the retarded readers, only the VS-VS task was correlated significantly with reading scores. The VS-VS task was also the task with the longest ISI. This study was not designed to test short-term memory effects, but the results suggested that a memory deficit might be involved.

Vande Voort, Senf, and Benton extended these results by examining the ISI variable as well as using a larger sample of subjects (48 each of retarded and normal readers). They also examined developmental trends by separating their groups by age. They used three tasks: AT-AT, VS-VS, and AT-VS.

Regarding Birch and Belmont's developmental hypothesis that auditory-visual integration improves with age, Vande Voort et al. found that the older normal readers did better than the younger ones, but only in the longer ISI condition. This suggested that the critical developmental factor may be one of memory rather than integration. In answer to Birch and Belmont's hypothesis that retarded readers would show delay in the development of integrative abilities, retarded readers were deficient on the AT-VS task relative to the normal readers, but they were also poorer on the VS-VS and AT-AT conditions.

One of the cautions Vande Voort, Senf and Benton suggest in interpreting these results is that a cross-sectional design in the study of reading disabilities may result in a sample with progressively more severe handicap in the older age groups, since readers with milder problems are returned to regular classes as their reading improves.

Intertask correlations were obtained on the screening variables used in the study. Normal readers had high correlations across all the skills involved in reading but the reading disabled children did not. Vande Voort et al. suggest that different subjects in the retarded reading group account for low scores on different tasks, depressing group scores without reflecting the individual weakness of each child.

The full range of stimulus combinations was finally used by Bryden (1972). He varied both the auditory-visual dimension and the temporal-spatial one. Bryden used tone sequences (AT), light flashes (VT), and visual-spatial dot patterns (VS). He presented them in all orders and combinations.

Subjects differed in reading level, with the poor readers having a mean reading retardation of 1.5 years compared to their grade level. The two subject groups were matched for age and IQ. There were 10 boys and 10 girls in each group. The initial analysis showed no sex differences in reading performance, and the groups were collapsed across sex.

The stimulus patterns were shorter than those of Kahn and Birch (1968) which had shown a correlation between reading and matching task performance in the older grades. The ISI's in the Bryden study were short (2 seconds); these two factors may have contributed to the ceiling effect which Bryden observed for the good readers. The ceiling effect limits the breadth of conclusions which should be drawn.

Results from the analysis showed that the matching tasks did differentiate the two reading groups. There was no task by reading group interaction--the poorer readers did more poorly than the good readers on all the tasks. This study provided no support for the Birch and Belmont hypothesis that there is a specific auditory-visual integrative deficit for retarded readers.

Analysis of variance did indicate differences in the difficulty of the various matching tasks. The tasks presenting a spatial pattern first were much easier (results of whole group). A subsequent series of multiple t-tests revealed that the poor readers found the AT-AT task significantly harder than the good readers did.

Bryden found different intertask correlations in the two groups, and different correlations between the matching tasks and the screening tests; the poor readers had higher correlations between matching tasks and IQ than the normal readers. However, the ceiling effect for the normal readers calls both of these findings into question.

The Bryden study is cited as one of the few adequate tests of Birch and Belmont's sensory integration hypothesis (Bryant, 1975). Though Bryden's results suggest that a great deal more than sensory integrative ability differentiates good and poor readers, a clearer pattern of differences might emerge from a series of tasks with a higher ceiling for the good readers.

The tasks used in the studies reviewed above were appropriate to the hypotheses under investigation. The studies explored the way that simple perceptions from different sensory modalities were recognized as equivalent. The studies have indicated that the tasks are not as simple as they looked on first viewing; the tasks can indeed discriminate between groups of good and poor readers, but the basis of that distinction is not clear.

Furthermore, early studies of cross-modal sensory integration often used auditory and visual perceptual measures to rule out perceptual deficits, and assumed they had demonstrated competence on the ipsi-modal counterparts of the integration tasks. Bryden's testing of the ipsi-modal performance of the poor readers did not support that view. His subjects were impaired on all versions of the tasks. With this in mind, it is appropriate to review some recent studies which have investigated specific deficits which might be relevant to dyslexia.

1.2.2 Specific Deficits

To begin with an elementary level of information processing: Pavlidis (1981) reports irregular eye movements in dyslexics in a task designed to be free from memory requirements and linguistic factors. He attributes sequencing difficulties in dyslexic reading behavior to sequencing problems in the eye movements of dyslexic readers.

Maisto and Sipe (1980) used a reaction time measure in a task requiring recognition of letters as the same or different from a set of two, three or four letters presented first. Some of the stimuli were visually degraded by placing a checkerboard design over the letter. Dyslexic subjects took longer to recognize the degraded letters than the normal control subjects, and the dyslexic subjects' reaction times were more strongly affected by the degraded stimuli than the times for normal subjects. The results suggests that visual processing may be more vulnerable to interference in dyslexics than in normal readers.

Blank, Berenzweig, and Bridger (1975) found that retarded readers had slower reaction times to complex visual stimuli than to simple ones, and that all reaction times were slowed in the retarded readers when a complex stimulus was present. This effect occurred whether all stimuli were in the same modality or not.

Negative evidence for a visual perceptual deficit has been asserted by Vellutino et al. (1975b, 1975c). The first study presents visual material briefly and requires the subjects to copy it or read it aloud. The dyslexic and normal groups were not different in the copying task, but they did differ in pronouncing the recalled stimuli. Vellutino concludes that visual perception in dyslexic children is intact, but that verbal codifying is the skill in which dyslexics are deficient. Since the subjects were matched by age and not by reading skill, Vellutino has demonstrated that dyslexic children are indeed poorer readers than other children of the same age.

It is useful to compare dyslexic children with normal children of the same age when the performance being measured is thought to be a part of the complex task of reading. When the experimental task is itself a reading task the groups must be matched by reading level rather than age, or the experimental task does no more than verify the assignment to groups on the basis of reading skill.

In the second study, Vellutino (1975c) tested three groups of children for their ability to recognize Hebrew letters after being given three of them to study. One group was disabled in reading; one, normal; and the third group consisted of very bright Hebrew children from a Hebrew school. Between the children who were not familiar with the

Hebrew alphabet, there were no group differences on the tasks. It was unclear from Vellutino's description what a chance level of performance would have been, but none of the non-Hebrew groups had mean scores higher than Vellutino's estimate of chance performance. The great IQ differences between the groups would have confounded the results further if either of the non-Hebrew groups had been able to execute the task. From this material Vellutino concludes that there are no differences in visual memory between good and poor readers. A more appropriate conclusion would have been that good and poor readers do not differ on a task that neither can do at all.

Another type of specific deficit which might be involved in dyslexia is one of auditory temporal perception. Tallal and Piercy (1974, 1975) have investigated this with dysphasic children and have found that these children have particular difficulty with speech sounds which have fast formant transitions, such as the stop consonants. In a study of dyslexic children, Tallal (1980) used nonverbal stimuli and found the greatest deficit in conditions of short interstimulus intervals. These results correlated highly with the difficulties the subjects had with phonics testing: the subjects poorest on the short ISI task conditions were the ones with the lowest phonics test scores.

Brandt and Rosen (1980) took another approach to the issue of presumed deficits in auditory perception. Their study used consonant-vowel combinations differing in the time of voice onset ('ta' versus 'da'), or in place of articulation ('ba' or 'ga'). Children were required to repeat the stimuli, then on other tasks they were asked to indicate whether the two stimuli were the same or different. Brandt and Rosen concluded that the dyslexic children were not significantly impaired in the ability to extract phonemic information from speech. This conclusion may be premature, since it may be more difficult to extract phonemic information from speech than from isolated syllables.

1.2.3 Memory

The importance of memory effects has been suggested by several of the studies reviewed above. As in most of the literature on memory and dyslexia, a distinction is made between visual and verbal memory.

A study by Ceci, Iea and Ringstrom (1980) examined coding processes and memory in dyslexics. Ceci et al. separated groups according to scores on the visual and auditory memory subtests of the Detroit Tests of Learning Aptitude (Baker & Leland, 1959). Children with low scores on the auditory subtest were defined as auditory-memory handicapped, and

those with low visual subtest scores as visual-memory handicapped. The dependent variable was a measure of the extent to which a semantic cue improved memory. In both groups memory was improved by a semantic cue for items presented in the weaker modality, though memory was not improved in the modality which was not difficult for the child. Specifically, children defined as auditorially handicapped would remember auditorially presented material better when given a semantic cue; their memory for the visually presented material was equally good with or without the cue. A similar pattern was found for the children defined as visual-memory handicapped: they benefited from a semantic cue with material presented visually, but the cue did not improve memory for items presented auditorially.

Ceci et al. interpret their results as evidence for separate access to semantic memory by auditory and visual systems. An alternative explanation is that children may have differed in their spontaneous use of verbal codes for the stimuli in these tasks.

A study by Hicks (1980) examined another memory task and discovered that the verbal or non-verbal quality of test materials may be less clear-cut than the designers of a test intended. Though the Ceci et al. study is based on a distinction between auditory and visual materials, Hicks' study suggests that the children's use of verbal coding may bear on the interpretation of their results.

Hicks studied one subtest of the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy, & Kirk, 1968). She administered the visual sequencing subtest in a series of experiments to see what the test measured, how children performed it, and how good and poor readers differed in the skills necessary to perform the test. She first gave the test to 20 competent readers and asked them to explain afterward how they did the tasks. She found that, though the test was supposed to be non-verbal, the children who did well on it had used a strategy of naming the symbols. She then readministered the test, requiring all the children to label the stimuli, and recall the verbal sequence. The labelling strategy eliminated the difference between the groups (though there may be a confounding factor in that both groups had learned the items by repetition at the time of the second testing).

Hicks used this procedure several times, taking groups of dyslexic and normal children, giving them the visual memory subtest, asking them for their strategy and then repeating the test with modified instructions. She found more children who spontaneously used verbal coding in the good reader groups than in the dyslexic groups. After the first administration of the task, she separated the groups by the strategy used, and evaluated the changes in performance resulting from different instructions. She found that the

advantage shown by the verbalizers disappeared when they were required to say 'the the the the' as they were doing the task, but the visualizer's performance was not significantly different in that condition. She also found that when all the children were instructed to label the stimuli, the dyslexics still did more poorly, but they did show a significant improvement over their original performance using a visual strategy.

The Hicks study should be replicated, primarily because of the implications of the findings, but also because of some weaknesses in design. Though Hicks stated that all subjects were within average range on the WISC, she did not give group means and standard deviations. The possibility of ceiling effects with the second administrations of the test should also be examined. If the information is reliable, it is of moment for studies of memory in dyslexia and for the identification of dyslexics according to the visual or auditory nature of their handicap.

We are left with several questions raised in the course of this research. The first complex of questions arises from the issues of memory, temporal sequencing, and verbal facility. Though these topics are usually treated separately, it may be fruitful to consider them together.

Sequential stimuli, by the nature of their construction, take more time to present than spatially presented ones.

This in turn implies that the memory demands of the two types of stimuli are different. It may be most meaningful to consider temporal processing and short-term memory together, as Vande Voort, et al. (1972) suggest.

Blank, et al. (1966,1968) emphasised that verbal mediation may play an important part in mastering the more demanding stimuli. From this idea, a possible relationship between temporal processing and verbal skills emerges.

It might be useful to consider the type of verbal skills involved in these tasks. The high incidence of children with early language problems in the population of dyslexic readers points toward a general language deficit as being important in dyslexia (Yule & Rutter, 1976). Verbal skills may also be involved in learning to learn. A mental process one step removed from the activity itself may be involved as children learn to generate strategies which will help them perform a difficult task.

It is important to ask whether dyslexia is a unitary disorder or a symptom. Does it result from any of several unitary disorders, or from combinations of problems? Studies such as those reviewed above, which look for common characteristics of a group of subjects, may discover unitary disorders, but they are less likely to provide clear results if dyslexia is a symptom of many disorders or combinations of disorders. In the studies described above, evidence for

the presence of several deficits accounting for problems in different children arose incidentally, as in Vande Voort, Senf and Benton's (1972) intertask correlation matrices.

Several researchers have investigated dyslexic populations for evidence of subtypes of dyslexia. Some researchers described dyslexia in terms of the types of reading errors the children made (Bader, 1973; Doehring, 1979). Others based their definitions on characteristic profiles of scores on psychological or neuropsychological tests (Mattis, French & Rapin, 1975; Petruskas & Rourke, 1979; Satz & Morris, 1980). Although this is an important area of research in dyslexia, detailed comparison of these classification systems is beyond the scope of this paper.

1.3 CROSS-MODAL COMPARISON IN A READING TASK

In her 1978 review, Blank wrote of two general approaches to the study of dyslexia. One approach is to examine the dyslexic reader to find deficits which might be causing the reading problem; the other is to examine the demands of the reading task itself. Birch and Belmont's original article was a result of the second approach, though the research generated by it has had more to do with the deficits of the dyslexic.

One recent study which has returned to the reading task as the basis of analysis is that of Snowling (1980). This study compared normal and dyslexic readers in their performance of a cross-modally presented reading task which required comparing words which they had never seen before. Snowling's hypothesis was that the groups would differ in their grapheme-phoneme conversion skills.

Snowling used a same-different comparison of four-letter nonsense words as her experimental task. Words were presented either visually or auditorially, and subjects indicated whether a comparison stimulus, which could be either visual or auditory, was the same or different. Thus she presented four conditions: visual-visual, auditory-auditory, visual-auditory and auditory-visual.

Snowling's nonsense word pairs differed only in the order of the middle two letters: e.g. 'snd-sond'. All were pronounceable. Twelve pairs were given in each of the four conditions; of these, six pairs were the same and six were different.

Subjects were normal readers and dyslexics of both sexes at different reading levels. Children were matched by reading level instead of age. Since the experimental task was a reading task, it was essential that the word recognition skills of the two groups be comparable.

Scores were calculated as d' values. This statistic from signal detection analysis estimates a score in z units for the distance between the means of two distributions formed by the subject's perceptions of same and different stimuli. (For detailed explanation of the d' statistic, see Coren, Porac & Ward; 1979, Chapter 2.) Analysis of variance was performed on these scores, with subsequent t -tests and correlational analyses.

Snowling reported no overall differences between the groups, but different age trends did emerge. Performance in the normal group increased with increasing reading age, but in the dyslexic group it did not. Comparing performance on the cross-modal tasks, the dyslexics performed more poorly at all levels except for the lowest reading age. Analysis of variance showed one significant interaction between conditions and groups. Multiple t -tests indicated that the interaction effect was due to the normal group's superior performance on the Visual-Auditory matching task.

Snowling concluded that reading performance of the dyslexic group was qualitatively different from that of normal readers of the same level. She suggested that dyslexics develop a fairly large sight vocabulary but that their skills at grapheme-phoneme conversion remain at a primitive level. Since the groups did not differ in the other three conditions, Snowling interpreted her finding as

evidence of a specific deficit in grapheme-phoneme conversion, which she considered to be analogous to cases of acquired phonemic dyslexia in adults. She stated that her results implied a selective impairment of the 'grapheme-phoneme route' to reading.

Several points should be made about Snowling's conclusions. First, she found that all of her groups did very well on the A-A condition where subjects compared two auditory presentations of the stimuli. When Snowling's four-letter nonsense words differed within the pair, they differed only in the order of the middle two letters. This was assumed to provide difficulty both auditorially and visually. However, examination of the stimuli shows that in the case of a ccvc-cvcc pair (e.g. 'kleg-kelg'), the initial and final consonant blends are different, producing several auditory differences in the pair. In the example given above, the initial sounds are /kl-/ vs. /k-/; the final sounds are /-g/ vs. /-lg/. The vowel sound also changes in interaction with the consonant blends. Snowling's subjects' high scores on the auditory-auditory condition may therefore indicate multiple auditory differences in the stimuli rather than acute auditory perception in the subjects.

Secondly, Snowling stated that only one strategy was available for the V-A task. She assumed that the children would have to convert the visual stimulus (the grapheme) to

its auditory counterpart (the phoneme) for comparison with the second stimulus of the pair, which was auditory. This may be the most likely strategy but it is not the only possible one. Children could also have read out the letters of the visual stimulus and tried to spell the auditory one. They could have used different strategies for different items in the same condition--there is no reason to assume consistent choice of strategies.

Snowling's interpretation may be expanded further by taking into account the ambiguities of English spelling and pronunciation. Letters may vary in pronunciation, and different letters may make the same sound. The consonants /c/, /s/, and /g/, for example, have more than one pronunciation. Vowels are particularly difficult. Each has a range of pronunciations which varies in different consonantal contexts (Strange, Edman & Jenkins; 1979). Vowel ranges overlap: one sound may be made by several different vowels. In spelling, several different letters are often available for each sound (Shankweiler & Liberman, 1972; Gibson & Levin, 1975).

These ambiguities add to the complexities of the comparison task. One comparison may not have been enough to complete the task. Subjects may have had to try several pronunciations or spellings before satisfying themselves that a pair was 'different'.

Thus it may be misleading to refer to poor grapheme-phoneme conversion skills as a 'specific' deficit. The complexities of English spelling and pronunciation make learning the grapheme-phoneme conversion code a very complex task indeed. Furthermore, while the dyslexics were more disabled in this task than readers of the same overall skill level, it must be remembered that they were also disabled in all reading skills relative to children of their own chronological ages.

In her conclusion Snowling makes an analogy between the dyslexic children's performance on the Visual-Auditory matching task and a reading deficit seen in some aphasic adults. She cites studies by Saffran and Marin (1977) and by Patterson and Marcel (1977) of aphasic patients who retain the ability to read real words with irregular spellings, such as 'character', while being unable to read regular nonsense words such as 'flcre'. These studies support the idea that different parts of the reading process may be disrupted by brain damage. However, Saffran and Marin (1977) caution:

Phonemic dyslexics learned to read before incurring brain damage. One should therefore be careful in drawing implications for the acquisition of reading skills. Orthographic reading mechanisms may, in fact be difficult to acquire without some basis in phonology. (p. 524)

Furthermore, one cannot assume that dyslexia is a result of brain damage. If, however, dyslexia resulted from a neurological abnormality not recognized as brain damage, the abnormality is likely to be subtle, in contrast to the adult dyslexics' obvious impairment. If neurological impairment were the result of an old, undetected injury, the structural changes resulting from the damage would not necessarily be restricted to the area immediately surrounding the injury. Since developing brains change more readily than adult brains, children are less likely than adults to have localized brain abnormality as a result of brain damage.

The study presented in this thesis also examined performance on a reading task presented in a cross-modal comparison paradigm. As in Snowling's study, pairs of nonsense words were presented auditorially, visually, and in two cross-modal presentations. Half of the word pairs differed within the pair and half were the same; subjects were required to indicate whether the pairs were the same or different. Four comparison conditions were presented: auditory-auditory (A-A), visual-visual (V-V), auditory-visual (A-V), and visual-auditory (V-A). Nonsense words were used as stimuli in order to compare performance between groups using phonetic skills without help from sight vocabulary.

Stimuli were chosen to present difficulty auditorially or visually. Some of the stimulus pairs were similar to those used by Snowling: four-letter nonsense words differing only in the order of the central two letters. Other pairs differed in one letter in the initial, central, or final position. The letters which varied within the pair were visually similar for some of the pairs (Liberman, Shankweiler, Orlando, & Bell Ferti, 1971). The remaining pairs differed in letters which were auditorially similar (Miller & Nicely, 1955). Some letter pairs were confusable both auditorially and visually (e.g. /b/ and /d/). Since the difficulty provided by each stimulus pair was theoretically rather than experimentally defined, the same stimulus master list was used for all four conditions of the experimental task, with the order differing for each condition.

The experimental task was given to three groups of subjects: normal, slow and dyslexic readers. All were reading at the level appropriate to grade two.

Chapter II

HYPOTHESES

The first hypothesis to be examined was whether there were overall differences between the three groups. If groups are matched for reading level, is there a difference between the performance of the three groups on the experimental task? Specifically, is there a multivariate effect of these four experimental conditions together? If phonetic skills in general are particularly difficult for dyslexic children, then the scores of the dyslexic group were predicted to be lower than for the normal and slow groups on a composite measure based on all four scores.

The second hypothesis to be explored concerned specific perceptual problems in dyslexia. If dyslexic readers have problems with phonetic skills primarily because of auditory perceptual problems, then it was predicted that scores for the dyslexic group would be lower than for the normal group on all but the V-V condition. Visual perceptual problems would produce a similar profile with the A-A condition being the only one not depressed.

A third hypothesis arose from Snowling's finding of a specific impairment in dyslexic children in visual-auditory

comparison tasks (Snowling, 1980). In the present study, replication of this finding would show in lower scores for the dyslexic children in the V-A condition compared to the other groups.

The author assumed that the ambiguities of English spelling and pronunciation added significantly to the difficulty of the cross-modal presentations. If the cross-modal conditions were more sensitive to general cognitive deficit, and if the slow reader group were less impaired in sensory perceptual ability than the dyslexic group, then the scores of the slow group would be similar to those of the normal group on the ipsi-modal conditions, and lower than scores of the normal group on the cross-modal tasks. The slow and dyslexic groups would both show deficits in performance of cross-modal tasks, compared to the normal group.

Hypotheses 2,3, and 4 are summarized graphically in Figure 1.

Two post hoc analyses were planned for these data. The first was related to Hypothesis 2. If dyslexia resulted from visual perceptual disability in some children and auditory disability in others, there would be two or more types of performance deficit visible in these data. Some of the dyslexic group would show high performance on the A-A condition and some on the V-V condition, relative to their

level of performance on the other conditions. A post hoc analysis was used to examine this possibility since the study was not designed to distinguish between subgroups of dyslexic subjects.

For the post hoc analysis a difference score was calculated by subtracting each subject's V-V score from the A-A score. The frequency of strongly positive or negative values was compared between the three groups.

A second post hoc analysis was planned to compare the types of errors made by each group of subjects. For this analysis the items were regrouped. Only the pairs which were different were considered; they were separated according to the location of the letters which were different. (For example, 'bok-vok' differed in the initial position; 'vop-vok', in the final, and 'bik-bek', in the central position. The percentage correct for each type of pair was calculated for each group of subjects.

level of performance on the other conditions. A post hoc analysis was used to examine this possibility since the study was not designed to distinguish between subgroups of dyslexic subjects.

For the post hoc analysis a difference score was calculated by subtracting each subject's V-V score from the A-A score. The frequency of strongly positive or negative values was compared between the three groups.

A second post hoc analysis was planned to compare the types of errors made by each group of subjects. For this analysis the items were regrouped. Only the pairs which were different were considered; they were separated according to the location of the letters which were different. (For example, 'bok-vok' differed in the initial position; 'vcp-vok', in the final, and 'bik-bek', in the central position. The percentage correct for each type of pair was calculated for each group of subjects.

Chapter III

METHOD

3.1 SUBJECTS

Three groups of thirty subjects each were selected from Greater Victoria School District 61 to form groups of slow, normal and dyslexic readers. The 90 subjects came from 14 schools, representing a cross-section of Victoria's socioeconomic environments.

All subjects were reading at a level appropriate to grade two as measured by the WRAT (Level 1). In Victoria the mean raw score for grade two is approximately 50 (mid-year; extrapolated from McAllister's norms). Scores in this sample ranged from 41 to 65.

Some of the children identified by teachers as reading at approximately grade two level obtained WRAT raw scores outside the 41-65 range; those children were not included in the sample. The three experimental groups were screened from 133 subjects given the WRAT, PPVT and Block Design measures.

Groups were defined in terms of the regression equation derived from McAllister's normative data, described earlier.

WRAT scores were predicted from the child's age, PPVT score, and WISC Block Design score; and the predicted WRAT score was compared to the child's observed WRAT score. Because McAllister's norms were based on the 1959 edition of the PPVT, the same edition was used in the present study.

The regression equation used to calculate the predicted WRAT score was:

$$\text{Pred. WRAT} = \text{Age} \times 6.33 + (\text{PPVT} \times .32) + (\text{B.D.} \times .17) - 22.56$$

Predictor variables were entered in the equation in order of variance accounted for. Age accounted for the most variance and Block Design raw score accounted for the least.

All scores were raw score values. Standard error of prediction on the regression equation was 8.65. A difference greater than 1.5 standard errors of measurement between predicted and observed WRAT scores was chosen as the cutoff point for defining the three groups. Thus, the normal group consisted of grade two children reading at grade level, whose predicted and observed WRAT scores differed by less than 13 points. Slow readers were defined as those children older than the age appropriate for grade two but reading at grade two level, whose predicted and observed WRAT scores were within a 13 point range. The dyslexic group were older

children ,reading at grade two level, whose observed WRAT scores were more than 13 points lower than the score predicted for them on the basis of their age, PPVT score and Block Design score. Difference scores and the other defining measures are shown in Table 1.

TABLE 1

Group Defining Measures: Ages, Test Scores and Difference Scores

Measure	GROUP								
	Normal			Slow			Dyslexic		
	Mean	SD	%ile	Mean	SD	%ile	Mean	SD	%ile
Age	7.4	.3		9.0	.8		10.8	1.3	
PPVT	73.1	7.9	50	73.4	7.7	30	81.7	7.8	25
Block Design	21.4	5.9	60	20.9	9.7	20	29.7	11.0	20
WRAT	54.2	6.0	65	56.2	5.8	>2	53.4	6.1	>2
Difference	+2.8	5.8		-5.0	4.7		-23.5	8.2	

Difference = (Observed - Predicted WRAT scores)

The dyslexic and slow groups were obtained through remedial reading programmes offered by Greater Victoria School District 61. The study began with children enrolled in the 1981 Summer School reading programme, and continued through January 1982. Poor readers were located with the help of learning assistance teachers in the schools. Normal readers were selected from the grade two classes of the

schools attended by the slow and dyslexic readers. Parental permission forms were sent home with all children suggested by the teachers for this study, and those who returned signed forms were tested. All children were given the WRAT, PPVT and Block Design subtest by the author and placed in groups on the basis of those scores.

3.2 STIMULUS SELECTION

Pilot work with 10 normal children at the end of grade one indicated that stimulus pairs such as Snowling's resulted in near-perfect performance in the A-A condition and chance performance in the V-V condition. These stimuli were difficult to distinguish visually but very easy auditorially.

A master list of items providing sufficient visual and auditory difficulty was then constructed (Appendix A). The stimuli were orthographically regular nonsense words, not homophonic with real words. There were 42 stimulus pairs in the master list. The list contained three- and four- letter nonsense words; the three-letter words differed in only one letter and the four-letter pairs differed in the order of the middle two letters. All nonsense words were pronounceable. The three-letter words were cvc combinations; the four-letter ones ccvc-cvcc.

Eighteen of the pairs differed in ways that are difficult to distinguish auditorially. Consonants which are known to be easily confused (Miller & Nicely, 1955) were varied in the initial position in six of the pairs, (e.g. 'bok-vck') and in the final position in another six pairs (e.g. 'fep-fek'). Six more pairs differed in vowels having similar sounds ('bip-bep'). Some of the easily confused sounds identified by Miller and Nicely are written in English by digraphs: e.g. /th/ - /f/. For this reason the auditorially confusable pairs contained some words of unequal length such as 'fip-thip'.

Another eighteen pairs were constructed to provide sources of visual confusion. Similar-looking consonants were varied in the initial position for six pairs ('biv-div'), in the final position for six more ('lut-luđ'), and visually similar vowels differed in the remaining six three-letter pairs.

Six four-letter nonsense word pairs were also used, differing only in the order of the middle two letters. These four-letter word pairs were similar to those used by Snowling (1980), except that for the present study all items began and ended with a consonant, and all were of one syllable.

Each stimulus pair from the master list could be presented in four ways, differing in order and sameness.

Thus the pair 'bck-vok' could be given in four different forms: 'bck-vok', 'vok-bok', 'bok-bck' or 'vck-vok'. The stimuli on the master list were all presented in each of the four experimental conditions (A-A, V-V, A-V, and V-A). They were given in a different form in each condition. The order of stimuli was randomized for each experimental list, with equal numbers of same and different pairs given on each list (Appendices E-E).

The auditory stimuli were recorded on audio tape, read by the author, a female with a North American accent inconspicuous in Victoria. The nonsense words were printed by hand in MacLean's manuscript alphabet on 3" X 5" white index cards.

3.3 PROCEDURE

The WISC-R Block Design subtest, the PPVT, and the WRAT reading subtest were given first, in that order, in a session lasting about twenty minutes. Standard test administration was followed for these three tests, and the children were given a decorative sticker at the end of this session.

The second session followed after a variable amount of time. Most children received both sessions the same day but in some classrooms this amount of interruption was not possible and the second session had to be given on another day.

During the second session the experimental tasks were given. The A-A condition was given first, V-V second, A-V third and V-A fourth. Since it was expected that the demands of the cross-modal tasks were greater than the ipsi-modal ones, the easier conditions were given first to familiarize the children with the procedure. It is unlikely that there was any learning of the items themselves since the children had no way of predicting the order of the items or whether the pairs were to be the same or different on any trial. They were not given the same form of any pair twice. This session lasted about forty minutes, and the children were rewarded with stickers at intervals throughout the session.

Instructions were spoken rather than read. The author repeated instructions or demonstrated as necessary, checking that subject and author were using the same words for the coding symbols. When the child showed understanding of the instructions by repeating them in his own words, a number of practice trials were given orally, with correction of errors.

The instructions were "I am going to say two words that don't mean anything. I want you to tell me if they are the same as each other or if they are different. The way I want you to tell me if they are the same is to put a check on your paper." At this time the author made sure that she and

the child called the same symbol a check. "And if the two words are different, put an 'X' on your paper.

"Now what if you heard the words 'vck' and 'vcf'. Are they the same or different? What would you put on your paper? What about 'bik', 'bek'? What if you heard 'tck', 'vok'?" After the child demonstrated understanding of this part of the instructions, a short practice session was given with the author reading the stimuli. Then another practice was given using tape recorded practice trials. Before the experimental tasks were begun the child was told, "You will have to listen carefully, because I can stop the tape if you need more time, but I can't make it go backward."

A similar introduction was given for each of the experimental conditions, with spoken instructions first, followed by practice trials using the tape recorder.

Each trial in the A-A condition took approximately ten seconds, allowing time for the child to respond. If ten seconds were not long enough, the tape could be stopped before the next trial. The voice on the tape announced the number of each trial at second zero, then after two seconds the two nonsense words were spoken about one second apart. The child was given as much time as he needed to write his answer on the answer sheet. In order to stop the tape before the next stimulus if necessary, a tap was recorded at the seventh second of each trial, signalling three seconds to the beginning of the next trial.

In the V-V condition the tape was not used. The experimenter announced the number of the trial and then turned up the first card for approximately two seconds, put it face down and turned up the next one for another two seconds. When the child finished writing his response the next pair was similarly presented.

The A-V condition made use of the tape again, and again ten seconds was used for for each trial. The number of the trial was announced and at two seconds the first member of the pair was spoken on the tape. Then the experimenter turned up the corresponding card, visually presenting the second member of the pair for two seconds, then laid the card face down. Three seconds before the next trial was a warning tap (for the experimenter) so that the tape could be stopped if the child needed more time.

The V-A condition took longer for each trial--approximately twelve seconds. In the third condition (A-V) the experimenter could get ready to turn up the card while the auditory stimulus was being presented, but when the visual stimulus was first there was a time lag of about two seconds while the card was being picked up. In this condition the trial number was read at second zero; there was a four-second pause for turning up the card and exposing it for two seconds, followed by a tap to tell the experimenter to turn the card down again. The auditory

stimulus was read at second five, there was another warning tap at second nine, and the next stimulus was announced at second twelve.

Each condition consisted of 42 trials. At the end of each condition the recorder was turned off, and the child was allowed to choose a sticker. An extra sticker was given at the end of the experiment.

Chapter IV

RESULTS AND DISCUSSION

4.1 SCORES

Scores for each subject were calculated as the percentage correct for each experimental condition. Mean scores for each group, in each condition are shown in Figure 2. It will be noted that the scores on the A-A condition were all high: 92.5%, 91.7%, and 90.6% for the normal, slow and dyslexic groups respectively. This ceiling effect restricts the interpretation of results for Hypotheses 2 and 4, and for the first of the post hoc analyses.

The data were analysed by multivariate analysis of variance (three group by four dependent variable design), followed by four one-way analyses of variance comparing the three groups on each of the four conditions. The multivariate test of significance was chosen to protect against high experimentwise error rate. However, multivariate tests may also fail to detect significant univariate effects. The hypotheses of this study produced several specific predictions about group differences in profiles of scores on the four experimental conditions; for

this reason the author felt justified in using univariate tests of significance to explore group differences on each of the four experimental tasks (Harris, 1975). Hypotheses 2, 3, and 4 were then tested by comparing profiles of group differences predicted by the hypotheses as shown in Figure 1. Results of all the analyses of variance are shown in Table 2; each hypothesis is then discussed separately below.

One of the univariate comparisons was significant: there was a significant difference between the three groups in performance on the V-A matching task. The Student-Newman-Keuls procedure showed that the dyslexic group differed from the other two groups, and that the slow and normal groups did not differ from each other.

TABLE 2

Analyses of Variance: Percent Correct by Group for Each
Experimental Condition

Multivariate Analysis of Variance:
Three Groups by Four Experimental Conditions

Source of Variance	Wilks Lambda	Approx. Mult. F	Signif. of F
Group	.867	1.56	.14

One-Way Analysis of Variance

Source	df	Sum of Squares	MS	F Ratio	F Prob.
A-A Score by Group					
Between groups	2	50.35	25.17	0.64	0.529
Within groups	87	3410.05	39.20		
Total	89	3460.40			
V-V Score by Group					
Between groups	2	134.71	67.35	1.17	0.316
Within groups	87	5014.55	57.64		
Total	89	5149.26			
A-V Score by Group					
Between groups	2	387.03	193.52	2.56	0.083
Within groups	87	6579.55	75.63		
Total	89	6966.58			
V-A Score by Group					
Between groups	2	875.66	437.83	5.53	0.006
Within groups	87	6888.53	79.18		
Total	89	7764.18			

4.2 MULTIVARIATE CROSS-MODAL DEFICIT HYPOTHESIS

The first hypothesis stated above asked whether there were overall differences between the three groups of subjects. This hypothesis is similar to the Birch and Belmont cross-modal sensory integration hypothesis as restated by Snowling. The present study predicted that normal, slow, and dyslexic readers would perform differently in a cross-modally presented series of phonics tasks. This hypothesis was tested by the approximate F derived from the Wilks Lambda statistic in a multivariate analysis of variance (Hull & Nie, 1981). The results of the multivariate test were not significant, approximate multivariate $F = 1.56$; NS. If there are differences in phonics performance of these three groups, the differences are not of the magnitude to achieve significance on a multivariate test; hence, the first hypothesis received no support.

4.3 PERCEPTUAL DEFICIT HYPOTHESIS

The second hypothesis was the perceptual deficit hypothesis which stated that dyslexics as a group would show auditory or visual perceptual handicap. Perceptual deficits would also be expected in the dyslexic group if, for example, there were validity in Eoder's classifications of dysphonetic, dyseidetic, and mixed subtypes of dyslexia.

These subtypes might correspond to deficits in auditory perception, visual perception, and deficits in both. This hypothesis would have been supported by lower scores for the dyslexics on either or both of the ipsimodal tasks. In the present study, all groups achieved near perfect scores on the A-A task; there were no significant differences between the groups on the one-way analysis of variance performed on the scores of the three groups on the V-V task. (See Table 2.) The second hypothesis, therefore, received no support from the data; it should be remembered, however, that ipsimodal comparison tasks are only a partial measure of perceptual capacities.

4.4 POST HOC ANALYSIS BASED ON PERCEPTUAL DEFICIT HYPOTHESIS

As a planned post hoc analysis the possibility of two different types of performance reflecting two types of dyslexia was explored further. Two types of dyslexia would produce some score profiles for individual dyslexic children in which the A-A score was higher; other children would have score profiles in which the V-V score was higher. These different types of performance could be discovered post hoc in this study by subtracting each subject's V-V score from his A-A score, and by then comparing the frequencies of highly negative or highly positive scores in each group.

The presence of a ceiling effect in the A-A condition, however, invalidated this procedure.

4.5 PERCEPTUAL IMPAIRMENTS VS. GENERAL COGNITIVE DEFICIT

The fourth hypothesis proposed that dyslexic and slow groups differed in the origins of their reading deficits. Dyslexics would be expected to have auditory and/or visual perceptual impairments and slow readers to have general cognitive deficits. The dyslexic group was expected to show ipsimodal deficits compared to the slow group, and both dyslexic and slow groups would show cross-modal deficits compared to the normal group. This prediction was based on Yule and Rutter's (1976) study which found that, in their sample, 'generally backward' readers were of lower intelligence than 'specifically disabled' readers. However, Yule and Rutter's groups were matched for severity of reading retardation: all were two and one-half years or more below age level in their reading level. A relatively small discrepancy between predicted and observed reading levels was a defining characteristic for the 'backward' reading group in Yule and Rutter's study. By definition, the 'backward' readers would be of low intelligence, since children would have very low predicted reading levels only if they were of low intelligence.

In the present study, slow and dyslexic groups differed in the severity of their reading retardation. Slow readers had lower cognitive scores than the normal group, but higher scores than the dyslexic group. Even so, the severity of reading retardation in the dyslexic group was greater than their cognitive disadvantage compared to the slow group. Thus it was proposed that auditory and visual perceptual impairment contributed to the dyslexic group's reading retardation, while the slow group's reading problems were based only on general cognitive deficits. The dyslexic group was expected to perform more poorly than the slow group on ipsi-modal tasks; both slow and dyslexic groups were expected to perform more poorly than the normal group on the cross-modal measures.

The ceiling effect in the A-A condition invalidated a comparison of combined ipsimodal scores; however, the V-V scores, which were not at ceiling, did not differ between the three groups. The first part of the fourth hypothesis was not supported: no evidence was found to differentiate dyslexics from slow readers on the basis of perceptual deficits. The second half of the fourth hypothesis predicted that the slow and dyslexic groups would perform more poorly than the normal group on both cross-modal tasks. However, the slow group did not differ from normal readers on any experimental tasks, and the dyslexic group differed

from normal performance on only one of the cross-modal tasks. The results did not occur in the pattern which would be expected if dyslexics were significantly perceptually impaired and slow readers, cognitively impaired.

4.6 DYSLEXIC V-A DEFICIT

The third hypothesis was based on a finding in Snowling's (1980) study. Snowling found no overall difference between her two groups (normal and dyslexic readers) but she did find that the dyslexic group performed more poorly on the visual-to-auditory comparison (V-A task). She regarded this difference as a selective impairment in grapheme-phoneme conversion, analogous to the impairment of aphasic adults with acquired phonemic dyslexia. The findings of the present study, while failing to support a general cross-modal or perceptual deficit hypothesis, do replicate Snowling's finding of depressed performance on the V-A matching task. In the present study the only clear difference between the three groups occurred in the V-A condition, $F(2, 87) = 5.53, p < .01$. (See Table 2.) Subsequent Student-Newman-Keuls analysis showed the dyslexic group to be different from both the normal and slow groups; This difference may also be seen in Figure 2.

If we use the term grapheme-phoneme conversion to mean phonetic skills, we may accept this study as confirmation of

deficient grapheme-phoneme conversion skills in dyslexic readers compared to normal and slow readers of the same reading level. Support for this conclusion may be seen clearly in the significant V-A task difference between the dyslexic group and the other two groups.

4.7 POST HOC ERROR ANALYSIS

Further evidence of deficient grapheme-phoneme conversion skills in dyslexic readers may be seen in the results of the second planned post hoc analysis. This second comparison was based on the position of the differing letter in the 'different' stimulus pairs. Considering only the stimulus pairs which were different within the pair, the stimuli were separated into categories according to the position of the letter which differed. Thus some of the pairs differed in the initial position, some in the central position, and some in the final one. The fourth type of pair differed in the order of the central two letters and also contained consonant blends. Percentage correct scores were calculated for each group of subjects, for each type of different pair across all conditions. (See Figure 3.) These results were then analysed by a multivariate analysis of variance and four one-way analyses of variance. These analyses are shown in Table 3. It was found that dyslexics performed more poorly on all types of 'different' pairs, whether the pairs

differed in the initial, central, or final position. Performances of the three groups did not differ significantly on the four-letter word pairs with the order of the middle two letters reversed, though the dyslexics scored lowest on this fourth type of stimulus pair, as well.

TABLE 3

Post Hoc Analysis: Performance by Three Groups on Four Types
of Differing Word Pairs

Multivariate Analysis of Variance
Three Groups by Four Locations of Difference

Source of Variance	Wilks Lambda	Approx. Mult. F	Signif. of F
Group	.792	2.59	.011

One-Way Analysis of Variance

Source	df	Sum of Squares	MS	F Ratio	F Prob.
Pairs Differing in Initial Letter					
Between groups	2	786.43	393.21	3.76	0.027
Within groups	87	9098.31	104.58		
Total	89	9884.78			
Pairs Differing in Central Letter					
Between groups	2	1109.73	554.87	3.77	0.027
Within groups	87	12813.90	147.29		
Total	89	13923.63			
Pairs Differing in Final Letter					
Between groups	2	1900.86	950.43	7.64	0.001
Within groups	87	10818.26	124.35		
Total	89	12719.11			
Pairs Differing in Central Two Letters (Blends)					
Between groups	2	1686.71	843.35	2.30	0.107
Within groups	87	31955.93	367.31		
Total	89	33642.63			

4.8 INTERPRETATION: SOME RESERVATIONS

The present study does replicate Snowling's finding of a deficit in dyslexic readers on a visual-auditory comparison task, compared to normal readers of the same reading level. Furthermore, the present study indicates that dyslexic readers also differ from slow readers at the same skill level. It is reasonable to accept these data as demonstration that the phonetic skills of dyslexic readers are poorer than those of other readers with comparable word recognition skill. However, there are several reasons to be hesitant to accept this study as evidence of selective impairment of the 'grapheme-phoneme route to reading' in these children.

4.8.1 Ipsi-modal Controls

Ipsi-modal tasks were provided which were intended to be the counterparts of the cross-modal tasks used in the study. However, it became apparent during data collection that the ipsi-modal tasks were not adequate tests of the auditory and visual components of the cross-modal tasks. To decide if the members of an ipsi-modal stimulus pair were the same or different did not require that the children remember accurately what the pair was. Sometimes a child would repeat an auditory pair incorrectly, or misread a visual one, and still make the correct same-different judgement for

the trial. The author suspects that it was necessary to remember both stimuli correctly, and to translate one of them, to make the cross-modal comparison. This fact, combined with the presence of a ceiling effect in the A-A condition, leaves open the possibility that there were group differences in auditory or visual skills required for the cross-modal tasks, though there were no differences in performance of these particular A-A and V-V tasks. Thus, the impairment of the dyslexic group may not be 'selective'.

4.8.2 What IS a 'Grapheme-Phoneme Route'?

Secondly, the phrase 'grapheme-phoneme route' is ambiguous. It is not clear whether the phrase refers to a physiological route or a strategic sequence. If one interprets the phrase in its physiological connotation, one set of cautions applies.

The idea of a 'grapheme-phoneme route' as opposed to a 'grapheme-semantic route' to reading may be a helpful analogy in understanding deficits of adults with acquired dyslexia. Dyslexic adults may indeed have had well-established functional patterns which were disrupted by structural damage of some kind. But the hazards of equating acquired adult disorders with developmental ones are well known; some have been stated above. The children in this study have not lost the ability to read, they have been

unable to acquire it in the usual way, and the reservoir of old associations which recovering adults may be able to draw upon in their post-injury reading has never been gathered in these children. Furthermore, these children have not been diagnosed as brain-damaged; if they are neurologically abnormal the abnormality is probably subtle and probably not localizable. It is not appropriate to infer a focal neurological source of deficient phonetic skills from this study.

If one interprets 'grapheme-phoneme route to reading' as meaning a strategic or functional sequence, several other cautions apply. There are at least three strategies which could be used to compare the cross-modal presentations in this study. Subjects might translate all visual stimuli to their auditory counterparts ('read' them), whether the visual stimulus came first or second, and make all comparisons on the basis of the read phonemes. They might use a similar strategy changing all auditory stimuli to visual ones, i.e., spell them, and make comparisons by spelling. Alternatively, the children might use the item presented first as the basis of comparison and translate the second stimulus as necessary. In this study there is no basis for guessing which strategy was used by whom.

The ambiguities of English spelling and pronunciation present another factor which is likely to be overlooked in a

neuropsychological approach to reading problems. Both auditory and visual nonsense words present ambiguities: the auditory stimuli can be spelled more than one way and the visual ones may be pronounced more than one way. This means that whatever strategy children use to make the comparison between nonsense words, they may have to recall more than one possible spelling or pronunciation for one of the stimuli. If the first response for that pair is to say that the two items are different, the child may also realize that there are some alternate spellings of the nonsense word that was heard, or alternate pronunciations of the word that was seen. The child could then return in memory to the initial stimulus and try some of the other possibilities, to see if the pair which looked different might really be the same.

Another strategy would be to begin the task by imagining several possible spellings for the first stimulus in the A-V condition, and to compare them to the visually presented second stimulus. For the V-A condition, the equivalent strategy would be to imagine several pronunciations of the written word, to be compared with the auditory second stimulus.

4.8.3 Other Factors: Memory, General Cognitive Deficit, and Experience.

If memory is considered an attribute, then these groups may have differed in auditory or visual memory. Hicks' (1980) study suggests that it may be more productive to think of memory as a skill. Depending on the strategies the children used to deal with the ambiguities of English, different memory demands would have been made during the process. Conversely, different levels of skill with different types of memory tasks may have led to the choice of different strategies.

If dyslexia is one symptom of a subtle but pervasive cognitive deficit, the problem of learning to cope with ambiguities of spelling and pronunciation at all may be strongly related to that deficit. In this case, the dyslexic children's reliance on sight vocabulary could reflect a deficit in the learning of codes in general.

One more observation should be noted before making inferences about the source of the V-A deficit in the dyslexic group. During the visual-to-auditory comparison, some of the dyslexic children seemed to be interpreting the second stimulus in the V-A pair (the spoken syllable) as a correction to the one they had just read. This may have been a result of long years of having their oral reading corrected, and it may have reflected their general uncertainty with the phonetic code.

4.9 CONCLUSION

We may conclude from the present study that dyslexic children were more impaired on a phonics task than other readers of the same skill level. The information gathered in this study does not provide a basis for defining the source of the deficit. Though neither the general cross-modal integration deficit hypothesis nor the perceptual deficit hypothesis was supported by the data, experience gained in the present study can provide some suggestions for subsequent investigation of what might constitute the deficit in phonetic skills seen in dyslexic readers.

4.10 FUTURE RESEARCH

The first task of the next study is to replicate the finding of a deficit in phonetic skills relative to overall reading level in dyslexic children. One way to test that relationship would be to match subjects by scores on a standardized phonics test, then measure the correlation of the WRAT reading subtest with those scores. A regression equation could be used again to define reading groups in terms of differences between predicted and observed WRAT scores. Correlations between WRAT and phonics test scores could then be compared between reading groups defined in this manner.

It is apparent from the current study that the cross-modal comparison paradigm is not particularly useful for exploring phonetic skills in detail. Several important parts of the grapheme-phoneme conversion process are left hidden in this study. The experimental procedure used in the present study could be expanded, and performance at each step could be recorded in detail by the experimenter.

To begin with auditory stimuli: a same-different comparison task does seem appropriate for exploring auditory discrimination. A wider range of stimulus difficulty should be used, including multi-syllable nonsense words and possibly, added white noise.

Verbal repetition of auditory stimuli could be measured as well. Nonsense words of varying lengths should provide a sufficient range of difficulty. It might also be useful to include a standardized sentence repetition test to examine repetition of meaningful verbal material.

A possible strategy for the A-V task in the study reported here was to think of spellings for an auditory stimulus, to be compared to the visual stimulus presented second. One measure of knowledge of the phonetic code would be to produce as many legal spellings as possible for an auditory nonsense word. Subjects could spell their answers aloud for the experimenter to record.

The A-V task of the present study could be used. While this task raised more questions than it answered, it would aid understanding of both studies to see if the subjects in a future study replicated the pattern of results seen in the four tasks of the present study.

A similar progression could be followed for visual stimuli. A same-different comparison of visually presented nonsense words could be given. Memory and repetition for visual stimuli could be tested by having the children remember and spell aloud the letters of one visual stimulus at a time. The children could then be asked to read the nonsense words, giving as many pronunciations as possible for each word. Responses would be recorded without correction. Finally, the V-A task of the original study could be given.

Subjects' responses to these tasks could be recorded in detail. Analysis of the types of errors made by each reading group could then provide a basis for evaluating theories of subtypes of dyslexia such as that put forth by Eoder (1973).

It would also be useful to choose several psychological measures which other theorists use as the basis for their subtype classifications (Mattis, 1978; Petruskas & Rourke, 1979). It would then be possible to see if the subtypes proposed by these authors were present in the data. Perhaps more importantly, it would be possible to compare

the reading performance of the different dyslexic subtypes and describe specific aspects of their performance in detail.

REFERENCE NOTE

McAllister, M. WISC Characteristics of Clinic-Referred Subgroups of Disabled Learners. Unpublished Master's Thesis, University of Victoria, 1981.

REFERENCE LIST

- Baker, H.J., & Leland, B. Detroit Tests of Learning Aptitude. Indianapolis, Indiana: Bobbs-Merrill, 1959.
- Beery, J. Matching of auditory and visual stimuli by average and retarded readers. Child Development, 38, 828-833, 1967.
- Birch, H.G., & Belmont, L. Auditory-visual integration in normal and retarded readers. American Journal of Orthopsychiatry, 34, 852-861, 1964.
- Birch, H.G., & Belmont, L. Auditory-visual integration, intelligence, and reading ability in school children. Perceptual and Motor Skills, 20, 295-305, 1965.
- Blank, M. Review of 'Toward an understanding of dyslexia: Psychological factors in specific reading disability'. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An Appraisal of Current Knowledge. New York: Oxford University Press, 1978.
- Blank, M., & Bridger, W.H. Deficiencies in verbal labelling in retarded readers. American Journal of Orthopsychiatry, 36, 840-847, 1966.
- Blank, M., Berenzweig, S.S., & Bridger, W.H. The effects of stimulus complexity and sensory modality on reaction time in normal and retarded readers. Child Development, 46, 133-140, 1975.
- Blank, M., Weider, S., & Bridger, W.H. Verbal deficiencies in abstract thinking in early reading retardation. American Journal of Orthopsychiatry, 38, 832-834, 1968.
- Boder, E. Developmental dyslexia: A diagnostic approach based on three atypical reading-spelling patterns. Developmental Medicine and Child Neurology, 15, 663-687, 1973.
- Brandt, J., & Rosen, J. J. Auditory phonemic perception in dyslexia: Categorical identification and discrimination of stop consonants. Brain and Language, 9, 324-337, 1980.

- Bryant, P. E. Cross-modal development and reading. In D.D. Duane & M.B. Rawson (Eds.), Reading, Perception and Language. Baltimore: York Press, 1975.
- Bryden, M.P. Auditory-visual and sequential-spatial matching in relation to reading ability. Child Development, 43, 824-832, 1972.
- Ceci, S.J., Lea, S.E.G., & Ringstrom, M.D. Coding processes in normal and learning disabled children: Evidence for modality-specific pathways to the cognitive system. Journal of Experimental Psychology: Human Learning and Memory, 6, 785-797, 1980.
- Coren, S., Porac, C., & Ward, L.M. Sensation and Perception. New York: Academic Press, 1979.
- Critchley, M. The Dyslexic Child. Springfield, Ill.: Charles C. Thomas, 1970.
- Doehring, D.G., Hoshko, I.M., & Bryans, B.N. Statistical classification of children with reading problems. Journal of Clinical Neuropsychology, 1, 5-16, 1979.
- Dunn, L.M. Peabody Picture Vocabulary Test. Circle Pines, Minnesota: American Guidance Service, Inc., 1959.
- Gaddes, W.H. Prevalence estimates and the need for definition of learning disabilities. In R.M. Knights & D.J. Bakker (Eds.), The Neuropsychology of Learning Disorders. Baltimore: University Park Press, 1976.
- Gibson, E. & Levin, H. The Psychology of Reading. Cambridge: MIT Press, 1975.
- Hicks, C. Matching of auditory and visual stimuli by average and retarded readers. Child Development, 38, 828-833, 1967.
- Hull, C.H., & Nie, N.H. (Eds.), SPSS Update 7-9: New Procedures and Facilities for Releases 7-9. New York: McGraw-Hill, 1981.
- Jastak, J.F., Bijou, S.W., & Jastak, S. Wide Range Achievement Test. Wilmington, Delaware: Jastak and Associates, 1978.
- Harris, R.J. A Primer of Multivariate Statistics. New York: Academic Press, 1975.

- Kahn, D., & Birch, H.G. Development of auditory-visual integration and reading achievement. Perceptual and Motor Skills, 27, 459-468, 1968.
- Kirk, S.A., McCarthy, J.J., & Kirk, W.D. Illinois Test of Psycholinguistic Abilities. Urbana, Illinois: University of Illinois Press, 1968.
- Lieberman, I.Y., Shankweiler, D., Orlando, C., Harris, K.S., & Bell Berti, F. Letter confusions and reversals of sequence in the beginning reader: Implications for Orton's theory of developmental dyslexia. Cortex, 7, 137-142, 1971.
- Maisto, A.A., & Sipe, S. An examination of encoding and retrieval processes in reading disabled children. Journal of Experimental Child Psychology, 30, 223-230, 1980.
- Mattis, S. Dyslexia syndromes: A working hypothesis that works. In A.L. Benton & D. Pearl (Eds.), Dyslexia: An Appraisal of Current Knowledge. New York: Oxford University Press, 1978.
- Mattis, S., French, J.H., & Rapin, I. Dyslexia in children and young adults: Three independent neuropsychological syndromes. Developmental Medicine and Child Neurology, 17, 150-163, 1975.
- Miller, G.A., & Nicely, P.E. An analysis of perceptual confusions among some English consonants. In S. Saporta & J.R. Eastian (Eds.), Psycholinguistics: A Book of Readings. New York: Holt, Reinhart and Winston, 1961.
- Myklebust, H.R. (Ed.). Progress in Learning Disabilities (Vol. 1). New York and London: Grune and Stratton, 1968.
- Neale, M.D. Neale Analysis of Reading Ability Manual. London: MacMillan, 1958.
- Patterson, K.E., & Marcel, A.J. Aphasia, dyslexia, and the phonological coding of written words. Quarterly Journal of Experimental Psychology, 29, 307-318, 1977.
- Pavlidis, George Th. Do eye movements hold the key to dyslexia? Neuropsychologia, 19, 57-64, 1981.
- Petrauskas, R.J., & Rourke, B.P. Identification of subtypes of retarded readers: A neuropsychological, multivariate approach. Journal of Clinical Neuropsychology, 1, 17-37, 1979.

- Repp, B.H., Healy, A.F., & Crowder, R.G. Categories and context in the perception of isolated steady-state vowels. Journal of Experimental Psychology: Human Perception and Performance, 5, 129-145, 1979.
- Rudnick, M., Sterritt, G.M., & Flax, M. Auditory and visual rhythm perception and reading ability. Child Development, 38A, 581-587, 1967.
- Saffran, F.M. & Marin, C.S.M. Feeding without phonology: Evidence from aphasia. Quarterly Journal of Experimental Psychology, 29, 515-525, 1977.
- Satz, P., & Mcorris, R. Learning disability subtypes: A review. In F. Pirrozolo & J. Wittrock (Eds.), Neuropsychological and Cognitive Processes in Reading. New York: Academic Press, 1981.
- Shankweiler, D., & Liberman, I. Exploring the relations between reading and speech. In R.M. Knights & D.J. Bakker (Eds.), The Neuropsychology of Learning Disorders. Baltimore: University Park Press, 1976.
- Snowling, M.J. The development of grapheme-phoneme correspondence in normal and dyslexic readers. Journal of Experimental and Child Psychology, 29, 294-305, 1980.
- Sterritt, G.M., & Rudnick, M. Auditory and visual rhythm perception in relation to reading ability in fourth grade boys. Perceptual and Motor Skills, 22, 859-864, 1966.
- Strange, W., Edman, T.R., & Jenkins, J.J. Acoustic and phonological factors in vowel identification. Journal of Experimental Psychology: Human Perception and Performance, 5, 643-656, 1979.
- Tallal, P. Auditory temporal perception, phonics and reading disabilities in children. Brain and Language, 9, 182-198, 1980.
- Tallal, P. & Piercy, M. Developmental aphasia: Rate of auditory processing and selective impairment of consonant perception. Neuropsychologia, 12, 83-93, 1974.
- Tallal, P. & Piercy, M. Developmental aphasia: the perception of brief vowels and extended stop consonants. Neuropsychologia, 13, 69-74, 1975.
- Thorndike, R.L. The Concepts of Over- and Under-Achievement. New York: Bureau of Publications, Teacher's College, Columbia University, 1963.

- Vande Voort, I., & Senf, G.M. Audiovisual integration in retarded readers. Journal of Learning Disabilities, 6, 170-179, 1973.
- Vande Voort, L., Senf, G.M., & Bentcn, A.I. Development of audiovisual integration in normal and retarded readers. Child Development, 43B, 1260-1272, 1972.
- Vellutino, F.R., Smith, H., Steger, J.A., & Kaman, M. Reading disability: Age differences and the perceptual deficit hypothesis. Child Development, 46, 487-493, 1975b.
- Vellutino, F.R., Steger, J.A., De Setto, L., & Philips, F. Immediate and delayed recognition of visual stimuli in poor and normal readers. Journal of Experimental Child Psychology, 19, 223-232, 1975c.
- Wechsler, D. Wechsler Intelligence Scale for Children. New York: The Psychological Corporation, 1949.
- Wechsler, D. Wechsler Intelligence Scale for Children - Revised. New York: The Psychological Corporation, 1974.
- Yule, W. Predicting reading ages on Neale's Analysis of Reading Ability. British Journal of Educational Psychology, 37, 252-255, 1967.
- Yule, W., Rutter, M., & Thompson, J. Over- and under-achievement in reading: Distribution in the general population. British Journal of Educational Psychology, 44, 1-12, 1974.
- Yule, W., & Rutter, M. Epidemiology and social implications of specific reading retardation. In R.M.Knights & D.J. Bakker (Eds.), The Neuropsychology of Learning Disorders. Baltimore: University Park Press, 1976.

Appendix A

**VICTORIA NORMS: RAW SCORES. FROM MCALLISTER,
1981.**

	Grade 1		Grade 3		Grade 5	
	n=75		n=74		n=75	
	mean	s.d.	mean	s.d.	mean	s.d.
Age	6.7	(.3)	8.7	(.3)	10.8	(.3)
Peabody Picture Vocabulary Test Form A, 1959	64.3	(8.3)	77.6	(9.5)	88.2	(9.9)
Block Design Subtest WISC-R, 1974	15.9	(8.2)	26.7	(9.8)	34.6	(10.9)
Wide Range Achievement Test (Reading), 1978	39.8	(10.2)	68.1	(7.2)	77.5	(6.1)

Appendix B

WORD PAIR MASTER LIST

- | | | |
|----------------|---------------|-----------------|
| 1. bok - vck | 15. fap - fep | 29. nud - nuḡ |
| 2. pif - kif | 16. sef - sif | 30. lem - len |
| 3. thip - fip | 17. ḡap - dup | 31. noḡ - nuḡ |
| 4. sab - thab | 18. lod - lud | 32. kol - kal |
| 5. gup - dup | 19. mof - ncf | 33. kel - kol |
| 6. bip - vip | 20. dup - bup | 34. poḡ - paḡ |
| 7. fak - fap | 21. bab - pab | 35. kug - kaḡ |
| 8. suth - suf | 22. hib - nib | 36. fot - fut |
| 9. vith - viss | 23. tup - fup | 37. gelt - glet |
| 10. ved - veg | 24. biv - div | 38. trob - torb |
| 11. hib - hiv | 25. kcm - kcn | 39. ḡars - ḡras |
| 12. nid - nig | 26. gub - guḡ | 40. slet - selt |
| 13. bik - bek | 27. teb - tep | 41. sond - snod |
| 14. kof - kuf | 28. ket - kef | 42. senk - snek |

Appendix C

STIMULUS LIST FOR AUDITORY-AUDITORY CONDITION

- | | |
|-----------------|-----------------|
| 1. bik - bik | 22. hib - hit |
| 2. bol - kcl | 23. suth - suth |
| 3. thip - fiḡ | 24. ḡap - ḡap |
| 4. fot - fot | 25. sef - sif |
| 5. slet - selt | 26. kug - kag |
| 6. nud - nup | 27. ḡars - ḡras |
| 7. tup - fup | 28. lem - len |
| 8. kel - kel | 29. sab - sab |
| 9. pif - kif | 30. vith - vith |
| 10. hib - nib | 31. nid - nid |
| 11. fak - fap | 32. loḡ - luḡ |
| 12. gub - guḡ | 33. ket - kef |
| 13. teb - teb | 34. poḡ - paḡ |
| 14. bok - bok | 35. nop - nup |
| 15. trob - trob | 36. kom - kom |
| 16. senk - snek | 37. guḡ - guḡ |
| 17. kof - kof | 38. gelt - gelt |
| 18. dup - dup | 39. fap - feḡ |
| 19. bab - paḡ | 40. piv - piv |
| 20. sonḡ - snḡ | 41. bip - vip |
| 21. mof - mof | 42. ved - veg |

Appendix D

STIMULUS LIST FOR VISUAL-VISUAL CONDITION

- | | |
|-----------------|-----------------|
| 1. sab - thak | 22. lod - lod |
| 2. nud - nud | 23. hiv - div |
| 3. mof - ncf | 24. hib - hit |
| 4. vith - viss | 25. sond - sond |
| 5. ket - ket | 26. bik - bek |
| 6. thip - thip | 27. tup - tup |
| 7. nop - nop | 28. fak - fak |
| 8. kug - kug | 29. pcb - pct |
| 9. gelt - glet | 30. gub - gud |
| 10. sef - sef | 31. dup - tup |
| 11. bok - vck | 32. pif - kif |
| 12. dap - dup | 33. lem - lem |
| 13. senk - senk | 34. kel - kol |
| 14. ved - ved | 35. bab - bap |
| 15. teb - tep | 36. dars - dars |
| 16. suth - suf | 37. hol - hal |
| 17. trob - torb | 38. kom - kom |
| 18. bip - bip | 39. gup - dup |
| 19. fot - fut | 40. nid - nig |
| 20. hib - hiv | 41. kof - kuf |
| 21. fap - fap | 42. slet - slet |

Appendix E

STIMULUS LIST FOR AUDITORY-VISUAL CONDITION

- | | |
|-----------------|-----------------|
| 1. fep - fap | 22. pab - bab |
| 2. fap - fak | 23. bel - bel |
| 3. sned - send | 24. kag - kug |
| 4. vok - vck | 25. suf - suf |
| 5. div - div | 26. nof - nof |
| 6. fip - thip | 27. tup - tud |
| 7. vip - bip | 28. nup - nop |
| 8. bek - bek | 29. lup - lup |
| 9. sif - sef | 30. tep - tep |
| 10. ved - veg | 31. gud - gud |
| 11. pat - pot | 32. torb - torb |
| 12. thab - thab | 33. kef - ket |
| 13. fut - fut | 34. nib - hib |
| 14. dras - dars | 35. lud - lod |
| 15. fup - tup | 36. kon - kon |
| 16. snek - senk | 37. selt - slet |
| 17. hiv - hiv | 38. dup - dup |
| 18. nig - nig | 39. kol - kol |
| 19. nup - nud | 40. gup - gup |
| 20. kif - pif | 41. glet - glet |
| 21. viss - viss | 42. kuf - kuf |

Appendix F

STIMULUS LIST FOR VISUAL-AUDITORY CONDITION

- | | |
|-----------------|-----------------|
| 1. kef - kef | 22. tep - teb |
| 2. bek - bik | 23. kon - kom |
| 3. thab - sab | 24. pab - pab |
| 4. kol - kel | 25. bal - bel |
| 5. fip - thip | 26. viss - with |
| 6. lud - lud | 27. fut - fct |
| 7. nup - nup | 28. div - biv |
| 8. mof - mof | 29. sif - sif |
| 9. dap - dap | 30. kif - kif |
| 10. snod - snod | 31. vip - vip |
| 11. dup - dup | 32. hiv - hib |
| 12. tup - tup | 33. suf - suth |
| 13. kag - kug | 34. torb - trob |
| 14. vok - bok | 35. glet - gelt |
| 15. snek - snek | 36. len - len |
| 16. veg - veg | 37. dup - gup |
| 17. fep - fep | 38. nit - nit |
| 18. gud - gub | 39. nig - nid |
| 19. hib - hib | 40. kal - bul |
| 20. fap - fap | 41. kuf - kef |
| 21. selt - selt | 42. dras - dras |

Appendix G

PERCENT CORRECT: GROUP BY EXPERIMENTAL CONDITION

Group	Condition			
	Mean			
	(s.d.)			
	A-A	V-V	A-V	V-A
Normal	92.5	87.1	77.9	81.3
n=30	(6.2)	(7.4)	(7.9)	(7.0)
Slow	91.7	88.1	75.3	78.7
n=30	(4.7)	(8.6)	(11.2)	(8.7)
Dyslexic	90.6	85.2	72.8	73.8
n=30	(7.6)	(6.6)	(6.4)	(10.6)

Appendix B

PEARSON CORRELATIONS BETWEEN EXPERIMENTAL
CONDITIONS

Normal Group (n = 30)

	A-A	V-V	A-V	V-A
A-A	1.000	0.063 p=0.370	0.441 p=0.007	-0.063 p=0.370
V-V		1.000	-0.089 p=0.320	0.520 p=0.002
A-V			1.000	0.434 p=0.008
sk				

Slow Group (n = 30)

	A-A	V-V	A-V	V-A
A-A	1.000	-0.243 p=0.449	0.006 p=0.488	0.271 p=0.074
V-V		1.000	0.424 p=0.010	0.447 p=0.007
A-V			1.000	0.612 p=0.000

Pearson Correlations, Cont.

Dyslexic Group (n = 30)

	A-A	V-V	A-V	V-A
A-A	1.000	0.144	-0.037	0.105
		p=0.225	p=0.423	p=0.290
V-V		1.000	0.415	0.235
			p=0.011	p=0.105
A-V			1.000	0.672
				p=0.000

All Groups (N = 90)

	A-A	V-V	A-V	V-A
A-A	1.000	0.076	0.147	0.134
		p=0.237	p=0.083	p=0.105
V-V		1.000	0.282	0.396
			p=0.004	p=0.000
A-V			1.000	0.586
				p=0.000

VITA

Name: Barbara Janice Burnside

Place of Birth: Sydney, N.S.W., Australia

Educational Institutions Attended:

Cabrillo College, Aptos, California	1964 to 1966
Boston University, Boston, Mass.	1967 to 1968
University of Victoria, B.C.	1976 to 1982

Degrees Awarded:

A.A.	1966	Cabrillo College, Aptos, Calif.
B.A. (Honours)	1980	University of Victoria, B.C.

Honours and Awards:

University of Victoria Fellowship, 1980-81

NSERC Postgraduate Scholarships, 1981-82 and 1982-83

PARTIAL COPYRIGHT LICENSE

I hereby grant the right to lend my thesis or dissertation (the title of which is shown below) to users of the University of Victoria Library, and to make single copies only for such users or in response to a request from the library of any other university, or similar institution, on its behalf or for one of its users. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by me or a member of the university designated by me. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Title of Thesis:

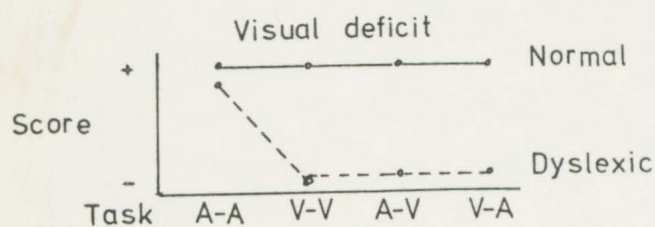
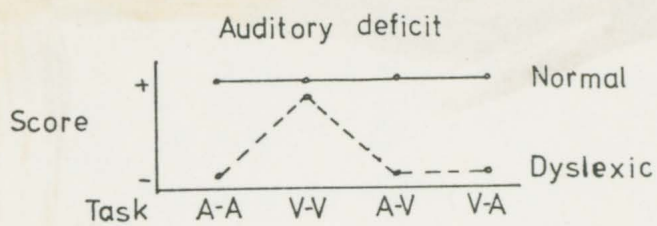
Phonetic Skills in Normal,
Slow, and Dyslexic Readers

Author_

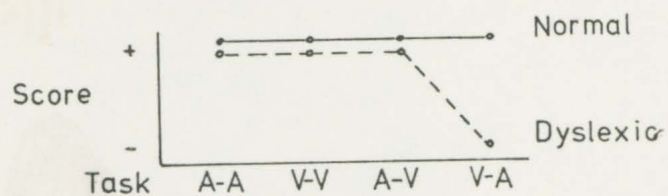
Barbara Janice Burnside

May 11, 1982

HYPOTHESIS 2: PERCEPTUAL DEFICIT



HYPOTHESIS 3: SPECIFIC V-A DEFICIT



HYPOTHESIS 4: CROSS-MODAL TASKS and GENERAL IMPAIRMENT

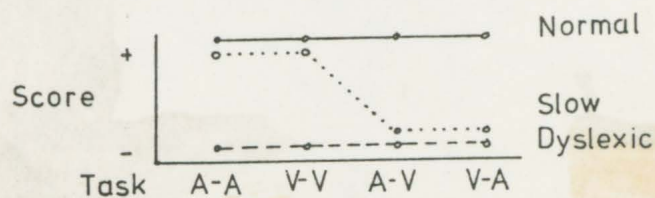


Figure 1: Graphic Representation of Hypotheses 2, 3, and 4

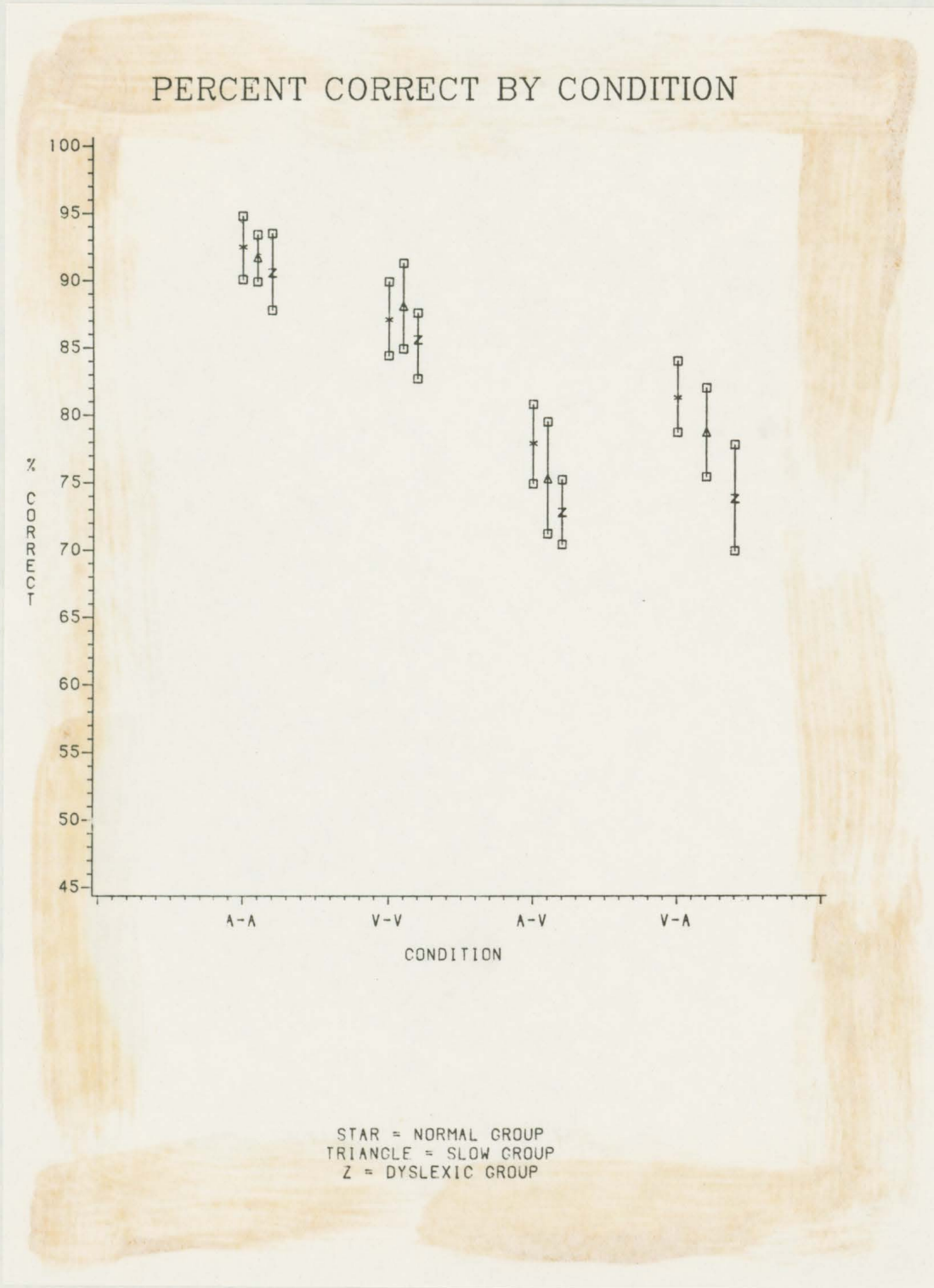


Figure 2: Percent Correct: Group by Experimental Condition

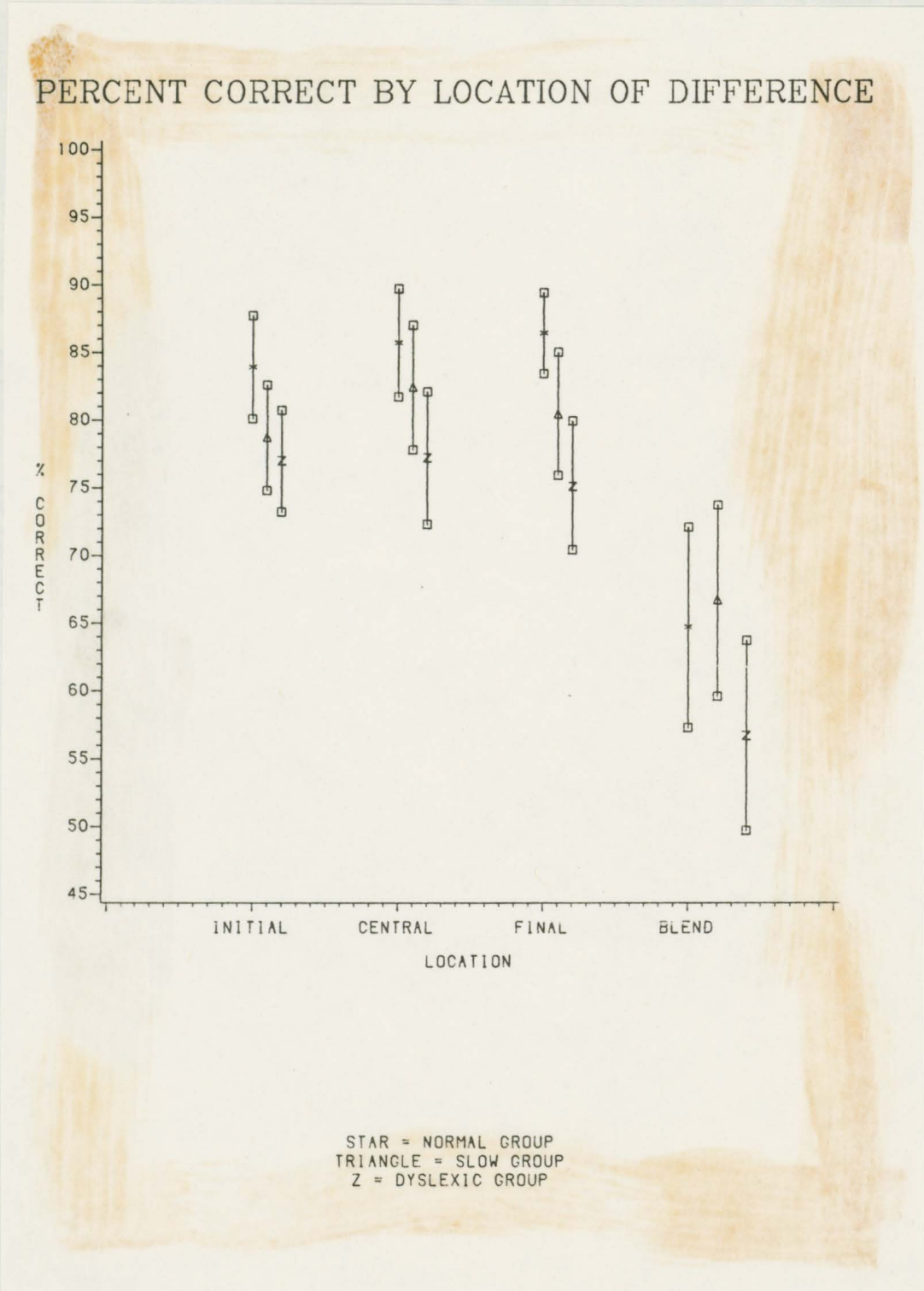


Figure 3: Post Hoc Analysis: Location of Difference