INVESTIGATION INTO THE NATURE OF b-d CONFUSION
AMONG SELECTED SAMPLES OF ELEMENTARY CHILDREN

DISSERTATION

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By

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Merwin, Marjorie Ann, *Investigation into the Nature of b-d Confusion Among Selected Samples of Elementary Children.* Doctor of Philosophy (Elementary Education), May, 1976, 337 pp., 46 tables, 41 illustrations, bibliography, 96 titles.

The problem explored by this study is the nature of b-d confusion as it is exhibited by remedial and nonremedial readers at various elementary ages in the areas of letter identification, spelling, and reading.

The purposes of Phase I of the study were to examine the progressive phase-out of b-d errors committed by samples of remedial and nonremedial readers and to explore certain factors that could be related to the problem. The object of Phase II was to describe subjects with extreme b-d reversal problems.

Ten schools in a large metropolitan school district were randomly selected from schools with learning centers staffed by diagnostic reading specialists. Nonremedial subjects were randomly selected from seven-, eight-, nine-, and ten-year-old categories (those identified as dyslexic or retarded excepted), and those receiving parent permission were included in the study. The remedial sample basically consisted of all subjects assigned to learning centers because of reading disability for whom parental permission for testing was granted.
Most of the tests used in this study were specifically developed for this purpose. Subjects were individually tested to assess reversal tendency in letter naming, word reading, and writing-spelling. Tests gauged sense of direction and ability to express differences between \( b \) and \( d \). Able subjects were also tested in sentence reading and with spelling and reading nonsense words.

Data were presented to describe the developmental phase-out of \( b-d \) reversals from ages seven to ten. Remedial subjects committed significantly more \( b-d \) reversals than nonremedials. Age was a significant negative correlate of \( b-d \) reversals of nonremedials, but not of remedials. Knowledge of right and left (with age held constant) was not generally found to relate significantly to \( b-d \) reversals. In word reading, the number of \( b-d \) reversals was found to exceed kinetic reversals significantly. Seven-to ten-year olds were not found to articulate differences between \( b \) and \( d \) reliably. Words which have meaningful counterparts when \( b-d \) reversals are made produce significantly more reversals than those with nonsense counterparts in reading, but not in spelling. Nonsense words produce significantly more \( b-d \) reversals than real words in nonremedials, but not remedials. In sentence reading, meaningfulness significantly influenced the number of \( b-d \) reversals. In word reading, \( b-d \) reversals significantly correlated with those in writing-spelling. Initial and
terminal positions significantly influenced b to d or d to b error shifts in both word reading and spelling. Significantly more b-d reversals were made at ends rather than beginnings of words in reading and in spelling.

Extreme b-d reversers were found to have been average or below on first-grade-readiness scores and significantly below grade-level placement in reading achievement. School marks were also generally low. As a whole, the extremes were predominantly right-handed and no sex bias was detected. When the extremes were compared to subjects above average in b-d responses, the extremes made significantly more errors on other letters, were able to read significantly fewer words, and required significantly more assistance in spelling. These groups significantly differed on position of b-d reversals in reading, but not in spelling, nor on the proportion of real words actually produced when reversals were made in reading. Reversal of b and d was not associated in the same population as b-p reversals.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>LIST OF TABLES.</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF ILLUSTRATIONS</td>
<td>ix</td>
</tr>
</tbody>
</table>

**Chapter**

I. **INTRODUCTION**                      1

- Statement of the Problem
- Purpose of the Study: Phase I
- Purpose of the Study: Phase II
- Research Questions and Hypotheses for Phase I
- Descriptive Study: Phase II
- Assumptions
- Limitations
- Definitions
- Background and Significance
- Procedure for Collecting Data
- Instruments
- Statistical Procedures

II. **A SURVEY OF RELATED LITERATURE**    30

- Problem of Interpreting the Literature
- Occurrence of Reversal Errors
- Factors Associated with Reversals
- Summary

III. **PROCEDURES FOR COLLECTING DATA**   89

- Selection of the Problem
- Selection and Development of Instruments
- Selection of Subjects
- Data Collection
- Treatment of Data
- Summary

IV. **PRESENTATION OF DATA.**            115

- Phase I
- Phase II
- Summary
V. SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER STUDY.  ...  217

Summary of the Study
Findings: Phase I
Findings: Phase II
Conclusions: Phase I
Conclusions: Phase II
Educational Implications
Suggestions for Further Research

APPENDIXES

A. The "b-d Discrimination Test". ............ 237
B. Rationale, Instructions, and Sample of "Test of Articulation of b-d Strategy". ............ 282
C. Rationale, Instructions, and Sample of "Kinetic Reversal Word Reading Test". ............ 285
D. Letter to Panel of Judges for Test Validity ........................................ 290
E. Study Answer Sheets. .................... 292
F. Parent Permission Letters. ................ 298
G. Letter to Panel for Proposal for Identifying Children with Severe Difficulty in Discrimination Between b and d. ................ 301
H. Proposal for Identifying Children with Severe Difficulty in Discrimination Between b and d. ................ 303
I. Percentage Distribution Charts for Each Test at Each of Four Tested Age Levels ........ 312

BIBLIOGRAPHY. ................................. 329
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Reliability of the &quot;b-d Discrimination Test&quot;</td>
<td>97</td>
</tr>
<tr>
<td>II. Other Reliability Scores</td>
<td>97</td>
</tr>
<tr>
<td>III. Socioeconomic Composition of the Ten Sampled Schools</td>
<td>102</td>
</tr>
<tr>
<td>IV. Ethnic Composition of Samples Schools</td>
<td>103</td>
</tr>
<tr>
<td>V. Ethnic Composition of Samples</td>
<td>104</td>
</tr>
<tr>
<td>VI. Age Profiles of Means and Standard Deviations of Errors Made by Nonremedial (Group A) and Remedial Readers (Group B) on a Battery of Tests</td>
<td>117</td>
</tr>
<tr>
<td>VII. Differences Between Nonremedial Readers (Group A) and Remedial Readers (Group B) in Reversal Errors Made in Varieties of Situations</td>
<td>135</td>
</tr>
<tr>
<td>VIII. Age Level Frequencies of Nonremedial and Remedial Subjects with Scores on the &quot;Sentence Reading Test&quot; and &quot;Nonsense Spelling Test&quot;</td>
<td>137</td>
</tr>
<tr>
<td>IX. Relationship of Age to Reversal Errors Made by Nonremedial Readers</td>
<td>139</td>
</tr>
<tr>
<td>X. Relationship of Age to Reversal Errors Made by Remedial Readers</td>
<td>141</td>
</tr>
<tr>
<td>XI. Degree to which Remedials and Nonremedials Differ on Correlation Between Age and Scores on Reversal Tests</td>
<td>142</td>
</tr>
<tr>
<td>XII. Correlation of Errors Made by Nonremedial Readers in Judging Right and Left with Reversal Errors when Age Is Held Constant</td>
<td>146</td>
</tr>
</tbody>
</table>
Table | Page
---|---
XIII. Correlation of Errors Made by Remedial Readers in Judging Right and Left with Reversal Errors when Age Is Held Constant. | 148
XIV. Comparison of the Incidence of b-d Reversals and Kinetic Reversals in Word List Presentation. | 150
XV. Comparison of Error Rate Made on Word Reading and Writing Tests by Subjects Able to Articulate the Differences Between b and d. | 153
XVI. Comparison of Groups with Different Ratings on Ability to Articulate the Differences Between b and d on Their Errors in Directional Judgment. | 155
XVII. Degree to which Words with Meaningful Counterparts Influence the Occurrence of b-d Reversals of Young Nonremedial Readers. | 158
XVIII. Degree to which Words with Meaningful Counterparts Influence the Occurrence of b-d Reversals of Young Remedial Readers. | 161
XIX. Comparison of Four Error Types Made by Contrasted Groups of Nonremedial and Remedial Readers. | 164
XX. Mean b-d Reversal Errors Made by Remedial and Nonremedial Subjects on the Four Word Types of the Sense-Nonsense Test | 165
XXI. F Ratios for the Multiple Comparisons of the Effects of Four Types of b-d Reversal Errors of Some Nonremedial and Remedial Subjects | 166
XXII. A Comparison of the Effects of Two Word Types on the b-d Reversal Errors of Nonremedial and Remedial Readers. | 168
XXIII. Comparison of b-d Reversal Errors Made by Nonremedial Subjects on Real Words and on Nonsense Words in Reading and Writing. | 170
XXIV. Comparison of b-d Reversal Errors Made by Remedial Subjects on Real Words and on Nonsense Words in Reading and Writing. | 172
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>XXV. The Effect of Sentence Context on Random b-d Reversal Errors of Remedial and Nonremedial Readers</td>
<td>174</td>
</tr>
<tr>
<td>XXVI. Relationship of Scores on the &quot;Word Reading Test&quot; and the &quot;Writing-Spelling Test&quot;</td>
<td>176</td>
</tr>
<tr>
<td>XXVII. Differences in Types of b-d Reversal Errors Made in Initial and Final Positions in Reading and Spelling</td>
<td>178</td>
</tr>
<tr>
<td>XXVIII. Differences in b-d Reversal Errors Made in Initial and Final Positions of Words in Reading and Spelling</td>
<td>181</td>
</tr>
<tr>
<td>XXIX. Number of Individuals with b-d Reversal Problems in Age Level Samples</td>
<td>187</td>
</tr>
<tr>
<td>XXX. A Comparison of the Number of Extreme Reversers in Nonremedial and Remedial Samples</td>
<td>189</td>
</tr>
<tr>
<td>XXXI. Comparison of Language and Nonlanguage Mental Factors of Subjects with b-d Reversal Problems</td>
<td>190</td>
</tr>
<tr>
<td>XXXII. First Grade Metropolitan Readiness Test Scores of Subjects with b-d Reversal Problems</td>
<td>191</td>
</tr>
<tr>
<td>XXXIII. Comparison of Reading Achievement and Grade Level Assignment of Twelve Subjects with b-d Reversal Problems</td>
<td>192</td>
</tr>
<tr>
<td>XXXIV. Analysis of Sexual Composition of Several Defined Groups</td>
<td>196</td>
</tr>
<tr>
<td>XXXV. Comparison of the Sexual Composition of All Subjects with That of the Group with b-d Reversal Problems</td>
<td>197</td>
</tr>
<tr>
<td>XXXVI. Comparison of Letter Naming Errors of b-d Reversers and an Above Average Group</td>
<td>199</td>
</tr>
<tr>
<td>XXXVII. Comparison of b-d Reversers and an Above Average Group In Average Number of Unread Words</td>
<td>201</td>
</tr>
<tr>
<td>Table</td>
<td>Page</td>
</tr>
<tr>
<td>-------</td>
<td>------</td>
</tr>
<tr>
<td>XXXVIII. Comparison of Number of Dictations Required on the &quot;Writing-Spelling Test&quot; by Two Groups</td>
<td>202</td>
</tr>
<tr>
<td>XXXIX. Relationship of b-d with b-p Errors in Two Samples</td>
<td>203</td>
</tr>
<tr>
<td>XL. Comparison of Two Groups in the Production of Meaningful and Nonsense Words when b and d Are Reversed in Word Reading</td>
<td>204</td>
</tr>
<tr>
<td>XLI. Comparison of Two Groups in the Production of Meaningful and Nonsense Words when b and d Are Reversed in Writing-Spelling</td>
<td>205</td>
</tr>
<tr>
<td>XLII. Comparison of Two Groups on the Location of b-d Reversals Within Words Being Read</td>
<td>206</td>
</tr>
<tr>
<td>XLIII. Comparison of Two Groups on the Location of b-d Reversals Within Words Being Spelled</td>
<td>207</td>
</tr>
<tr>
<td>XLIV. A Comparison of Two Groups as to the Types of b-d Reversals Made in Word Reading</td>
<td>209</td>
</tr>
<tr>
<td>XLV. A Comparison of Two Groups as to the Types of b-d Reversals Made in Writing-Spelling</td>
<td>209</td>
</tr>
<tr>
<td>XLVI. Statistical Procedures of Phase I</td>
<td>220</td>
</tr>
</tbody>
</table>
LIST OF ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. &quot;Letter Naming Test&quot;: a Profile of Medians if b-d Reversal Errors for Four Age Groups</td>
<td>120</td>
</tr>
<tr>
<td>2. &quot;Word Reading Test&quot;: a Profile of Medians of b-d Reversal Errors for Four Age Groups</td>
<td>122</td>
</tr>
<tr>
<td>3. &quot;Writing-Spelling Test&quot;: a Profile of Medians of b-d Reversal Errors for Four Age Groups</td>
<td>123</td>
</tr>
<tr>
<td>4. &quot;Kinetic Reversal Word Reading Test&quot;: a Profile of Medians of Reversal Errors for Four Age Groups</td>
<td>125</td>
</tr>
<tr>
<td>5. Percent of Subjects Making No Reversal Errors of the &quot;Letter Naming Test&quot;</td>
<td>126</td>
</tr>
<tr>
<td>6. Percent of Subjects Making No Reversal Errors on the &quot;Word Reading Test&quot;</td>
<td>127</td>
</tr>
<tr>
<td>7. Percent of Subjects Making No Reversal Errors on the &quot;Writing-Spelling Test&quot;</td>
<td>127</td>
</tr>
<tr>
<td>8. Percent of Subjects Making No Reversal Errors on the &quot;Kinetic Reversal Word Reading Test&quot;</td>
<td>128</td>
</tr>
<tr>
<td>9. Frequency Distribution of Yearly Grades Received by Students with b-d Reversal Problems</td>
<td>194</td>
</tr>
<tr>
<td>10. &quot;Letter Naming Test&quot; Seven-Year-Old Sample</td>
<td>313</td>
</tr>
<tr>
<td>11. &quot;Letter Naming Test&quot; Eight-Year-Old Sample</td>
<td>313</td>
</tr>
<tr>
<td>12. &quot;Letter Naming Test&quot; Nine-Year-Old Sample</td>
<td>314</td>
</tr>
<tr>
<td>13. &quot;Letter Naming Test&quot; Ten-Year-Old Sample</td>
<td>314</td>
</tr>
<tr>
<td>14. &quot;Word Reading Test&quot; Seven-Year-Old Sample</td>
<td>315</td>
</tr>
<tr>
<td>15. &quot;Word Reading Test&quot; Eight-Year-Old Sample</td>
<td>315</td>
</tr>
<tr>
<td>16. &quot;Word Reading Test&quot; Nine-Year-Old Sample</td>
<td>316</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>17</td>
<td>&quot;Word Reading Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>18</td>
<td>&quot;Writing-Spelling Test&quot; Seven-Year-Old Sample</td>
</tr>
<tr>
<td>19</td>
<td>&quot;Writing-Spelling Test&quot; Eight-Year-Old Sample</td>
</tr>
<tr>
<td>20</td>
<td>&quot;Writing-Spelling Test&quot; Nine-Year-Old Sample</td>
</tr>
<tr>
<td>21</td>
<td>&quot;Writing-Spelling Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>22</td>
<td>&quot;Kinetic Reversal Word Reading Test&quot; Seven-Year-Old Sample</td>
</tr>
<tr>
<td>23</td>
<td>&quot;Kinetic Reversal Word Reading Test&quot; Eight-Year-Old Sample</td>
</tr>
<tr>
<td>24</td>
<td>&quot;Kinetic Reversal Word Reading Test&quot; Nine-Year-Old Sample</td>
</tr>
<tr>
<td>25</td>
<td>&quot;Kinetic Reversal Word Reading Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>26</td>
<td>&quot;Sentence Reading Test&quot; Seven-Year-Old Sample</td>
</tr>
<tr>
<td>27</td>
<td>&quot;Sentence Reading Test&quot; Eight-Year-Old Sample</td>
</tr>
<tr>
<td>28</td>
<td>&quot;Sentence Reading Test&quot; Nine-Year-Old Sample</td>
</tr>
<tr>
<td>29</td>
<td>&quot;Sentence Reading Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>30</td>
<td>&quot;Sense-Nonsense Test&quot; Seven-Year-Old Sample</td>
</tr>
<tr>
<td>31</td>
<td>&quot;Sense-Nonsense Test&quot; Eight-Year-Old Sample</td>
</tr>
<tr>
<td>32</td>
<td>&quot;Sense-Nonsense Test&quot; Nine-Year-Old Sample</td>
</tr>
<tr>
<td>33</td>
<td>&quot;Sense-Nonsense Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>34</td>
<td>&quot;Nonsense Spelling Test&quot; Seven-Year-Old Sample</td>
</tr>
<tr>
<td>35</td>
<td>&quot;Nonsense Spelling Test&quot; Eight-Year-Old Sample</td>
</tr>
<tr>
<td>36</td>
<td>&quot;Nonsense Spelling Test&quot; Nine-Year-Old Sample</td>
</tr>
<tr>
<td>37</td>
<td>&quot;Nonsense Spelling Test&quot; Ten-Year-Old Sample</td>
</tr>
<tr>
<td>38</td>
<td>A Standardized Road-Map Test of Direction Sense Seven-Year-Old Sample</td>
</tr>
<tr>
<td>Figure</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>39.</td>
<td>A Standardized Road-Map Test of Direction Sense Eight-Year-Old Sample</td>
</tr>
<tr>
<td>40.</td>
<td>A Standardized Road-Map Test of Direction Sense Nine-Year-Old Sample</td>
</tr>
<tr>
<td>41.</td>
<td>A Standardized Road-Map Test of Direction Sense Ten-Year-Old Sample</td>
</tr>
</tbody>
</table>
CHAPTER I

INTRODUCTION

In the last decade there has been an increased emphasis on reading instruction. A growing awareness of reading deficiencies among public school students has prompted a plethora of approaches, activities, strategies, and programs to ameliorate the situation. Assistance has come from national through local levels, from public and private sources, from groups acting in concert to individuals independently volunteering their services. The aim was to equip each child with essential reading skills and to secure for every young American the "right to read." Yet, in spite of the proliferation of activities, problems in the teaching of reading remain. Individuals exhibit persistent reading disabilities that appear resistant to the intensified effort which has been directed to their difficulty. Many questions concerning factors associated with reading disabilities are yet unanswered.

In considering how best to answer these questions, one must first probe the basic nature of the disabilities. Reading disabilities are individualized problems. Failure to learn to read is not a single syndrome, but it may ensue from a variety of causes. If this widely held premise is
correct, research into the nature of reading problems should not seek to investigate reading disability in general. Such a broad view cannot provide a clear picture of specific reading problems. A more productive approach would be to focus on specific problems associated with reading disability in an effort to gain a deeper understanding of particular aspects of the problem. At a later time, the individual pieces of research may be fitted into a more comprehensive picture of the general problem. This research focuses on one specific confusion that for many years has been linked to some cases of reading disability--that of reversals. In discussing the importance of reversal errors to reading disability, Bond and Tinker state, "Although reversals are not the most common kind of errors in word perception, they may be significant when they occur frequently and persistently" (6, p. 351). This project was conducted (1) to discover more about the developmental nature of the problem, (2) to provide information that would be helpful in evaluating or in generating adequate remedial techniques for some types of reversal errors, and (3) to investigate some factors that may be involved in letter perception and production.

Statement of the Problem

The problem explored by this study is the nature of  
\( b-d \) confusion as it is exhibited by remedial and nonremedial
readers at various elementary ages in the areas of letter identification, spelling, and reading.

Purpose of the Study: Phase I

The purpose of the first phase of this investigation was a cross sectional study of b-d reversal problems in two populations, a remedial group and a nonremedial group. Subjects were tested to determine the degree to which they reversed b and d, the extent to which they committed kinetic reversals, and the degree to which they distinguished left from right. The results of these tests were used to explore both the developmental nature of the reduction of b-d reversals and some basic aspects that relate to the errors. Hypotheses were formulated to answer four basic questions. First, how do remedial reading students differ from non-remedial reading students in reversal errors? Second, how do problems of b-d reversals relate to maturation, direction sense, kinetic reversals, and ability to articulate the differences between the two letters? Third, are b-d reversals or kinetic reversals more common? Fourth, what influence does context, words with meaningful counterparts, and locations of key letters influence pupil reaction to b and d.

Purpose of the Study: Phase II

Phase II of the investigation was a descriptive study of students whose reversal tendencies in dealing with b and d were severe enough to constitute an instructional problem.
First, an operational definition of the \( b-d \) reversal problem was made. Scores from three subtests of the "\( b-d \) Discrimination Test" were used as a basis of identifying the extreme cases. Second, subjects from the study who had problems with reversing \( b \) and \( d \) were described in terms of available data from the school records and performance on tests given in this study.

Research Questions and Hypotheses for Phase I

Phase I of the study was subdivided into two parts. For the developmental study of the remedial and nonremedial populations, five research questions were used. To examine particular factors related to the \( b-d \) reversal problem, fourteen hypotheses were tested.

Developmental Study

The following research questions were designed to investigate the way in which key letter reversals subsided as children matured:

1. What will be the average number of reversal errors made by samples of remedial and nonremedial readers at age groups of seven, eight, nine, and ten on the battery of tests administered in the study?

2. How will profiles of age group changes for \( b-d \) reversal patterns in word reading compare with kinetic word reading reversal patterns for the same groups?
3. a. Will the percentage of subjects who make no reversal errors tend to increase at each age level on the following tests?
   (1) "Letter Naming Test"
   (2) "Word Reading Test"
   (3) "Writing-Spelling Test"
   (4) "Kinetic Reversal Word Reading Test"

   b. At what age will fifty percent of the non-remedial sample make no reversal errors on each test?

4. What specific comparisons can be made between remedials and nonremedials from percentage distributions at each age level sample?

5. How will remedials and nonremedials compare on age group error means in judgment of right and left (as measured by a Standardized Road-Map Test of Direction Sense), and how will these patterns compare with those of reversal errors?

   **Related Factors**

   These hypotheses were used to explore the incidence and nature of b-d reversals:

   1. Subjects aged 8.0 through 10.11 in Groups B will have a significantly higher degree (p ≤ .05) of error responses than in Group A on the following tests:
      a. "Letter Naming Test"
      b. "Word Reading Test"
      c. "Sentence Reading Test"
d. "Writing-Spelling Test"

e. "Nonsense Spelling Test"

f. "Sense-Nonsense Test"

g. "Kinetic Reversal Word Reading Test"

2. a. In Group A, a correlation coefficient significantly different from zero (p ≤ .05) will result when age in months is correlated with scores on the following tests:

(1) "Letter Naming Test"
(2) "Word Reading Test"
(3) "Sentence Reading Test"
(4) "Writing-Spelling Test"
(5) "Kinetic Reversal Word Reading Test"

2. b. In Group B, a correlation coefficient significantly different from zero (p ≤ .05) will result when age in months is correlated with scores on the following tests:

(1) "Letter Naming Test"
(2) "Word Reading Test"
(3) "Sentence Reading Test"
(4) "Writing-Spelling Test"
(5) "Kinetic Reversal Word Reading Test"

3. In Group A, a correlation coefficient significantly different from zero (p ≤ .05) will result when, with age held constant, knowledge of left and right as measured by
the Standardized Road-Map Test of Direction Sense is correlated with scores on the following tests:

a. "Letter Naming Test"
b. "Word Reading Test"
c. "Sentence Reading Test"
d. "Writing-Spelling Test"
e. "Kinetic Reversal Word Reading Test"

4. In Group B, with age held constant, a correlation coefficient significantly different from zero (p ≤ .05) will result when knowledge of left and right as measured by the Standardized Road-Map Test of Direction Sense is correlated with scores on the following tests:

a. "Letter Naming Test"
b. "Word Reading Test"
c. "Sentence Reading Test"
d. "Writing-Spelling Test"
e. "Kinetic Reversal Word Reading Test"

5. When scores on the "Word Reading Test" are compared to those on the "Kinetic Reversal Word Reading Test," a significant difference (p ≤ .05) will result.

6. Those who are able to differentiate between b and d* on the "Test of Articulation of b-d Strategy" but who make errors on either or both the "Word Reading Test" and the "Writing-Spelling Test" will make a significantly smaller proportion of errors on the "Writing-Spelling Test."

*Those whose answers are rated as correct or uncertain correct.
7. Pupils who are grouped by rankings on the "Test of Articulation of b-d Strategy" will significantly differ \( (p = .05) \) on knowledge of left and right as measured by the \textbf{Standardized Road-Map Test of Direction Sense}.

8. a. In Group A, subjects under 9.0 years of age will make significantly more \( b-d \) reversal errors \( (p \leq .05) \) in words which form actual words when the error is made than in those words which have no meaningful counterpart on the following tests:

   (1) "Word Reading Test"

   (2) "Writing-Spelling Test"

8. b. In Group B, subjects under 9.0 years of age will make significantly more \( b-d \) reversal errors \( (p \leq .05) \) in words which form actual words when the error is made than in those words which have no meaningful counterpart on the following tests:

   (1) "Word Reading Test"

   (2) "Writing-Spelling Test"

9. A significant difference \( (p \leq .01) \) will be found on the number of \( b-d \) reversal errors committed on the four word types of the "Sense-Nonsense Test" by the following groups:

   a. Group A

   b. Group B

10. a. In Group A, those who complete all subtests of the "\( b-d \) Discrimination Test" and who make at least one error, will make a significantly higher proportion of
errors on the following comparisons:

(1) Real words to nonsense words on the "Sense-Nonsense Test"

(2) "Writing-Spelling Test" to "Nonsense Spelling Test"

10. b. In Group B, those who complete all subtests of the "b-d Discrimination Test" and who make at least one error, will make a significantly higher proportion of errors on the following comparisons:

(1) Real words to nonsense words on the "Sense-Nonsense Test"

(2) "Writing-Spelling Test" to "Nonsense Spelling Test"

11. On the "Sentence Reading Test" a significantly smaller proportion of b-d reversal errors (p ≤ .05) will be made in key words preceded by prior meaning determinants than in key words where no prior meaning clues are present for the following samples:

a. Group A

b. Group B

12. When scores of the "Word Reading Test" are compared with scores on the "Writing-Spelling Test," a significant relationship (p ≤ .05) will be found.

13. In comparing types of errors (b for d and d for b), initial errors will be found to differ significantly (p ≤ .05) from terminal errors on the following tests:
14. The proportion of b-d reversal errors made in the initial position of a word will significantly differ (p ≤ .05) from the proportion of errors made in final positions on the following tests:

a. "Word Reading Test"

b. "Writing-Spelling Test"

Descriptive Study: Phase II

Students who had a b-d reversal problem (as opposed to the normal developmental confusion of the two letters) were identified by their performance on the reversal tests. Those subjects who exhibited a b-d reversal problem (i.e., those found to be extreme cases) were described in terms of their scores on the various reversal tests and with available district data.

Assumptions

Because of the length of time required to test each subject and because one examiner did all of the testing, the examination of subjects extended over a four-month period. The cross-sectional categories were, therefore, based upon age in months at the time of testing. It was assumed that the added school experience of students tested in the latter part of the study did not seriously affect the validity of the study.
It was also assumed that the elementary-aged youngsters were sufficiently familiar with a tape recorder so that the use of this device exerted a negligible influence on the response pupils made to b and d.

Limitations

Generalizations from this study are restricted because the sample was drawn from one locality. Although the locality had a basically cosmopolitan make-up, there was also a disproportionately high incidence of Blacks and Mexican-Americans in the population. The ethnic proportions within the sample are reported in Chapter III.

A second limitation of the study is that a purely random selection of subjects within age groups of the sampled schools was abridged. As a condition of granting permission to conduct the study, the cooperating school district required that parental permission be obtained before subjects could be tested. This provision violated to some degree the assumptions of statistical procedure and to that extent biased the findings of the study.

Another restriction on the validity of the findings resulted from the nature of the testing. The test situation required a degree of prior knowledge of the alphabet. Therefore, at the lower end of the continuum, four immature individuals had to be eliminated from the study. The seven-year-olds who were excluded may exhibit more primitive types
of form errors and may later evidence the same types of reversal errors. The result at the seventh-year level will need to be viewed with caution and the competency reflected may be regarded as spuriously high.

Definitions

b-d reversal problem--commission of b-d reversals to such a degree as to significantly interfere with the reading and spelling processes. In this study individuals whose error total on the "Letter Naming Test," the "Word Reading Test," and the "Writing-Spelling Test" significantly differed from the mean of their age group were identified as having a b-d reversal problem.

diagnostic reading specialist--a teacher of reading who through state certification or clinical experience qualifies her for employment as a remedial reading clinician.

dyslexia--a term used interchangeably with specific reading disability. See specific reading disability.

frustration level--reading material with a difficulty factor so far beyond the range of the reading skills of a given individual that it is thought to be poor material for use in instructing the individual. For the purpose of this study, the level will be defined as material in which the subject makes more than five uncorrected errors per hundred words. Self-corrections, regressions, and errors on key words were excluded from this count.
general reversal problem--difficulties indicated by combining evidence of two or more types of reversals (i.e., static and kinetic reversals).

**Group A**--a sample of the elementary school population which has not been selected for remedial reading instruction. The sample was selected from yearly age groupings (7.0 - 10.11).

**Group B**--a sample from a population of remedial readers in a randomly selected group of learning centers staffed by diagnostic reading specialists. The sample was selected from yearly age groupings (7.0 - 10.11).

**High incidence words**--words which occur frequently in children's reading material and therefore are regarded as easy words. In this study, the term refers to the 769 words of Stone's revision of the Dale list of easy words (26).

**Irrelevant response**--substitution of any letter besides b for d or d for b.

**Key letters**--For the purposes of this paper, the letters b and d are designated key letters.

**Key words**--In this investigation, key words will be used to refer to test words used to measure accuracy in handling the key letters.

**Kinetic reversal**--a confusion of directional sequence in word reading; for example, confusion of felt for left (17, p. 500).
laterality--sidedness; preferential use of a hand, foot, or eye, with assumed dominance of a particular hemisphere of the cerebrum (adapted from 17, p. 300).

nonremedials--(See nonremedial readers.)

nonremedial readers--students who were not identified by the school district in which they reside as needing remedial reading instruction. It should be noted that some members of this population may exhibit those characteristics which could qualify them for remedial reading instruction, but for some reason have not been screened for inclusion in remedial classes.

random selection--a method of selecting subjects which affords every member of a population an equal opportunity for inclusion in the sample. For this study, the procedure always was performed through use of a table of random numbers.

remedials--(See remedial readers.)

remedial readers--students who were selected by the school district in which they reside for inclusion in remedial reading programs.

specific reading disability--failure to learn to read with normal proficiency despite conventional instruction and average or better intelligence (adapted from 17, p. 473).

static reversal--the confusion of letters of similar or identical form normally distinguished by their spatial orientation, for example, the confusion of the letters n with u or the letters p, g, b, and d (17, p. 500).
transposition reversal—the error of reading words in a sequence that does not match their printed order, for example, the reading of "the wood fence" as "the fence wood."

Background and Significance

Since the end of the nineteenth century, reversal errors have been associated with cases of reading disability (9, p. 39). It was not, however, until the nineteen twenties that a noted neurologist Orton (23, p. 288) popularized the relationship between the two and supplied a neurological theory to explain the phenomenon. Since mental functions involved in the reading process were characteristically developed in the dominant cerebral hemisphere, he theorized that traces of mirrored copies of the printed symbols were made in the nondominant side of the brain. When for some reason one hemisphere was not used exclusively for reading skills development, the orientational confusion was the consequence according to this theory. Orton coined the term strephosymbolia, meaning twisted symbol, to describe the condition (13, p. 39). This neurological theory which explains reading disability as a function of confused brain dominance that results in directional confusion still has its devotees (8, 22), but many subsequent researchers have called the theory into question (e.g., 2, p. 50; 8; 9, pp. 47-48; and 16, p. 540).
Nevertheless, several studies have linked reversal tendency with poor achievement in reading. Goins (16, p. 81) found that scores on her reversal test were associated with reading achievement to a higher degree than most of the perceptual measures which she administered. In fact, she discovered that this reversal score combined with two other perception scores could predict reading success of first graders more accurately than mental maturity scores. Teegarden (27, p. 356), who also studied first graders for their general reversal inclinations as well as their reading achievement and mental maturity, concluded that if other factors are equal, the children who make fewer reversal errors will make better progress in reading. Weber (28, p. 361) noted a relationship between poor progress in remedial reading and reversal difficulties. Reversals accounted for a high proportion of the errors made by those college freshmen who failed to improve with remedial instruction. Johnson (19) found that ninety-seven percent of a sample of remedial cases made some reversals in reading and writing. However, most investigators have not concluded that reversals are a cause of poor reading. Reversals are merely felt to be associated with a particular immature stage of reading (18, 19). Since studies have demonstrated that reversal errors were common among young children and that the tendency to make reversals diminished with age, the indication is that reversal errors cannot be viewed solely
as a pathological condition which leads to reading retardation (20). Three basic types of reversal errors in reading and writing have been identified (5). The reversal of a single letter is commonly called a static reversal. This type of error may include letter inversions, such as confusion of u with n and m with w, or it could involve confusing letters that are identical if rotated on a vertical axis as b and d or p and q. These right and left reversals are by far the most common of the static reversal errors (24). A second kind of reversal relates to confusing letter order and is known as a kinetic reversal. Examples of this type of error are the confusion of was and saw or no with on. A third type of reversal error results in the production of jumbled word orders. A student may read, "The boy can . . ." as "The can boy . . . ." This sort of error is designated as an error in transposition.

Although the three types of errors are classed as reversal errors, there is some evidence that they may not all be a part of the same basic difficulty (21, p. 840). They may represent different disabilities and hence their degree of incidence may not be similar within the same individual. In the past, static and kinetic reversals have often been lumped together for analysis. This practice may represent an instance of examining a confounded variable. It was an objective of the present research project to compare the incidence of the most persistent static reversals with the
occurrence of kinetic reversals to determine which of the two types of errors may be most troublesome to young readers.

In the interest of reducing the possibility of equating error types that may be fundamentally different in nature, only one type of static reversal was specifically tested. The fact that letter inversions tend to disappear at an earlier age than right to left reversals may indicate that not all static reversals are similar in nature (9, p. 464). Informal observations of children with reading disability also led to the conclusion that confusion of b and d may not always be related to the confusion of p with b. For these reasons and because b and d confusion causes the most difficulty in spelling and reading of the static reversal problems, this study focused primarily upon a thorough examination of this difficulty.

Although earlier researchers have indicated that reversal tendencies are overcome with maturation and experience (4), little had been done previously to demonstrate the developmental nature of the lessening of b-d reversal errors in various settings. It is not known if b-d reversals in the recognition of isolated letters, in word reading, in writing, and in sentence reading produce similar or different patterns of reduction. Disagreement among authorities as to whether contextual involvement increased or decreased the likelihood of letter reversals (cf. 23 and 18, p. 14)
can be offered as an argument for the need of a more thorough investigation into the matter. Therefore, this research was designed to test these aspects of the problem separately so that the developmental nature of each could be examined.

In the past, reversals in writing and reading have often been combined for analysis (18, 27), but these two aspects of reversal problems have not been statistically compared. There are many characteristics about these activities which differ. The speed, level of cognition, motor requirements, and influence of meaningfulness involved in the two activities could produce a disparity in the way children in general or individuals in particular may be able to overcome reversal errors in these situations. This study also provides normative data to describe the decline of b-d reversals from age seven through ten. The one developmental study which concentrated on the static reversal of b, d, p, and g involved only kindergarten and first-grade students and tested them with copy tests (8). It has since been demonstrated that control over reversals in copy tests is an easier task than tasks that involve reproduction from longer term memory (9). The present project, then, extends knowledge of the developmental nature of ability to discriminate between b and d in tasks that more nearly resemble those which children are asked to perform in classroom writing and reading activities. The need for the extension of a study into a problem beyond the lower grades is underlined by
inaccurate statements by noted authorities in the field of remedial reading. These incorrect assumptions foster unwarranted conclusions that in turn result in remedial techniques which may not be helpful in assisting children in overcoming letter reversals. The statement, "Children never reverse the d or b in cursive writing" (25, p. 101), belies the experience of remedial teachers who have observed the persistence of the problem in the cursive writing of some students into the adolescent years. The extension of knowledge concerning the reversal of b and d beyond the first two grades has long been needed.

Investigators have been able to demonstrate a significant negative relationship between reversal tendencies and ability to deal with position in space (7, 18). Knowledge of right and left, however, has not been established as a significant correlate of the problem. Chapman and Wedell (7) determined that an early developing skill on the sense of direction continuum, the ability to identify right and left on one's own body, was not significantly related to reversal errors. By contrast, Alexander and Money (1) had found that a group of dyslexic boys from age eleven to fourteen made significantly more errors on a test of direction sense than did normal subjects. The test used in the Alexander-Money research required a more sophisticated knowledge of left and right than those used in the Chapman-Wedell study (7). It was, therefore, decided to test the
younger children in the present study with the instrument developed by Money, Alexander, and Walker (22) to see if it measured a directional skill that would significantly correlate with competence in distinguishing between b and d. Since maturation was known to relate to skill in dealing with letter orientation, as well as the development of directional sense, it was decided to eliminate the effects of age before making a judgment concerning the possible relationship of direction sense on b and d discrimination.

In working with remedial students whose key letter reversals significantly effected spelling and reading accuracy, it appeared that when students were provided kinesthetic or mnemonic clues to assist them in distinguishing between b and d, they were able to correct the confusion more readily in spelling than in reading. For this reason, an investigation was conducted into the possible influence of the child's ability to correctly articulate the difference between b and d and his performance on spelling and reading tests which involved words containing those key letters.

Close but untabulated observations of remedial students had provided evidence that students were more likely to make b-d reversal errors at the beginnings of words than at the ends of words. This observation was in direct contrast to findings of researchers who investigated letter reversals in spelling. Chapman and Wedell (7) reported that children made fewer reversal errors in initial positions. The
The current study, therefore, explored the possible influence of positional location of \( b \) or \( d \) in short words.

Still another possibility was that production of meaningful words and sentences may also influence the ability to discriminate between \( b \) and \( d \). This is another aspect of key-letter reversal that was explored by this research.

In addition to the foregoing considerations, this study was conducted to provide a description of those individuals who make a large number of reversal errors. How do extreme reversers differ from those above average in \( b-d \) response in the number and situations of \( b-d \) reversal errors? In what ways do school records and test performances describe those students who have a severe problem with \( b-d \) discrimination? These are among questions which prior research had inadequately explored.

The basic significance of this study is that it provides an in-depth inquiry into the nature of a great many factors which may relate to a rather narrow educational problem. It is not supposed that the findings of this research would attract wide attention from those who concern themselves with more general education problems, but some useful information concerning the nature of the development of letter perception and some concepts important to the structuring of remedial strategies have been produced.
Procedure for Collecting Data

The study was conducted in ten elementary schools in a large metropolitan school district in Texas. The schools were selected at random from those schools which have learning centers staffed with diagnostic reading specialists. The nonremedial elementary sample was drawn from four yearly age groupings from seven through ten years. Students involved in remedial reading instruction in the schools' learning centers were eliminated from this sample. In each school, the first three in order of random choice in each age group whose parents gave permission and who demonstrated sufficient knowledge of the alphabet were tested. The overall sample consisted of one hundred twenty students, thirty in each of four age categories, three of these being supplied by each of ten school areas.

The remedial samples were selected from students assigned to the learning centers located in the same ten schools. All students within the same four age categories described above whose parents granted permission were tested. For those age divisions in which more than the necessary twenty students were tested, the sample was reduced by random-exclusion. This procedure was followed to preserve, as nearly as possible, the proportional relationship of the sample sizes of each age section of the nonremedial and remedial groups in the eight-, nine-, and ten-year-old categories.
The data were collected by one examiner over a four-month period. Subjects were examined individually in school areas that were as free from distraction as possible. A tape recorder was used for purposes of rechecking pupil responses.

Instruments

Most of the instruments used in this study were designed specifically for this research project. A copy of the "b-d Discrimination Test" together with the "Examiner's Manual" is located in Appendix A. The "Kinetic Reversal Word Reading Test" and the "Test of Articulation of b-d Strategy," along with their rationale and instructions, are contained in Appendixes B and C. The content validity of these tests was established by a panel of reading specialists. Reliability data were produced during the course of this study.

A Standardized Road-Map Test of Direction Sense (19) was used to test each subject's competence in dealing with concepts of right and left. The test was standardized on subjects from age seven through eighteen. The general consensus of reviewers in The Seventh Mental Measurements Yearbook (6, pp. 1291-1293) is that the test is an acceptable instrument for research. Since reliability data for the test were lacking, a split-half reliability was obtained for ages seven through ten as a part of this study.
Statistical Procedures

Phase I

The following statistical procedures were utilized to analyze the data. The two-way analysis of variance (12, pp. 241-243) was used to test Hypothesis Nine. Hypothesis Seven was tested with the one-way analysis of variance (12, pp. 208-221). The test of significance of a proportion in a population (15, pp. 321-324) was employed to test Hypotheses Eight, Ten, and Eleven. The \( t \) test for correlated samples (12, pp. 153-155) was used with Hypotheses Five and Six. The \( t \) test for independent samples was used to test Hypothesis One (12, pp. 151-153). Chi square test of independence (12, pp. 182-186) was used to test Hypotheses Thirteen and Fourteen. The statistical procedure used for Hypotheses Two and Twelve was the Pearson product-moment correlation coefficient (12, pp. 99-103). Hypotheses Three and Four were partial correlation studies (12, pp. 390-392). Follow-up testing which was done to assist in the proper interpretation of hypothesized findings included the use of chi square (12, pp. 173-192), the test of significant differences between two independent correlation coefficients from independent samples (12, pp. 170-171), the test for significant difference between two independent proportions (12, pp. 160-162), and the Scheffé test (12, pp. 270-271). The patterns which characterized the developmental trends in

25
responding accurately to b and d were displayed by a series of charts reflecting the changes that were found in the two samples (nonremedial and remedial) at successive age levels. The progressive lessening of errors in responding to b and d were shown by changing means and standard deviations, median differences, distributions of error frequencies, and percentages of individuals making no reversal errors on the various tests.

Phase II

After the b-d reversal problem was operationally defined, subjects who exhibited this problem were described in terms of their scores on tests used in this study and available data from the school district. Appropriate tables were devised for the presentation of these data. Statistical tests used in this portion of the study included the t test for correlated samples (12, pp. 153-155), the Cochran and Cox adjusted t test (12, pp. 155-157), chi square (12, pp. 173-192), and the test for significance of a proportion in a population (15, pp. 321-324).


CHAPTER II

A SURVEY OF RELATED LITERATURE

Reversal errors in reading and spelling have been the concern of researchers for more than three-quarters of a century. A great deal of information regarding the nature of this difficulty has already been amassed, yet some aspects of the problem remain unsolved. Of first concern in this discussion of previous research is the problem of interpreting the literature. Next, attention is focused on the degree to which reversal errors affect the reading of various populations of children and the relative difficulty of various types of reversal errors. The third area of discussion treats a composite of factors which are associated with reversals. Fourteen personal qualities which have been related to reversal errors are considered, as well as an array of extrapersonal factors which are involved. Fourth, attitudes and advice of authorities toward persistent reversal difficulties are presented.

Problems of Interpreting the Literature

In educational literature, the term reversal has been used ambiguously to designate several distinct types of errors. Some attempts have been made to classify these types of errors (9, p. 345; 35, p. 1). The primary purpose
of this analysis will be to examine the type of error called a static reversal, reversal of a single letter, and note its relationship to kinetic reversals, reversals of letter order in words. One of the difficulties in interpreting research on these phenomena is that many of the past studies have grouped these types of errors together as though they had a common etiology and were part of the same syndrome, yet Vernon (71, p. 51) indicated these error types are undoubtedly different in nature. In order to keep in mind that many of the conclusions of researchers regarding the nature of reversals are based on scores which combine several types of errors, the term general reversal will be used to refer to conclusions based on studies which combine more than one reversal type in data analysis.

A further possible source of confusion in interpreting the literature is failure to categorize the levels of reversal errors tested. Matching tests, for example, may test only the awareness of the fact and significance of spatial orientation in graphic material. Conversely, reading or correct naming of letters having a reversed counterpart probably involves both recognition of orientational differences and the association of an appropriate sound or label. Writing may involve association of letter to sound, recall of letter form with proper orientation and proper motoral responses to produce the symbol. When researchers indicate that reversal errors disappear at a given age, one
must be careful to observe what type of reversal and what level of testing is implied.

**Occurrence of Reversal Errors**

Previous research does give some insight into the importance of reversals among reading and writing errors. Information is also available to indicate which sorts of populations are most likely to make reversal errors, and data (though sometimes conflicting) have been gathered to determine the types of reversal errors which are most common.

**Reversals and Other Reading Errors in Various Populations**

Hildreth (35) in testing second-, third-, and fourth-grade students in schools with average to above average mean intelligence scores found that general reversals constituted less than one-tenth of one percent of errors made in reading and on written-copy tests. The reading material used was considered equivalent to that utilized in normal school-type oral reading. Nikas (56), however, found that in reading unrehearsed passages from preprimer through first-grade level general reversal errors were common among seven- and eight-year old subjects. He reported that they made no more than one such error in twenty words. This incidence would be enough to define an instructional reading level even if no other errors were made.
General reversal errors accounted for approximately twelve percent of the errors made by Bennett's remedial subjects (7). In her study, reversals ranked fourth among the most common types of reading errors made by retarded readers. Harris (32, p. 370) maintained that reversal errors were prominent among the word recognition errors of about ten percent of reading disability cases. In instances in which reversals comprise a significant portion of the reading errors, Harris declared they "... deserve careful analysis and treatment" (32, p. 370). His statement did not make clear, however, the degree of difficulty with reversals which should be considered significant at successive age or grade levels. Other researchers have found reversal errors to be a pervasive characteristic among retarded readers (11, 23, 40, 41, 64).

Occurrence of Reversal Types

From available data, it is difficult to determine whether static reversals or kinetic reversals occur more frequently. Woody and Philips (77) indicated that kinetic reversals accounted for fifty percent of the reversal errors made by first and second graders in their study, while static reversals comprised thirty-five percent of the total. Among third graders, however, the trend reversed and kinetic reversals made up thirty-eight percent of the reversal errors while static reversals increased to around forty-five
percent of the total. These errors were tabulated from student reactions to test items which do not appear to have provided either a balanced opportunity for each particular type of reversal or a situation that would simulate the opportunities as they might present themselves in grade-level reading. Therefore, it is not possible to draw any conclusions concerning the likelihood of occurrence of various types of reversal errors from this study. Bennett (7) found kinetic reversals to be more numerous and persistent than the confusion in discrimination between d, b, p, and g. She tested only remedial students on sentences containing a progressively difficult vocabulary of high frequency words. In this study, again it was not clear whether the occurrence or the reduction of types of reversal errors was a function of the degree to which the subjects overcame reversal tendencies or a result of the changing nature of the test stimuli as the students were tested on a progression of vocabulary. Contrary to the above findings, Kennedy (43) indicated that reversed orientation of letters was more common than kinetic or mirrored reversals. She observed that, as children progressed from kindergarten through grade two, static reversals were also overcome more slowly than kinetic reversals.

Errors of transposition (the reading of words out of sequence) appears to be less common than are static or kinetic reversals. Woody and Phillips (77) found word
sequence errors to be rare in samples of primary children. Likewise, reversal of words in mirrored form (rather than merely in reversed sequence) has not been demonstrated to be a significant problem (35, p. 19; 43, p. 169).

Among static reversal errors, the confusion of the letters b, d, p, and g have consistently been shown to be the most common and persistent reading and spelling errors made by both young children and remedial reading students. Popp (61) tested five-year olds for their ability to match all lower case letters and found the confusion of the letters b, d, p, and g to be the most common errors. In a study testing the letter matching skills of kindergarten and first graders, Davidson (18) found the confusion of g with p and b with d to be the most troublesome of all the commonly confused letters on which the subjects were tested. Frank (23) found that b and d were the letters most frequently confused by retarded readers. She found this type of reversal to be a characteristic error with each of the three levels of reading retardation which she delineated. Sidman and Kirk (64) also found that the b, d, p, g combinations of letters were the letters most confused by retarded readers and that the problem was pervasive in their remedial sample. Fildes (22) also found that these same four letters were among the most common letters reversed by a sample of "high-grade defective boys." Hymen (37) suggested that the
vertical elements in these letters were distracting and intensified the directional difficulty.

Factors Associated with Reversals

A great many factors have been linked to reversal errors. Some aspects are related to the personal attributes of individuals who make reversal errors. Others deal with the characteristics of letters and words that are most often reversed.

**Personal Factors**

As the investigations into the nature of reversal errors continued, numerous personal qualities were suspected of relating to the problem. Some were confirmed as factors associated with reversals and others were not. Both those characteristics which relate and those which appear independent of reversal tendencies will be reviewed.

**Maturity.**—As has been known for many years, the ability to distinguish between letters which differ only in spatial orientation is related to the maturity level of the child. Young children seem to be able to master discrimination of inverted forms earlier than right to left reversals (75). In other words, confusion of the letters u with n and m with w has been found to disappear at younger ages than difficulty with b and d or p and q (43). An age level of seven and one-half has been defined as the point at which
fifty percent of the subjects can match the letters d, g, and b repeatedly without error. A mental age of eight must be attained before seventy-five percent of the subjects can eliminate errors in discriminating between them in matching exercises (18). Skill in handling orientation of symbols is related to maturity as expressed by both chronological and mental age.

A great many studies of normal children support the thesis that maturity is a negative correlate of reversal tendencies. Even in matching unfamiliar letter-like symbols, children (as they advanced through the primary grades) showed an increased use of the orientational dimension in discriminating (28).

Even though no cross sectional nor longitudinal studies have been conducted above the primary grades, the maturational trend toward overcoming general reversal difficulties has been demonstrated to continue through grade six in normal subjects (74). The same developmental trend has also been observed many times in poor readers (23, 49, 50, 74). Since maturity has been observed as a factor related to the reduction of reversal errors in both normal and remedial populations, it might be argued that the phenomenon of reversals in disabled readers may be explained largely in terms of a maturational lag. This was precisely the term which both Bannatyne (4) and Money (54) use to describe the persistent reversal problem that is associated with many
cases of specific reading disability. There is research
evidence to confirm this impression. Lyle and Goyen (50)
studied samples of normal and retarded readers from second-
and third-grade classes which had been matched on several
crucial measures. The difference between these two groups
in making visual perceptual reversals was greater in the
second-grade groups than third-grade samples. This indica-
tion of a lessened differential in orientational confusion
as pupils grow older is indicative of a maturational lag at
least in the visual perceptual dimension of the reversal
problem. In reviewing the types of writing errors made by
normal children age four to seven with remedial readers
age seven to eleven and one-half, Frank (23) detected the same
types of errors. This is further evidence that a lag in
development may explain some of the anomalies which charac-
terize many retarded readers. Hildreth (35), one of the
early researchers into the developmental nature of reversals,
concluded that remedial readers make reversals for the same
reasons as immature normal readers. Her formal study, how-
ever, did not include samples of remedial readers.

Training.--It would be a mistake, however, to view the
reversal difficulty as attributable to maturation alone (46).
Researchers (35, 69) have maintained that maturity could not
be regarded as an isolated factor in overcoming orientational
confusion. Training was also identified as an essential
ingdrient. While young children are in the process of maturing, they are usually gaining a great deal of experience in working with words and letters through writing and reading activities. The feedback they receive from these activities undoubtedly assists them in developing the peculiar schemes by which symbols are distinguished. Gibson (26) reviewed more than two hundred research articles concerning the improvement of perceptual judgment, and her conclusions support this position. She stated that there is sufficient evidence to establish that improving perceptual judgment is a function of the frequency of practice (26, p. 413) and that periodic practices with knowledge of accuracy is essential in maintaining the perceptual skill. She felt that it was safe to conclude that reinforcement through external correction is a very significant factor in the improvement of perceptual judgment (26, p. 416). If these generalizations are correct, it seems obvious that training is an essential factor in learning to respond accurately to usually confusing letters.

Initially, of course, the child must develop the concept that spatial orientation is crucial in letter identification. Caldwell and Hall (14) illustrated that young children could be assisted or hampered in matching letters through a brief period of training. Subjects were divided into three groups. One group was trained to regard spatial orientation of symbols as crucial, a second group was
trained to disregard spatial orientation, and a control group was trained with shapes that lacked sidedness. On a subsequent letter-matching test, the first group performed significantly better than the control group, but the control group scored significantly better than the second. The inference from this research is that the development of the proper mental set through training is very important in eliminating reversals; yet, it is doubtful that one should conclude that this concept structure is all that is needed or that young children can be so easily trained to develop a lasting skill in working with letters. Reading and writing require deeper cognitive levels than are called for on matching tasks. Involvement in a task that is more complex might possibly dim the focus of young children on the orientational aspect of the letters. In view of Gibson's conclusions, it would have been interesting as well to have retested the children at a later time to see if they maintained the degree to which they could apply their concept training. Wohlwill and Wiener (75) demonstrated that four-year olds who are generally considered too young to consistently use directional orientation as a distinguishing feature can be trained to use directional cues in discriminating between synthetic letters. The task only required comparing shapes and determining if they were the same or different. This skill, as the authors pointed out, is considerably less demanding than the discriminations and associations required in reading. There is little doubt,
though, that training with letters does effect children's orientational awareness. Teegarden (69) demonstrated a strong negative relationship between kindergarten training and reversal tendency. Hildreth (35) observed that children in public school who had early training with letters made fewer reversals in the early grades than did children from private school who were more intelligent as a group but whose skill training was delayed. These results, however, should not be interpreted to dismiss mental maturity as a factor, for the private-school youngsters showed a more rapid diminution of reversal tendencies when scores of private-school pupils in third and fourth grades were compared with youngsters at the same levels in public school.

In the same study (35), it was established that training in two languages, which require opposite orientational approaches, did not adversely prolong reversal behavior. In a bright population of Jewish children, the learning of Hebrew with a right to left orientation did not produce an elevated incidence of reversals in working with graphic representations of English.

Handedness.--The possibility that intractable general reversal difficulty could be related to left-handedness was explored in a rather thorough study by Woody and Phillips (77). One hundred thirty-six pairs of right- and left-handed subjects were matched for sex, age, mental maturity, and reading skill. When these two groups were given a
series of tests designed to measure reversal tendencies, it was found that handedness had little or no influence on the number of reversal errors made. Other investigators have drawn the same conclusion from responses of both normal and remedial subjects (35, p. 19; 36; 64, p. 619).

Vision.--Faulty vision and faulty eye movement have been suspected as causal factors in reversal errors. Gates and Bennett (25, pp. 19-20) suggested that kinetic reversals may be caused by incorrect movement of the eyes. It seems logical that regression interrupting continuous left to right eye movement could result in a confusion of words which differ merely in letter order. However, Wolfe (76) concluded after a study of both retarded and normal readers that the direction of visual perception could not account for reversal errors. By use of a rather elaborate device, Wolfe presented a series of isolated words in such a way that subjects were unable to make reactive eye movements while perceiving the word. This presentation did not affect the number of reversal errors made by the normal nine-year-old readers. Although it significantly reduced the number of reversals made by the group of poor readers, it did not convert these errors into correct responses. The more rapid exposure of the forced left to right perception resulted in errors of either a grosser nature than a mere reversal or a "don't know" response.
It may be that Wolfe's results can best be interpreted in the light of Goins' later findings. Goins (3) found two factors which related to success in early reading. One she called speed of perception and the other was labeled strength of closure. She determined that reversals were related to the latter factor. Wolfe, in forcing direction of perception, also shortened perception time. She had thus compounded the perceptual problem. The poor readers as a group were probably deficient in both factors that relate to reading success. Their reversal errors possibly were lessened and translated into grosser errors because their retarded speed of perception prevented the strength of closure factor from becoming operative in the speeded exercises. If this explanation is valid, Wolfe's conclusion that reactive eye movements were not related to reversal errors in normal readers would still hold, but no judgment can be made regarding the nature of reversal errors among poor readers since all the factors involved in the difficulty were not operative. Perhaps slow perception speed may encourage reactive eye movements which may complicate difficulties with closure. This explanation would explain Lyle's contradictory findings. In untimed reading tests, he found that the ratio of reversal errors to total errors very significantly (.005) discriminated the retarded from the adequate readers. In speeded tachistoscopic tests, however,
no differences on this ratio score even approached significance (49).

In an early study with youngsters in the second through the fourth grade, known visual defects as evidenced by the prescription of glasses was found to exist with twice the frequency among students with reversal difficulties as among those who were classified as "Nonreversals" (25, p. 19). Although the researchers advised further study, their conclusion was that reversal errors seemed to be related to visual irregularities. On the other hand, Orton (59, p. 77) reported that some of the extreme cases of streposymbolia (his term for a tendency to make reversal errors) had vision that greatly exceeded the average of those children who have no difficulty learning to read. Goldberg, who summarized medical research on the subject and combined that with his own observations stated, "... poor vision is not a cause of the child's reversing letters or reading 'saw' for 'was'" (31, p. 102).

Faulty binocular vision also has not been confirmed as a factor in the general reversal errors of second-grade children. Children with a wide intelligence range showed no significant difference in the number of reversals made when viewing symbols and words in either a binocular or monocular presentation. Beck (5) concluded that symbol reversal cannot be generally attributed to poor binocular vision, but he cautioned that persistent reversal
difficulties may have a different origin than those made by young children and that inferences from his findings should not be applied to different populations, such as older remedial subjects.

Lyle and Goyen (50) concluded from their study that the difficulty associated with reversals is more apt to be explained by factors other than optical defects. Frank (23) demonstrated that reversal errors were not totally a function of visual distortion. She reported that sequence errors after aural input were also common. For example, the verbal spelling of e-a-t may produce a response of tea from a severely retarded reader. Results from Cohn's study (16) also fail to support a visual perceptual problem as the root of reversal confusions. He found that individual children did not consistently produce the same types of rotational errors as would be expected of a problem rooted in perceptual distortions. He concluded that the problem is more likely to be a product of the student's failure to utilize the unique characteristics of each letter.

**Spatial perception.**-Frostig (24, p. 29) has indicated that those children who have difficulty with perceiving position in space may have continued difficulty with static reversals. This view is also held by Birch (10). In a study with adults using reversible substitutes for vowels, Krise (46) established that ability to overcome reversal
errors was significantly associated with ability in space perception. Similarly, in a previous study (47) using the same synthetic letters, he determined that superior adults could be induced to make reversal errors, but they could overcome the difficulty with increased familiarity with the symbols and without special training. He attributed the original confusion to lack of familiarity with the proper figure-ground relationship. Both studies could be used to support the thesis that reversal difficulty is related to problems with spatial perception. It does not follow, as Krise suggests, that maturation and a host of other possible causes can be ruled out as factors contributing to reversal errors in children, merely because reversal errors can be induced in adult subjects. Spatial perception itself is presumably subject to the developmental process. The quick recovery of the adult subjects from the artificial word recognition problem is indicative perhaps of their maturity and their previous development of a cognitive structure which allowed them to learn the discriminations quickly, as contrasted to the slower process of learning in children.

The Krise studies, however, isolated a possible cause of reversal difficulties which has received some corroboration in studies conducted with children as subjects. As discussed earlier, Goins' study revealed two factors in visual perception that relate to reading, speed of perception and strength of closure. Strength of closure,
which received high loadings from a reversal test, she defined as "... the ability to keep in mind a figure against distraction" (30, p. 98). This factor possesses a large measure of common variance with reading ability. From the data collected in her study, she concluded that reversal errors in reading result from difficulties in visual spatial perception. Specifically, she implicated confusion with figure-ground relationships as related to reversal problems (30, p. 100). Wechsler and Pignatelli (73) also felt that static reversal problems could be in part a problem with figure-ground relationships. If one concentrates on the circular portion of the letter ą, for example, the orientational feature which distinguishes it from a p becomes only a part of the background and is of no help to the subject in fitting the symbol into the other contextual background. Primarily, though, Wechsler and Pignatelli perceived static reversals to be a perceptual problem which could primarily be explained as a function of axial rotation. The confusion of b and d or p with g would represent a rotation on a vertical axis. A u-n inversion would be an example of rotation on a horizontal axis, while a b-g substitution could result from turning on a depth (or third dimensional) axis. This theory, for example, would require one to predict that b-g reversals would be more numerous than b-p confusions since rotations on both a vertical and depth axis would be required to effect the latter distortion.
Popp (61) found b-q confusions to be only a slightly more common error than b-p reversals among five-year olds. Out of 1,186 letter confusions, seven were b-g reversals and six were b-p substitutions. Cohn (16, p. 10) found similarly that there was little difference between these two confusions with primary-aged children.

Wechsler and Pignatelli (73) recognized that other factors may be involved in the static transformations. All of their alternative suggestions fell within the scope of spatial perception irregularities.

Knowledge of right and left:—Kephart (44, p. 89) maintained that the concept of right and left must be internalized before the letters b and d can be distinguished. However, it was not clear from his discussion if he regarded failure to establish this sense of direction as a causal factor in reversal difficulties. Before research into this matter is discussed, some background material concerning what is known of the development of a sense of direction should be presented. Belmont and Birch (6) used Piaget's Right-Left Awareness Items with middle-class American children and found the age norms for developing several aspects of the knowledge of right and left to be similar to those established by Piaget. They established that ability to distinguish right and left on one's own body was well established in normal children by the seventh year. At this age,
too, they developed the ability to identify right and left on other persons facing them. Sequencing of objects by using right and left as relative labels, however, was not well established until age eleven. Isom (39) agreed basically with this sequence of development except that he suggested nine as the age at which children as a whole can successfully identify right and left on a second person turned to a position of opposite orientation. Isom's discussion of the age norms common in the development of a sense of direction was for the purpose of pointing out the characteristic immaturity of poor readers in developing these skills. The ability to accurately identify right and left on one's own body may develop one to two years later with retarded readers than with normal youngsters. Fewer than half of the poor readers were able to identify right and left on a second person by age nine and some did not develop this ability until the thirteenth or fourteenth year. He found among these subjects a similar retardation in dealing with the orientation of two and three objects.

Cohn (17) also reported a right-left disorientation among subjects who were delayed in the development of reading and writing skills. Harris (33) interpreted this disability as indicative of a type of maturational retardation with a possible neurological origin. (For a more extensive discussion of directional confusion and retarded reading, see Benton [8]).
Ginsburg and Hartwick (29) who studied diagnostic indicators of dyslexia concluded that directional confusion is most strongly related to reading errors only in subjects who exhibited pervasive reading error patterns (more than the criterion number of reversal errors, sound symbol association errors, and confusion of similar words). Thus, they suggested that right and left confusion may be a good screening sign for identifying dyslexics. Alexander and Money's findings (1), however, should caution again overreliance on this single indicator, for some individuals (as in the case of those with Turner's Syndrome) may be severely disoriented in directional senses yet normal in reading skills. From Isom's work, it may also be inferred that retarded development of a sense of direction is true for some, but not all children who have difficulty in learning to read.

The possibility that the portion of the remedial reading population which is slow in developing the concept of right and left may also tend to be those who have particular difficulty discriminating between b and d seems logical. However, researchers have not been able to establish such a relationship. Chapman and Wedell (15) demonstrated that a seven- or eight-year-old's ability to distinguish right from left on his own body did not differentiate between reversers and nonreversers. However, it should be noted that in this study consistent confusion of right and left were judged as correct responses. This would prevent
detecting a problem of verbal labeling based on directional
distinction.

Some have concluded that the confusion, of b, d, p, and
q by remedial readers cannot be viewed as a problem of dis-
criminating between right and left because samples have
demonstrated through success on copy tests and some matching
exercises that they can respond to directional orientation.
The fact that reversals of other letters is much less common
than the four mentioned ones is also indicative that direc-
tional confusion may not be the core of the problem (64).
Nevertheless, the possibility of a relationship cannot be
dismissed on current research evidence.

Laterality.--Laterality is a term used to refer to an
awareness of sidedness within bilaterally symmetrical organ-
isms. Specifically, as it is used with reference to read-
ing, it implies a preference for using one side of the body,
such as the right hand, the right eye, or the right foot
(42). It was thought by some that patterns of lateral pre-
ference would indicate which cerebral hemisphere was used in
reading. Current evidence supports the conclusion that pre-
ference for using a particular hand, eye, or foot cannot
reliably predict the location of brain centers involved in
the reading process, although there is a ninety percent
correspondence in right-handed individuals (38).
Laterality has been thought to be related to reading retardation (32) and specifically to reversals in reading and writing. Youngsters who were slow in developing a preference for using particular limbs and sensory organs and those individuals who did not develop a uniform preference for using body parts on one side of the body only were considered disadvantaged in learning to read.

However, researchers have demonstrated that laterality is firmly developed subsequently to many of the basic reading skills. Belmont and Birch (6) determined that a definite preference for handedness is not established until age nine and that the development of this propensity is not a continuously developing function. The correspondence of eye with hand usage is not established until later. Ten years of age was found to be the most common age for the development of ipsilaterality in this aspect. These authors point out that use of laterality tests for hand-use consistency or hand-eye correspondence before these crucial ages would be of questionable validity for defining pathology in development.

It may be argued that, since most normal children are able to develop rather sophisticated reading skills before the normal establishment of firm lateral behavior, evaluation of this quality in young children may be unreliable and consequently of little value in diagnosing reading disability. In addition, a quality which is developed after normal
acquisition of basic reading skills and minimizing of reversal errors can hardly be regarded as a causal factor in failure to proceed normally in acquiring these abilities.

Many research findings have supported the thesis that laterality scores of young children are unrelated to reading achievement and reversal tendency. Youngsters who were judged to have established consistent hand dominance prior to first grade did not achieve significantly better in reading achievement than those of mixed laterality or those who established dominance later (3). Therefore, lateral dominance scores at seven years of age did not appear an important determinant of reading achievement. Tinker, who studied second-, fourth-, and sixth-grade subjects, came to the conclusion that laterality was not related to reversal tendencies. She matched disabled with normal readers by sex, intelligence, and grade level and found no significant correlation between laterality and reversal tendency in either sample.

Other researchers concur that laterality is not significantly related to reversal errors in either primary or upper-elementary grades (74, 77). Beck (5) noted further that when subjects viewed symbols and words with one eye at a time, they responded with an equivalent number of reversals in the dominant and nondominant eyes. In a factor analysis to explore many areas alleged to be associated with poor reading achievement, Lyle demonstrated that measures of
laterality did not yield high loadings on the same factor as did reversal errors and reading retardation (49).

One study did result in weak evidence to link laterality with reversals. Gates and Bennett (25) indicated that individuals with a left-eye preference in aiming had a greater tendency to make reversals than those who preferred the right eye, although they found little correspondence between hand dominance and reversals.

Perceptual-motor ability.—There is some evidence that reversals in writing may be associated with perceptual-motor distortion. Fabian studied nineteen of the most severely retarded readers in a third-grade population of more than two hundred. Subjects with inadequate intelligence, optical and physical defects, poor attendance, and school change had been eliminated from the group. Seventeen of these severely retarded readers made symbol reversals and fifty-three percent made errors in verticalization in copying Gestalt forms when only six percent of normal children this age do so. On this basis and on logical grounds, Fabian concluded that reversal errors were related to verticalization tendencies. Although such a conclusion needs stronger evidence than merely a high incidence of the two elements in the same sample, it does indicate a possibility that needs further research.
Attention.--Inattention may be a causal factor in some types of reversals. Hildreth (35, p. 15) noted that reversals of letter sequence are most likely to occur in the central part of the word. Kennedy (45, p. 169) further observed that transposition of internal letters or of a final with an internal letter persists longer than sequence reversals at the beginnings of words. According to Marchbanks and Levin (51), the terminal letters of a word are not as important to word recognition as the initial letters and the medial portion is the least likely to influence word recognition. Therefore, these sections of a word are undoubtedly less likely than the beginning portion to be the focus of a reader's attention. It may be deduced, then, that reversals of this type may be due to vagueness of perceptual impression rather than to twisted perceptual distortion as is implied by the term strephosymbolia which has been applied to a bent for reversal errors.

Hendrickson and Muehl (34) used arrows to direct the subjects' attention to the directional element needed to discriminate between the letters b and d. They determined that attention cues can significantly improve the ability of kindergarten children to attach the correct name to these letters. This finding supports the conclusion that some reversal errors are due to inattention to significant details.
Frank (23), however, did not concur with this position. From her research findings, she judged that inattention and poor concentration were not the cause of letter confusion in either beginning of retarded readers. She felt that some of the children she observed simply did not perceive the small differences between certain letters.

Wolfe (76) attempted to accentuate word form by an outlining technique to test its effect upon sequence reversals. She found that poor readers continued to make significantly more reversal errors than did average readers. Although Wolfe concluded from this finding that inattention to word form was probably not a factor in reversal errors, this deduction may not be correct. It is difficult to interpret this result because it cannot be determined whether this method of "accentuation" would increase attention or provide a distraction. Judging from Wolfe's discussion of the difficulty children evidenced in identifying outlined letters, the latter interpretation may be correct. In that case, the Wolfe findings would confirm the thesis that inattention is a factor in kinetic reversal errors.

Skill in recognizing distinctive features.--Researchers have offered insight into the nature of perception as it relates to static reversals. Gibson and Gibson (28) recorded the verbal comments of adults and children learning to distinguish between a variety of spiral forms. They
concluded that the process of discrimination involved the ability to note the distinctive features which make one object different from another. Subjects were asked to describe all samples which they were matching. Their adjective responses did not describe the item being observed alone but denoted the relationship between the viewed item and the standard with which it was being matched. The inference as it relates to static reversals is not startling. The meaning simply is that a child must be able to note the differences between letters before he can discriminate between them. For b, d, p, and g, the visual distinction is wholly dependent on the directional orientation of the circle portion and the line. Cohn (16) after a study of letter identification errors of primary-grade children concluded that the distinctive features theory is the most parsimonious and comprehensive explanation for letter confusions, including reversal errors.

Pick (60) tested Gibson's "distinctive features" theory against the "schema" hypothesis. This latter view is that discrimination consists of matching sensory input or "cues" about items to models of those items which have been put together through past encounters with the items and retained in the memory. According to this position, encounter with the item to be discriminated is important to the building of the structure needed to distinguish it. In Gibson's theory, the reason for practice is to discover what are those
particular characteristics that are essential in discrimination. Hence, Gibson's view is that learning to discriminate is basically a process of making generalizations and the alternate view is that learning to judge between objects is primarily a function of memory. Pick (60) conducted three experiments with kindergarten and first-grade children. In each experiment, the subjects were divided into three training groups. The "distinctive features" group was trained to distinguish one set of standards (letter-like forms) from three types of transformations of near matches of those standards. In the test situation, the subjects worked with different standards but the transformation of these new standards which served as foils in the matching test were of the same type used in the learning situation. That is to say, the incorrect matches differed from the new standards in the same way as had the improper matches in the learning exercise. The "memory model" of "schema" group worked with the same standards in both the learning and test settings. However, the incorrect matches in the test setting had a different set of distinctive features from those used in the learning exercise. The control group in the test situation had neither the same standard nor foils with the same types of distinctive features as had been used for the learning process. The "distinctive features" subjects performed significantly better than the control group under all conditions and
discriminated better than the "memory model" group, except in tests when the standard was not available for reference during the matching process. The "memory model" contingency did not significantly exceed the control group on any experimental conditions except the one in which the standard was removed during the matching procedure. Pick concluded that knowledge of distinctive features is always an important element in improving discrimination, whether the standard remains available for comparison or not. The only instance in which the "memory model" group could equal the "distinctive features" sample was in a situation requiring memory of the standard. Pick interpreted this circumstance to mean that in situations requiring successive comparison, a memory model will independently improve discrimination.

If this information from basic research is applied to the task of discriminating \(b\) from \(d\) under conditions common to reading and spelling, both awareness of distinctive features and memory of a model would appear to be significant factors in discriminating. As Cohn (16) pointed out in distinguishing between \(b\), \(d\), \(p\), and \(q\), pupils must go beyond gross characteristics to specific aspects. But reading and writing both require more than mere distinguishing. They require what Pick has called "successive comparison." Subjects must not only be able to discriminate between the letters, but must at the speed of an automatic response ascribe the correct phonetic properties to each. It is
apparent that to recognize these graphemes accurately (as in the case of reading) or to reproduce them with precision (as in the act of spelling), a more complex procedure involving an interrelationship of discrimination of distinctive features with a memory function is necessary.

**Concept.**--In order to discriminate between letters that differ only in spatial orientation, children must develop the concept that directional differences are crucial in graphic material while ignoring certain notions of the importance of form constancy. They must understand, for example, that phonetically D equals d but under no condition can d equal b. (For further discussion, see Money [54]). In early research into reactions of young children to reversible symbols, Davidson (18, p. 464) noted that some children who confused b and d were aware that the letters faced different directions, but did not regard these distinctive features as significant. The confusion in this instance and perhaps for many beginning readers is not a difficulty with perception, but with failure to understand rules which govern letter discrimination.

Gibson and others (27) conducted a cross-sectional study of children in age groups from four through eight testing their ability to match correctly letter-like forms to their exact duplicates from among twelve transformations of the original standard. The source of most errors in all age
groups was perspective transformations. This is a characteristic which is not used to discriminate between objects or letters. It remained a difficult distinction throughout the four-year-age span, though relatively slight improvement was noted. Rotation and reversal transformations were the most difficult to distinguish of the forms which have varying characteristics needed in letter identification. The improvement rate from the youngest to oldest age groups was much sharper than that made in response to perspective transformations. Gibson and others (27) concluded that between ages four and eight youngsters learn something about letter-like forms that improves their power of discrimination between letter substitutes with which they have had no previous experience. The difference in correct responses was considered too great to be accounted for merely in terms of perceptual improvement based on physical maturity. The distinctive features learned from letter patterns were undoubtedly important in this increased discrimination skill. The authors reasoned that orientational distinctions are not valid in discriminating objects. Children in learning to discriminate between objects have learned to disregard this directional aspect. As Davidson (18, pp. 464-465) pointed out, a chair is still a chair regardless of which way it happens to be facing. Since, in experience prior to the introduction of print position in space is not a distinguishing feature, young children are initially confused by having
to apply this basically new concept of position in space to letters.

Caldwell and Hall (14) illustrated in their experiment with kindergarten pupils that youngsters who have no information about the importance of orientational differences do not have the concept of same and difference that would allow them to match some letters successfully. Reversals by young children may be related to inadequate concept development. If Gibson and others (27) are correct, the process may be less a product of direct concept instruction than an inductive process gained from experience with letters. However, Strang (67) demonstrated that four-year olds could do significantly better in responding to b and d if shown the directionality of the stimuli than if no instruction was given.

It is important to note that immature concept development may not describe the deficiency that is associated with persistent reversal errors. Sidman and Kirk (67, p. 623) observed that the success of the remedial subjects in matching and copy tests demonstrates their awareness of the importance of orientational distinctions. In addition, the low incidence of the reversal of other letters with no reversible counterparts indicates directional orientation. Concept deficit is apparently not the root of reversal difficulties among many remedial subjects.
Coding.--Some regard the problem of reversals in reading as being related to coding deficits. Lyle and Goyen (50) concluded that general reversal errors in reading committed by second- and third-grade normal and retarded readers may be due to inadequacy in speed of decoding. They based their conclusion on the fact that retarded readers did not differ from adequate readers in scores from tachistoscopic matching tests designed to measure visual recognition only, but did evidence a very significant difference (.005 level) in reversal errors in untimed reading tests. However, their conclusions were based on ratio scores of reversal errors to total errors. As has already been explained in the interpretation of the Wolfe study with the Goins findings (see section on vision), speed of perception may be the factor which accounts for the relative reduction of reversal errors among retarded readers in speeded visual presentations. Tachistoscopic tests, therefore, may tend to wipe out actual differences in reversal errors between normal and inadequate readers. Assuming this interstudy analysis to be correct, conclusions based on reversal errors which follow rapid presentation may be invalid. From a ratio score on the visual matching tests, one cannot conclude that the inadequate readers were equivalent or even relatively equivalent to the normal readers when vision alone was considered. Poor perceptual speed of the retarded readers may have inflated the number of total errors (the denominator of the
ratio) and artificially equated their ratio average with that of the adequate readers. It could not be assumed, then, that the two groups were relatively equal in reversal errors in purely visual matching tasks, and hence it cannot be deduced that the important factor accounting for the highly significant difference between the groups in proportion of reversal errors in reading must be explained in terms of a coding problem, since speed of perception differences even without the coding dimension could also have accounted for the findings.

Other researchers have investigated the relationship between coding and reversal errors. Asso and Wyke (2) considered coding of visual input into verbal output to be the source of letter confusion in reading. Similarly, the coding of auditory input into writing was regarded as a source of writing confusion. However, the results of their research did not clearly support this position. They tested five- and six-year-old subjects with spatially confused letters and compared the intertask correspondence of two tests which did not require coding (copy and matching tests) with two tests which would require this skill (naming letters and writing them to dictation). They did establish that the tasks were not equally difficult; the latter two tests produced by far the most errors. In tests of intertask correspondence, the two "coding" tasks did significantly relate to each other and to scores on the matching tests, but none of the tests
significantly related to the copy test. Examination of the data explains this result. The copy test was extremely easy for these subjects, as evidenced by the high mean score. In view of the fact that this skill had almost certainly reached its asymptote, little correlation could have been expected. Therefore, it is probably inaccurate to conclude, as did these researchers, that this result indicates that the skill varies independently from the other tasks. This finding, then, cannot be used to support the suspicion of a coding deficit as a base of reversal problems. On the other hand, the seemingly contradictory finding that there was significant correlation of the matching task to the dictation and letter naming tests did not indicate that coding deficits were absent. The researchers failed to control for such factors as age (a one and one-half year span can be quite significant at this stage of development) and intelligence which could have been the source of high correlation. It appears that little information concerning the possibility of coding difficulties as a factor in reversal errors actually was produced by this study.

Sidman and Kirk (64) also suggested that the problem of reversals may not relate to input or output deficits but may be what Sidman termed a "relational deficit." They pointed to the important language functions which are involved in the handling of letters and indicated that this area may account for reversal errors among subjects with reading
deficits. According to this view, these subjects have all the perceptual information and discrimination skills to distinguish between the confusing letters; they simply confuse which name or sound goes with which symbol. The logic of this position cannot be denied, but research evidence has neither confirmed nor ruled out this possibility.

**Memory.**--Somewhat similar to the concept that reversals may be due to a coding deficiency is Vernon's view that a memory factor involved in the association of names with shapes may in part account for form confusion in backward readers (71). In an experiment which involved repeating from memory the names of a series of several simple geometric figures, poor readers were inferior to normal children in correctly naming the shapes and in ordering the names in proper sequence. Vernon, thus, concluded that with poor readers the basic difficulty may not reside in perception or in discrimination, but in a memory link between shapes and names. The difficulty would be confounded if the shapes have strong similarities.

Orton (59, pp. 77-78) also suspected a memory problem in reversal errors rather than perceptual input deficits. He noticed that individuals who confused b and d had no difficulty copying the letters as might be expected if the problem were basically one of perceptual input. He drew the conclusion that the area of difficulty was one of
recalling previous experience with the graphic material. When the memory function was tested in an exercise that required drawn reproduction of a shape after brief exposure, no significant difference was found between the poor and normal readers in the number of reversal errors, although the poor readers generally made more of these errors than did the adequate readers (76). The inference from this finding can be used to support Vernon's position that perception and discrimination per se do not account for the high incidence of reversal behavior among retarded readers.

Lyle and Goyen (50) found that performance in delayed responses did not correlate with reading scores to a higher degree than did reactions in immediate response. The deduction is that a storage deficit was not characteristic of poor readers who made many reversals in reading. However, the scoring fallacy and the use of rapid stimulus presentation (discussed in the previous section) make these findings of dubious value. In a factor analysis, Lyle found that reversal errors in reading and in writing letters yielded high loadings onto the same factor as did the Memory-for-Design Test. The design-memory test is described as a "constructional task which was scored largely according to reversal errors" (49, p. 836). This finding did seem to indicate a possible connection between memory and reversal errors.
Sidman and Kirk (64) found some conflicting data concerning the relationship of memory to reversals. In an experiment which involved repeated testing with rewards for correct responses, delayed matching tasks continued to produce many reversal errors when errors had become minimal in naming lowercase letters, in writing them to dictation, or in matching uppercase to lowercase counterparts. Presumably the writing and letter naming tasks required a longer memory function than the delayed response which required responses after a maximum wait of forty seconds. The writing and naming tasks, however, required memory of a generalized form for which mnemonic cues could be used, while the delayed response task required extended attention to remember a specific cue. Those who utilized the mode of repeated subvocalization to employ the auditory channel for attending and memory strength were faced with duel translation from visual stimuli to correct verbal label and vice versa. If coding or memory for matching name with symbol is involved in the reversal phenomenon, the subject was accorded twice as many opportunities for error in his deficit function.

The foregoing explanation, of course, is only speculation. The way in which memory and verbal labeling skills may influence letter perception needs much more research.
Finger agnosia.--Kinsbourne and Warrington (45) identified two extremely different types of dyslexics which they admitted would comprise only a minority of remedial reading populations. The subjects were primarily different in their scores on verbal and performance intelligence as measured by the Wechsler intelligence tests. Each individual in one group obtained a score on the verbal section that exceeded his score on the performance portion by more than twenty points. For the other group, the converse was true. Their performance scores were more than twenty points superior to their verbal ratings. Kinsbourne and Warrington noted that the group which was inferior in performance intelligence displayed many functional signs which were also characteristic of Gertsmann syndrome in adults. This syndrome which is a cerebral cortical disorder is typified by disability in naming fingers (finger agnosia), disorientation in sense of direction, and difficulty with sequential ordering in writing and calculating. Skill in ordering letters within words is disrupted. Although it is not supposed that the pathogenic loss of ability is identical in cerebral involvement to the developmental incapacity to perform many of these same functions, the common features in function that result from the disabilities is noteworthy.

In the "developmental Gertsmann" group, Kinsbourne and Warrington found generalized abnormalities in constructional
skills, addition and subtraction, finger differentiation, and sequencing. More than half of the group were also sub-normal in forming letters and in right-left orientation.

The researchers did not report any information concerning errors in kinetic reversals that may have been common in the group. On logical grounds, though, it might be expected that this differential diagnosis could be a means of identifying those individuals in remedial reading populations who have great difficulty with recognizing and producing the peculiar letter sequences within words.

This possibility was explored as a part of an analysis of many characteristics which may relate to reading retardation in a study by Lyle (50). The results from finger agnosia tests were part of what he identified as a neurological factor, but were not strongly related to either sequence or letter reversals in reading or writing. The indication from available data is that finger agnosia is not a significant correlate of static or kinetic reversal.

**Emotions.**—One of the newest theories related to reversals is that of Laurita (48) who felt that the intractable nature of reversal behavior in cases of reading disability displayed striking similarities to the fixated response described by Maier which results from persistent frustration. Miles (53) also saw stress as a concomitant of relapse into committing reversals. Nikas (56) indicated that subjects
committed more reversal errors in reading higher level material than in reading easier passages. This, too, would support the theory that stress is a factor related to the production of reversal errors.

**Extrapersonal Factors**

Researchers have concluded that some of the factors which contribute to reversal errors are unrelated to the eccentricities of the learner. Part of the explanation for the trouble can be traced to the nature of learning itself and some responsibility resides in the qualities of the items that are commonly reversed.

**Learning principles.**—Basic learning principles may account for a measure of the reversal difficulties. Some of the factors that may be involved are the basic rules governing perception, configuration, association, and learning (35, p. 15).

One dimension of the problem of letter reversals is a practice effect. If items are unfamiliar and have received little practice, spatial orientation is likely to be confused. Children may be operating from images that are not clear to them rather than from distorted ones. If two or more letters have mutually similar characteristics, except for figure-ground arrangement, they may cause problems with discrimination. Letters that receive equal practice and are similar in appearance would cause most
difficulty. When practice is unequal, the letter which receives least attention is likely to be identified as the item which receives more use. Rarely would the more common item be identified as the most obscure. \( P \), for example, would be less likely to be called \( q \) than the reverse. The familiar is substituted for the unfamiliar. Material that is not meaningful is also apt to produce or prevent reversal errors (35). It was observed by one investigator that children often exchanged \( \text{on} \) and \( \text{no} \) when reading, but never suggested that \( \text{it} \) was \( \text{ti} \) (35, p.10).

Mason described the kinetic reversal phenomenon as being an example of overgeneralization. The child may call \( \text{there} \), \( \text{where} \), or \( \text{they} \) by the single response \( \text{there} \). For words that have strong similarities, the first word learned may be substituted for those learned later. He demonstrated that kindergarten youngsters when taught to recognize words made familiar by commercial advertising, commonly overgeneralize their learning. They tend to respond with the first word taught when presented words with similar letters. Although some of the children may have responded incorrectly merely because they felt an answer was expected of them and they provided the pieces of information which they had learned which most nearly corresponded to the stimulus presented, it seems that previous learning can negatively influence later learning. Some reversal difficulty may result from this type of confusion.
Hildreth (35) maintained that the learning principles which she associated with reversal errors made by young children apply equally to beginning readers and remedial cases. Her conclusions were based on impressions while working with children rather than on statistically treated empirical data, and her samples did not include a remedial group. Further research is needed to confirm or qualify her impressions.

Context.--Textbooks which describe the reading process often discuss the importance of context in word attack skills. The contribution of meaning and syntax appear to facilitate identification of unfamiliar words. To what extent context clues may encourage or depress reversal errors has also drawn comment from those who have done research in the field of reversals. Bennett (7, p. 36) noted that the structure of the setting of a word appears to measurably influence the error possibilities for that word. She concluded that forty-one percent of the erroneous responses she tabulated approximated the thought expressed by the printed words they replaced and further that half of the irrelevant responses were of the same part of speech as the stimuli. Presumably the reader's expectation of extracting coherent, sensible thoughts from print would also affect the occurrence of reversal errors. Hildreth (35) commented from informal observations that some reversals seem to be
sensible alternatives for the actual printed words, as interpreted by the readers.

If certain contextual settings open the possibility for reversal errors, it may be conjectured that other contextual situations may greatly reduce the possibility of reversal error. Hildreth (35, p. 10-11) reported that one second-grade child who had made reversal errors on both on and pig when reading from a word list pronounced the words correctly and without difficulty when reading a paragraph orally. Johnson (40) added her opinion that the presence of meaning in a situation would lessen the chance of reversal error.

Other investigators who have attributed reversal errors primarily to other factors have given tacit confirmation of their conviction that context would be a deterrent to reversal errors. Krise (46), for example, who developed four reversible vowels, constructed a word-reading test composed of twenty words to be used with adults. The words he fabricated would produce sensible words no matter which of the four vowel substitutes was inserted. This strategy would have been unnecessary if the experimenter had not perceived the context could assist the subjects to make correct responses without closely attending to the directional orientation of the "vowels."

Orton (58, p. 288) indicated that for remedial students context can contribute a distracting factor which can increase the likelihood of reversal errors. He related
that such children may develop facility for discriminating between b, d, p, and q in isolation but confused them in reading and writing words. Schilder (63) who also observed remedial readers concurred with this view. The possibility that factors which assist normal children to avoid reversal errors but which interfere with the correct responses of remedial students has, thus, been raised. If such a factor could be demonstrated to differentiate between reversal errors made by normal readers and remedial students, it would indicate a constitutional difference in the reversal errors of the separate populations.

**Overcoming Reversal Errors**

Authorities disagree on advice for assisting those students who continue to make a significant degree of reversal errors in reading and writing long past the age at which normal readers mainly have eliminated these types of errors. The attitudes divide along suggestions for action on one hand and inaction on the other.

Those who feel that active steps should be taken by teachers of disabled readers with persistent static reversal problems suggest various therapies for alleviating the difficulty. Many of these approaches involve varieties of suggestions for tracing (12, 21, 32, 55, 72, 62). Monroe (55), for example, advised establishing motor cues by writing script over manuscript letters while tracing them
individually and in words. Strang (67) working with very young children and using a selection process which would eliminate the immature students, presented research evidence to question the efficacy of motor cues in establishing discrimination of b and d. His findings support the practice of verbal cuing in developing accuracy in perceptual judgment. Though Spalding and Spalding's method (66) is not a remedial technique, they proposed widely separated presentations of the letters b and d, pointing out the distinguishing characteristics and developing in the child a stereotyped form of writing the letters which makes misplacing the stem difficult. Bryant (13) agreed with the need for separate introduction and mastery of each item in a commonly confused pair before subjects were required to identify both elements in the same lesson. Some writers suggest use of mnemonic clues (4, 21, 62).

Other authorities have advised inaction in the face of reversal problems. Gibson and others (27) stated that there is no evidence that teaching is required to eliminate reversal errors. In their opinion, children learn these discriminations through an inductive process. Repeated observations of the items to be discriminated with feedback concerning accuracy of response is all that is necessary for accurate perceptual judgment to develop. Others support the position that retarded development in letter
discrimination is merely evidence of an immature stage in working with graphic symbols.

Hildreth (35, p. 12) expressed the view that reversal errors disappeared as "a natural result of learning and maturity," and indicated that no particular instructional attention needed to be provided for this process to occur. Spache (65) maintained that reversals are not the cause of reading retardation or even related to it. He stated that reversals are a characteristic of individuals at any age level who are confronted with an unfamiliar array of symbols. He apparently assumed that overcoming orientational errors was simply a function of continual contact with the symbols. This contact would naturally be involved in the processes of learning to read and spell.

Although Davidson (18) did not address the matter of whether specific instruction was necessary to eliminate reversals, she did outline specific steps through which young children passed in learning to discriminate between \(b\), \(d\), \(p\), and \(q\). Seemingly, those who view the disappearance of reversal errors as a natural process of passing through specific stages tend to conclude that maturity and experience will take care of reversal errors without special attention. Others have opposed focusing undue effort on the problem because of a further complication. The condition among remedial readers is peculiarly obdurate and resistant to treatment (48, 53). Fernald suggested that the problem
could be easily overcome (21). Bannatyne (4) advised against spending an inordinate amount of time attempting to overcome this problem. His opinion is that most remedial reading cases overcome the problem in adolescence and that concern for these types of errors should not supersede remedial instruction for alleviating more important deficits.

Summary

There is some difficulty in interpreting the findings concerning reversal problems because the term reversal is used ambiguously to refer to several types of errors. Although this constellation of errors does not collectively comprise the most common form of reading error, some reading authorities do consider reversal errors as significant, especially among ten percent of the specific reading disability cases.

There is contradictory evidence as to whether kinetic or static reversals are most troublesome. Among static reversals, however, b, d, p, and q have consistently been found to be the most confusing.

At least fourteen personal factors have been associated with reversal errors. Maturation has been found repeatedly to be related to reversal errors and some have theorized that the exaggerated problem of reversals among remedial students is merely an instance of maturational lag.
Training with letters has also been confirmed as an important factor in reducing reversal errors.

Handedness and vision were originally deemed very important in the production of reversal errors, but research has tended to discount these factors. Left-handedness has consistently been found unrelated to reversals. Although some of the conclusions drawn from research indicate a relationship of vision and reversals, evidence has mounted from many different types of studies to support the conclusion that visual perception is not the root of reversal errors.

Spatial perception has been linked to reversal errors in research with both adults and children. A factor labeled strength of closure which relates to figure-ground relationships has been found strongly associated with reversals. Conversely, knowledge of left and right, though it is significantly related to some cases of reading disability, has not been established as a factor in the production of reversal errors. In addition, laterality appears to be firmly established after most children have largely overcome reversal errors and can, therefore, not be considered an important source of reversal tendencies. There is some evidence which relates perceptual-motor skill to reversal errors.

Researchers do not agree as to whether inattention is a cause of reversals, but there is general agreement that
skill in recognizing distinctive features is crucial in letter identification—a factor which would presumably be particularly important in distinguishing letters with similar features, such as b and d. The development of the concept that directional orientation can be an important aspect in forming letters and distinguishing between certain of them has also been demonstrated to influence the letter-matching ability of young subjects.

Some investigators have concluded that coding skills are related to reversal errors, but the analysis on which these conclusions are based may be questioned. However, a related factor—memory—has been linked to reversal errors.

A neurological condition which results in finger agnosia has been associated with certain types of reading disability but does not appear related to reversal errors. Emotional factors have been suspected by some writers as being a cause of persistent reversal problems.

Some factors that are unrelated to the peculiar characteristics of individuals have been used to explain some of the reversal phenomenon. General learning principles which control perception and association have been offered as logical sources of reversal errors. The context in which a reversible item appears has been seen variously as a deterrent to reversal errors and as a distraction inducing reversal errors.
Authorities are divided on what approaches should be taken with subjects who exhibit a persistent reversal problem. Some advise ignoring the problem and relying on maturation and experience to eliminate the tendency to reverse. Others suggest specific therapies to alleviate the problem.

A review of the literature indicates contradictory conclusions regarding some of the factors which may be roots of the reversal problem and disagreement as to the proper avenue to take in assisting extreme reversers. Further research into patterns of error reduction in remedial and nonremedial readers may help solve some of the unresolved questions that remain.
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CHAPTER III

PROCEDURES FOR COLLECTING DATA

This account of the procedures followed in collecting the data used in this study is divided into sections. Initially, the factors considered in the selection of the problem are discussed. Next, the development and selection of testing instruments are detailed. A section is included on the selection of subjects, and another describes the methodology for gathering data. Finally, treatment of the data for Phase I and Phase II of the study is described.

Selection of the Problem

Teachers of remedial readers are often faced with puzzling questions for which no adequate answers have been found. One such question relates to the nature of reversals. Too little has been known concerning how the problem phases out in populations of normal young readers as compared with individuals selected for remedial instruction. Although meaninglessness has been informally observed as a factor influencing these types of errors, no hard data has been produced to indicate ways in which this factor may interact with reversal errors.

Certain parts of words have been found more important in word identification than others, but no research had
explored how the aspect of location within a word may relate to the problem of static reversals. The way in which broader contextual settings may relate to the problem had also been left un researched.

Insight into the ways these factors operate in inducing or alleviating reversal confusion may trigger important insights into the basic nature of the persistent problem that plagues some remedial readers and may be used to make a more enlightened judgment as to whether therapy is needed for this specific problem. This study was prompted by some basic questions which arose while attempting to devise an adequate method to assist dyslexics in overcoming severe reversal problems.

Selection and Development of Instruments

Since a review of the literature revealed that there were no standardized or experimental instruments which were designed to measure the particular aspects of the reversal problem under examination in this study, a series of eight short tests, six of which were combined as subtests of the "b-d Discrimination Test," were developed. The six tests, which were grouped together because their primary purpose was to gauge various aspects connected with the reversal of b and d, are the "Letter Naming Test," the "Word Reading Test," the "Writing-Spelling Test," the "Sentence Reading Test," the "Sense-Nonsense Test," and the "Nonsense
Spelling Test." Tests which were developed to test other dimensions of the reversal problem were the "Kinetic Reversal Word Reading Test" and the "Test of Articulation of b-d Strategy."

Test Preparation

Prototypes of the first three subtests of the "b-d Discrimination Test" were developed and used for measuring progress of remedial students in overcoming the tendency to confuse the letters b and d. The "Word Reading Test" and the "Writing-Spelling Test" were later revised so that they would fit the purposes for which they were used in this study, and the additional tests were written. The "Examiner's Manual" for the "b-d Discrimination Test" (Appendix A) thoroughly describes each of the subtests. It presents the purpose for which each test was designed, gives the criteria used in the selection of items, and details general procedures to be used in administering and scoring each of the subtests. Similarly, Appendix B and Appendix C contain pertinent information relating to the development of the "Test of Articulation of b-d Strategy" and the "Kinetic Reversal Word Reading Test," respectively.

Validity and Further Preparation

In order to establish the content validity of all of these tests, a panel of five judges was selected from among diagnostic reading teachers and college professors who teach
courses covering aspects of the field of reading instruction. Each judge was sent a letter to direct him in performing his task (Appendix D). In addition, he was provided an initial form of the "Examiner's Manual" for the "b-d Discrimination Test" and copies of each of the proposed subtests. For the "Sentence Reading Test," each panel member checked the ten pairs of sentences from the thirteen pairs presented which he judged most suitable for inclusion in the final test. Those sentences receiving the most checks were included on the test. Item pairs which were tied for tenth position were assigned numbers and a table of random numbers was used to select the final sentence pair. The twenty selected sentences were each assigned a number and randomly assigned their location on the final test. Random procedure was abridged only when sentence pairs would have been placed consecutively on the test card.

To assist panel members in assessing items on the other subtests, information illustrating the balance which had been written into each test was provided (Appendix A). No suggestions for item changes were made.

In addition to ruling on test items, the judges were asked to make any other suggestions regarding the test manual, procedure, or scoring which might seem appropriate. Only a few suggestions were made and all were followed, except for one, which would have necessitated the development of another test. It was decided not to use the rigid
age levels originally assigned for each test, and instead to allow each subject to continue through the progression of tests as far as his developmental reading and spelling levels would allow. It was left to the discretion of the examiner who was experienced in diagnostic testing and remedial teaching to determine those tests which were within the competence range of the child. Since the tests were roughly arranged in order of difficulty, this was a feasible approach, which resulted in the gathering of much more usable data than would have been possible under the original structure.

The same panel evaluated the "Test of Articulation of b-d Strategy" and the "Kinetic Reversal Word Reading Test." Information regarding the purpose, method of administering, and procedure for scoring accompanied both of these tests. In the case of the "Kinetic Reversal Word Reading Test," the judges participated in the selection of the ten pairs of words to be included on the final test. They assigned two points to the pairs which they knew from experience to be those confused by beginning readers. One point was accorded other choices (to complete the number of ten choices) which seemed on logical grounds to be most subject to reversal errors. Those items which received the highest total points from the five judges were included on the final test. Random procedure, again, was used to determine the pair to be included at the tenth position. The twenty items
were also randomly assigned to their position on the test card, but items in a pair of words were not allowed to appear in succession on the final instrument.

**Final Test Form**

When all the items had been approved and selected by the panel, test cards were prepared for each of the tests (except for the spelling tests and the articulation test, which required no visual stimuli). The items for the tests and for the "Sample Card" were typed on plain white paper in pica type and mounted on tagboard. For use with subjects in the first and second grades, the "Sample Card," "Letter Naming Test," and the "Word Reading Test" were also typed on a primary typewriter and similarly mounted. Each of the sample and test cards was overlaid with clear adhesive plastic so that smudges could be wiped away and the stimuli would remain equally sharp for all subjects.

For each test, a manila file folder was prepared. In each folder, the instructions for administering the test were mounted and portions to be read by the examiner underlined in yellow. The test cards to be used by the subjects were also placed in the appropriate folder. The cover card was a white four by six inch index card.

Two types of paper were used for the spelling tests. One type resembled that commonly used in the primary grades of the sampled school district, and the other, with lines
five-eighths of an inch apart, was similar to that used in the upper-elementary grades. Samples of the paper are contained in Appendix A.

In none of the material to be handled by the subjects was the word reversal or the letters b and d highlighted. In addition, the material to be used by the examiner during the testing used titles which would not tip the subjects as to the particular factor on which they were being tested.

Data Collection Sheets

Special sheets were also designed to facilitate the collection of data. Because these sheets were designed in the early phases of the planning for the study, they reflect some aspects of the original planning that were not employed in the actual study. Some other aspects which were added to the study were not shown. For reasons of economy, the original design was used and additional information added in the margin. Sheets like those actually used in the data collection in the study are included in Appendix E. Those desiring to replicate the study may wish to revise the sheets before having them reproduced.

Reliability Study

In order to provide a more meaningful interpretation of data, a reliability study for these ad hoc instruments was carried out as a part of the study. Split-half reliability coefficients were obtained for each of the subtests
of the "b-d Discrimination Test," the "Kinetic Reversal Word Reading Test," the total of the first three subtests of the "b-d Discrimination Test," and the total battery of ad hoc tests (including the "Test of Articulation of b-d Strategy"). A separate test-retest reliability coefficient was also computed for the "Test of Articulation of b-d Strategy."

The "Letter Naming Test" was split by using alternate items. The other tests were divided so that an adequate balance of types of items would appear in each half of the test. Items which appeared on the halves of any tests and subtests can be identified by referring to the "Study Answer Sheets" in Appendix E. Items preceded by asterisks comprised one-half of the test. Those with no preceding mark made up the alternate half. The scores made by individuals on the separate halves of the tests were correlated, using the Pearson product-moment correlation, and the Spearman-Brown formula was applied to determine the final coefficient of reliability. The results of this computation are shown in the following Tables I and II.

It will be noted that the reliability of all subtests of the "b-d Discrimination Test" are adequate, except the "Sentence Reading Test." Caution was, therefore, advised in the interpretation of findings based on error scores on the "Sentence Reading Test." Part of the reason for the low reliability may be that the difficulty level of the material was rated at the 3.1 level with the Spache
**TABLE I**

RELIABILITY OF THE "b-d DISCRIMINATION TEST"

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample Size</th>
<th>Number of Items</th>
<th>Coefficient of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Letter Naming Test&quot;</td>
<td>195</td>
<td>20</td>
<td>.91</td>
</tr>
<tr>
<td>&quot;Word Reading Test&quot;</td>
<td>194</td>
<td>20</td>
<td>.85</td>
</tr>
<tr>
<td>&quot;Writing-Spelling Test&quot;</td>
<td>194</td>
<td>20</td>
<td>.92</td>
</tr>
<tr>
<td>&quot;Sentence Reading Test&quot;</td>
<td>80</td>
<td>20</td>
<td>.43</td>
</tr>
<tr>
<td>&quot;Nonsense Spelling Test&quot;</td>
<td>122</td>
<td>20</td>
<td>.43</td>
</tr>
<tr>
<td>&quot;Sense Nonsense Test&quot;</td>
<td>120</td>
<td>40</td>
<td>.87</td>
</tr>
<tr>
<td><strong>Total b-d Score</strong>*</td>
<td>120</td>
<td>60</td>
<td>.85</td>
</tr>
</tbody>
</table>

*Total of first three subtests.

**TABLE II**

OTHER RELIABILITY SCORES

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample Size</th>
<th>Number of Items</th>
<th>Coefficient of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Kinetic Reversal Word Reading Test&quot;</td>
<td>194</td>
<td>20</td>
<td>.25</td>
</tr>
<tr>
<td><strong>Total Battery Score</strong>*</td>
<td>195</td>
<td>161</td>
<td>.82</td>
</tr>
</tbody>
</table>

*Based on the split halves of all tests in the "b-d Discrimination Test," "Test of Articulation of b-d Strategy," and "Kinetic Reversal Word Reading Test."

Readability Formula(14). Students who read these sentences and demonstrated that their instructional level was at or
above this degree of difficulty tended to make few reversal errors. In addition, since prior meaning clues significantly reduced the chance for static reversal errors, the probability of error existed strongly in only half the items. These two factors may have contributed to the reduced range of errors. For the nonremedial group, the standard deviation was only 1.8, as compared with 2.97 for the "Letter Naming Test." As a consequence, low correlation between scores of the test halves could have been expected.

The "Kinetic Reversal Word Reading Test" is an unreliable test for perhaps the same reason as the "Sentence Reading Test." This test generated very few errors. The directionality factor gauged by this test appeared never to be subject to the random guessing or systematic reversals that characterized the way some individuals responded to static reversals. The implication of this circumstance is important and will be discussed later. However, other analyses based on the scores of the "Kinetic Reversal Word Reading Test" must take this low reliability into account.

For the test-retest reliability of the "Test of Articulation of b-d Strategy," individuals were asked the question a second time, fourteen to eighteen days after their original testing. Not all subjects were used in this study. Two entire school samples had to be omitted because an intervening holiday did not allow retesting at the specified time interval. Pupils who were absent, or who were
unavailable due to other reasons, were likewise not included. The sample size for this study was one hundred seventeen.

The result of the study demonstrated that pupils within the age range of seven to ten do not respond reliably to the query, "Pretend that I am just learning the alphabet. Pretend that I can't remember how to tell a little b from a little d. Can you tell me how I can remember the difference between them?" (See Appendix B.) The subjects' first and second responses produced a reliability coefficient of only .34. It should be noted that sixty-nine percent of the subjects were ranked the same on both testings. Since subjects of this age span cannot be counted on to reliably answer the question, the score on the "Test of Articulation of b-d Strategy" cannot be regarded as a reliable measure of the pupils' ability to explain or demonstrate the difference between b and d. Analysis based on this score must be viewed in this light.

**Selection of Test for Sense of Direction**

Some previous studies which had investigated the relationship of the sense of direction and reading appeared to have used an unstandardized technique of asking a subject to identify parts on the right or left side of his own body. For example, the subject might be asked to point out his right foot or to designate his left arm (8, 5). Others have used Piaget's questioning procedure (10, 4).
The only commercial test which had been standardized for use with all of the age levels involved in this current study was the Standardized Road-Map Test of Direction Sense. The test had been developed by Money, Alexander, and Walker (11) at the Johns Hopkins University School of Medicine and had been used in research in reading and neurological disorders (2, 3). Scores on the test were found to significantly correlate with the reading achievement of boys from eleven to fourteen (3).

The reviewers in Buros (6, pp. 1293-1296) expressed confidence that the test could be used to investigate impairment of directional orientation and for use in research on learning and reading retardation. Some reservations concerning the test were also expressed. No reliability data were available and the standardization had not been the product of a nationwide sampling procedure. It was further estimated that the test would be most useful for testing subjects between the ages of eleven and fifteen. The test did have established norms for ages seven through ten and fifteen through eighteen as well.

Since the test was the only available standardized instrument measuring the sense of right and left, it was decided to use this instrument as opposed to the informal measures used in other studies. In addition, a split-halves reliability study was undertaken to provide data needed to interpret results from the present study. The havles were
split by grouping items according to the difficulty factors which had been discovered in the standardizing process (11, p. 23) and then randomly assigning items within each difficulty level to a test half. These scores were correlated using Pearson product-moment correlation, and the Spearman-Brown formula was applied to derive the reliability coefficient. The error scores of the Standardized Road-Map Test of Direction Sense produced a reliability coefficient of .80.

Selection of Subjects

The study was conducted in a large metropolitan school district in the Southwest. In order to assure an adequate population of students accepted for remedial reading instruction, the sampling was done in schools which housed learning centers staffed by diagnostic reading teachers. Of the schools with such facilities, ten were randomly selected for the study. Since one of the randomly selected schools had no primary grades, samples of seven- and eight-year olds for the nonremedial group were randomly drawn (by age groups) from a sister school located on the same campus and drawing student population from the same community.

In order to provide some information to assist others in assessing the external validity of the study, a sociological description of the ten samples schools is provided in Table III. The source of this information was the latest
<table>
<thead>
<tr>
<th>School Area</th>
<th>Single-Family Housing Valuation (Mean)</th>
<th>Predominant Zoning</th>
<th>Public Housing</th>
<th>Apartment Rental 1 and 2 Bedroom Monthly (Mean)</th>
<th>Years of Education (Mean-Median)</th>
<th>SES Level</th>
<th>Percentage of Total School Ethnic Composition</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>$17,000</td>
<td>Res.*</td>
<td>No</td>
<td>$110/120</td>
<td>10.8</td>
<td>2</td>
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<tr>
<td>2</td>
<td>41,000</td>
<td>Res.</td>
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<td>. . .</td>
<td>13.4</td>
<td>3</td>
<td>98 1 0 1</td>
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<tr>
<td>3</td>
<td>18,000</td>
<td>Multi-family</td>
<td>No</td>
<td>120/150</td>
<td>11.7</td>
<td>1</td>
<td>50 8 38 4</td>
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<tr>
<td>4</td>
<td>17,000</td>
<td>Res.</td>
<td>No</td>
<td>140/200</td>
<td>11.9</td>
<td>2</td>
<td>22 1 76 1</td>
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<tr>
<td>5</td>
<td>23,000</td>
<td>Res.</td>
<td>No</td>
<td>120/150</td>
<td>12.3</td>
<td>2</td>
<td>94 0 6 0</td>
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<tr>
<td>6</td>
<td>41,000</td>
<td>Res.</td>
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<td>170/210</td>
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<td>4</td>
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<td>7</td>
<td>25,000</td>
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<td>150/180</td>
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<td>3</td>
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<td>8A</td>
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<td>No</td>
<td>. . .</td>
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<td>1</td>
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<td>Res.</td>
<td>No</td>
<td>. . .</td>
<td>10.8</td>
<td>1</td>
<td>2 90 8 0</td>
</tr>
<tr>
<td>9</td>
<td>10,000</td>
<td>Res.</td>
<td>No</td>
<td>115/105</td>
<td>11.0</td>
<td>1</td>
<td>0 92 8 0</td>
</tr>
<tr>
<td>10</td>
<td>44,000</td>
<td>Res.</td>
<td>No</td>
<td>140/200</td>
<td>12.7</td>
<td>4</td>
<td>95 0 5 1</td>
</tr>
</tbody>
</table>

*Residential
report on the socioeconomic profiles of the school communities within the school district in which the study was conducted (1). Table III is self-explanatory except for two aspects. "SES Level" refers to a ranking of socioeconomic status which was based on a weighted formula explained in the report (1, pp. 3-4). Each school community was assigned a SES level of from one to five. These classifications are (1) lower class, (2) lower-middle class, (3) middle class, (4) upper-middle class, and (5) upper class. It should be noted also that school 8A (the primary school) and school 8B (the upper-elementary school) represent the same scholastic community.

The latest data concerning the ethnic composition of each school at the time of testing is presented in Table IV.

<table>
<thead>
<tr>
<th>SCHOOL</th>
<th>ANGLO</th>
<th>BLACK</th>
<th>MEX-AM</th>
<th>OTHER</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>416</td>
<td>62</td>
<td>43</td>
<td>5</td>
<td>526</td>
</tr>
<tr>
<td>2</td>
<td>436</td>
<td>3</td>
<td>0</td>
<td>7</td>
<td>446</td>
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<tr>
<td>3</td>
<td>134</td>
<td>22</td>
<td>137</td>
<td>8</td>
<td>301</td>
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<tr>
<td>4</td>
<td>113</td>
<td>9</td>
<td>462</td>
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<td>598</td>
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<tr>
<td>5</td>
<td>485</td>
<td>13</td>
<td>19</td>
<td>3</td>
<td>520</td>
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<tr>
<td>6</td>
<td>330</td>
<td>17</td>
<td>5</td>
<td>3</td>
<td>355</td>
</tr>
<tr>
<td>7</td>
<td>316</td>
<td>91</td>
<td>16</td>
<td>11</td>
<td>434</td>
</tr>
<tr>
<td>8A</td>
<td>9</td>
<td>739</td>
<td>70</td>
<td>0</td>
<td>818</td>
</tr>
<tr>
<td>8B</td>
<td>14</td>
<td>611</td>
<td>42</td>
<td>0</td>
<td>667</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>976</td>
<td>71</td>
<td>2</td>
<td>1,053</td>
</tr>
<tr>
<td>10</td>
<td>427</td>
<td>0</td>
<td>19</td>
<td>3</td>
<td>449</td>
</tr>
<tr>
<td>TOTAL</td>
<td>2,684</td>
<td>2,543</td>
<td>884</td>
<td>56</td>
<td>6,167</td>
</tr>
</tbody>
</table>
The ethnic composition of the sample is given in the following chart.

**TABLE V**

*ETHNIC COMPOSITION OF SAMPLES*

<table>
<thead>
<tr>
<th>Sample</th>
<th>Anglo</th>
<th>Black</th>
<th>Mex-Am</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonremedial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>74</td>
<td>32</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>Percent</td>
<td>61.6</td>
<td>26.6</td>
<td>10</td>
<td>1.6</td>
</tr>
<tr>
<td>Remedial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>43</td>
<td>27</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Percent</td>
<td>57.3</td>
<td>36</td>
<td>6.6</td>
<td>0</td>
</tr>
</tbody>
</table>

Before initiating the study, a schedule of testing was set up for each school. The order was determined by random selection except for two schools whose test dates were interchanged because a camping program in one school would have interfered with the testing. Sampling within each school was done from an alphabetical listing of the entire student body. Each name was assigned a number. Numbers were chosen by proceeding variously up or down, and to the right or to the left on a table of random numbers (13). The birthdate of the individuals chosen was checked. If the child at the scheduled time of testing would fit into a seven-, eight-, nine-, or ten-year-old category, his name was listed in the appropriate bracket and other pertinent information was recorded. Children whose birthday did not qualify them for
inclusion in the study and students who were involved in the remedial reading program or special education classes were disregarded. Before the week of testing, letters (Appendix F) were sent to parents requesting permission to test the child and to use school data in the study. (Although the parent-permission letter was available in Spanish translation, only two such letters were requested. Neither of these was returned granting permission.) Such permission was requested by the school district as a condition for approving the study. In each school, the first three pupils in order of random selection in each of the four age groups who received parent approval before testing in his school was completed and who demonstrated adequate knowledge of the alphabet were included in the study.

The remedial population was composed of students who attended learning centers for special reading instruction. The specific criteria used in screening students for work in learning centers staffed by diagnostic reading specialists were listed as follows:

1. The language and/or learning disabled student has a significant discrepancy between his ability and his achievement.
2. Teacher observations indicating further possibility of potential development in area of reading.
3. Student desirious [sic] or willing to be involved in a program centering on reading.
4. No severe peripheral sensory deficits.
5. No severe emotional problems noted.
   a. Students with mild emotional overlay problems apparently related to reading disability may be served on a trial basis.
b. Students whose emotional problems appear related to both reading needs and need for support from supportive person may be served provided support personnel such as Associate Psychologist, Counselor, Visiting Teacher and others assist (12).

The entire population of students from age seven to ten attending the learning centers for remedial reading instruction were invited to participate. Only three parents in this group refused to give permission although phone contacts were also necessary to achieve this high permission rate. In the seven- and eight-year-old categories, the entire population receiving parental permission did not provide the desired twenty subjects at either level. The ten-year segment contained the exact twenty individuals, but the nine-year-old category contained four extra subjects. This sample was reduced to twenty by random exclusion. The sample was pared in order to adhere as closely as possible to a proportional balance between the remedial and nonremedial samples at each age level.

For Phase II of the study, subjects were identified as having a b-d reversal problem based on their extreme total score for the first three subtests of the "b-d Discrimination Test." Means and standard deviations were computed for each age group in the nonremedial sample. Using this data, extreme criterion scores were defined for each age level. This operational definition was agreed upon by a panel of five judges composed of university professors in the field
of reading instruction and experienced diagnostic reading teachers. Each member of the panel approved a proposal which outlined and explained the criteria to be used in the selection of children with significant problems in distinguishing \( b \) and \( d \). (See Appendix G.)

Subjects in either the remedial or nonremedial samples whose error scores equaled or exceeded the criterion score at his age level was identified as having a \( b-d \) reversal problem. These individuals were described in more detail in Phase II of the study.

Data Collection

The data were collected over a four-month period in the winter and spring of 1975. Each subject was individually tested by one examiner who was qualified for this task by twenty years of teaching experience. Eight of those years were spent as a remedial reading teacher with duties in diagnostic testing. The environment in school surroundings could scarcely be described as sterile. Small amount of background noise from workmen or children in hallways or on playgrounds was sometimes in evidence.

The time it took to test each individual varied from forty-five minutes to approximately one hour. The examiner marked errors as the subjects responded. Lip involvement in the production of letters and words was regarded as closely as possible. The students' oral responses on the reversal
test were recorded, and the recordings were later employed in rechecking each test.

In addition, for subjects who were identified as having a b-d reversal problem, data were collected from the school records for use in describing this group.

Treatment of Data

After tests were rechecked and scored, the data were transferred to fortran coding forms so that cards could be punched for computer analysis of the data. Most of the statistical analysis was performed at the computer center at North Texas State University. Some simple correlations, proportions, tests of significance, and chi square analyses were computed on a desk calculator.

Phase I

The five research questions required analysis that would reveal specific patterns of decrease in reversal errors with age in both nonremedial and remedial samples. These trends were represented by a table displaying the means and standard deviations of the battery of tests used in the study and by polygons showing age level changes for the median scores on the four reversal tests taken by all subjects. Other figures display the percent of each age level sample who completed each of four reversal tests without making a reversal error, and a series of graphs
compare the percentage distributions for the nonremedial and remedial samples on each test at each age level.

The first hypothesis was tested by using a series of \( t \) tests for independent samples (7, pp. 151-153). Pearson product-moment correlations (7, pp. 99-103) were performed to relate age with scores on each of the tests listed in Hypotheses Two A and Two B. Significance was tested by using a table of critical values of the correlation coefficient (7, p. 457). Because of the surprising nature of the results, further analysis was indicated and this was accomplished through a test for significant differences between two correlation coefficients with independent samples (7, pp. 170-171).

Hypotheses Three and Four were partial correlation studies to determine the influence of knowledge of right and left as measured by the Standardized Road-Map Test of Direction Sense when the effects of age were factored out (7, pp. 390-392). To test Hypotheses Five and Six, a \( t \) test for correlated samples was used (7, pp. 153-155).

A one-way analysis of variance (7, pp. 153-155) was employed to test Hypothesis Seven. Hypothesis Eight was analyzed with the test of significance for a population proportion (9, pp. 321-324). A two-way analysis of variance (7, pp. 223-243) was used with Hypothesis Nine, and the Scheffé test (7, pp. 270-271) was used to test for significant differences in multiple comparisons.
For Hypotheses Ten A and Ten B and for Hypothesis Eleven, differences were gauged by a test of significance for a population proportion (9, pp. 321-324). Pearson product-moment correlation was used to correlate the test scores in Hypothesis Twelve. The significance of the relationship was determined by use of a table of critical values for the coefficient of correlation (7, p. 457). Hypotheses Thirteen and Fourteen were both analyzed with chi-square test of independence (7, pp. 182-186).

**Phase II**

The purpose of Phase II of the study was to identify and describe those subjects having extreme difficulty with b-d reversals. For each of these subjects, data were obtained from the pupil's cumulative record and from the psychological services department of the school district. These data were used in a discussion of characteristics of these extreme cases. This group with reversal difficulties was also described in terms of their responses to the battery of tests used in the study.

Comparisons were made using the *t* test for correlated samples (7, pp. 153-155), the Cochran and Cox adjusted *t* test (7, pp. 155-157), chi square (7, pp. 173-192), and the test of significance of a proportion in a population (9, pp. 321-324).
Summary

This investigation into the incidence and nature of b-d reversals was undertaken to provide insights that might assist in determining what, if any, techniques may be needed to develop effective remedial procedures for use with extreme reversers. Because no tests were available to measure the specific reversal errors to be examined in this study, tests were specifically designed for this study. Content validity was established by a panel of five judges from a field of reading instruction. The one standardized test used--Standardized Road-Map Test of Direction Sense--lacked reliability data. As a part of this study, reliability data were developed for all tests. Split-half reliability coefficients were adequate for all but the "Sentence Reading Test" and the "Kinetic Reversal Word Reading Test." Test-retest reliability for the "Test of Articulation of b-d Strategy" was also low.

In selecting subjects, ten schools were randomly selected from among schools with learning centers staffed by diagnostic reading specialists. Nonremedial subjects were randomly selected for each of four yearly age groups from seven through ten, but those who were involved in remedial reading or special education classes and who did not receive parental permission were tested and approximate proportional balance between the age levels of the nonremedial and
remedial samples was maintained, where necessary, by random exclusion of remedial subjects.

Of the schools used in the sample, four were in lower-class neighborhoods, three in lower-middle-class communities, two in middle-class sections, and two in upper-middle-class areas. The majority of subjects were Anglos, but a rather large percent of the remedial and nonremedial samples were made up of Blacks and Mexican-Americans. The data were collected in the elementary schools during the spring semester of 1975. Much of the statistical analysis was done by computer. Both parametric and nonparametric techniques were used.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

PRESENTATION OF DATA

There were two basic aims of this study. The first was to examine two types of readers—remedials and nonremedials—and to describe and analyze their b-d reversal patterns on a variety of tests. The second main objective was to identify from the two samples individuals with extreme difficulty with key letter reversals and to describe this group.

Phase I

The first objective was to explore several research questions regarding the developmental nature of b-d reversals. A further aim was to investigate, through fourteen hypotheses, factors which might be related to reversal errors.

Developmental Study of Reversal Errors

In order to present the developmental picture of the reduction of the tendency to reverse the letters b and d, five research questions are posed. To answer each of them, tables and/or figures are presented and discussed.

Average scores by age groups.—Although previous researchers have indicated a progressive abatement of b-d reversal tendencies through the primary grades, little was actually known of the extent to which nonremedial and remedial
populations reduce these errors year by year in such activities as letter naming, reading, and spelling. In order to add to the understanding of the way reversal errors phase out of the two populations, the following research question was posed. What will be the average number of reversal errors made by samples of remedial and nonremedial readers at age groups of seven, eight, nine, and ten on the battery of tests administered in the study? In order to give a complete picture, two average scores are presented. First, a table of means and standard deviations at each age level of the remedial and nonremedial sample is presented and discussed. Second, since the distributions were skewed and means do not, therefore, represent a "typical score," the median was used for graphic representation of the developmental picture of key letter reversals in letter naming, word reading, and writing-spelling. Table VI contains the means and standard deviations for the battery of reversal tests used in this study.*

The progression of error means with the increase in age reflected a general trend for a lessening of b-d reversals as age increased. This trend was most apparent in letter naming, word reading, and writing-spelling. These tests were administered to every subject in both samples. For the nonremedial group, where the mean appeared to show a regression

*The "Test of Articulation of b-d Strategy" produced only nominal level data and, therefore, is not included on the chart.
### TABLE VI

AGE PROFILES OF MEANS AND STANDARD DEVIATIONS OF ERRORS MADE BY NONREMEDIAL (GROUP A) AND REMEDIAL READERS (GROUP B) ON A BATTERY OF TESTS

<table>
<thead>
<tr>
<th>Test</th>
<th>Age Group</th>
<th>Seven</th>
<th></th>
<th>Eight</th>
<th></th>
<th>Nine</th>
<th></th>
<th>Ten</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\bar{X}$</td>
<td>$S$</td>
<td>$\bar{X}$</td>
<td>$S$</td>
<td>$\bar{X}$</td>
<td>$S$</td>
<td>$\bar{X}$</td>
<td>$S$</td>
</tr>
<tr>
<td>(1) Letter Naming</td>
<td>A</td>
<td>2.90</td>
<td>3.59</td>
<td>1.80</td>
<td>3.14</td>
<td>1.23</td>
<td>2.92</td>
<td>.40</td>
<td>1.19</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.18</td>
<td>3.24</td>
<td>4.94</td>
<td>2.95</td>
<td>4.75</td>
<td>3.32</td>
<td>3.55</td>
<td>4.27</td>
</tr>
<tr>
<td>(2) Word Reading</td>
<td>A</td>
<td>3.60</td>
<td>3.06</td>
<td>1.60</td>
<td>2.53</td>
<td>1.20</td>
<td>2.78</td>
<td>.83</td>
<td>1.23</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.38</td>
<td>2.58</td>
<td>3.53</td>
<td>3.12</td>
<td>4.05</td>
<td>2.84</td>
<td>3.40</td>
<td>4.27</td>
</tr>
<tr>
<td>(3) Writing-Spelling</td>
<td>A</td>
<td>3.21</td>
<td>4.25</td>
<td>1.83</td>
<td>2.63</td>
<td>2.23</td>
<td>4.86</td>
<td>1.03</td>
<td>2.48</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.41</td>
<td>4.89</td>
<td>5.18</td>
<td>4.90</td>
<td>4.15</td>
<td>4.04</td>
<td>3.95</td>
<td>4.70</td>
</tr>
<tr>
<td>(4) Sentence Reading</td>
<td>A</td>
<td>1.20</td>
<td>1.62</td>
<td>.75</td>
<td>.93</td>
<td>.52</td>
<td>.75</td>
<td>.96</td>
<td>1.14</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td></td>
<td></td>
<td>.75</td>
<td>.93</td>
<td>2.67</td>
<td>1.53</td>
<td>.60</td>
<td>1.34</td>
</tr>
<tr>
<td>(5) Nonsense Spelling</td>
<td>A</td>
<td>2.94</td>
<td>2.79</td>
<td>2.00</td>
<td>2.60</td>
<td>1.42</td>
<td>3.16</td>
<td>.48</td>
<td>.99</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.00</td>
<td>1.41</td>
<td>1.67</td>
<td>2.08</td>
<td>2.33</td>
<td>1.87</td>
<td>1.60</td>
<td>2.87</td>
</tr>
<tr>
<td>(6) Sense-Nonsense</td>
<td>A</td>
<td>5.25</td>
<td>5.79</td>
<td>2.36</td>
<td>3.19</td>
<td>1.58</td>
<td>3.70</td>
<td>1.31</td>
<td>2.14</td>
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<tr>
<td></td>
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<td>12.00</td>
<td>2.83</td>
<td>5.00</td>
<td>2.82</td>
<td>8.00</td>
<td>6.89</td>
<td>3.79</td>
<td>4.02</td>
</tr>
<tr>
<td>(7) Kinetic Reversal Word Reading</td>
<td>A</td>
<td>.77</td>
<td>1.04</td>
<td>.17</td>
<td>.38</td>
<td>.20</td>
<td>.55</td>
<td>.10</td>
<td>.40</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>.94</td>
<td>.90</td>
<td>1.17</td>
<td>1.13</td>
<td>.90</td>
<td>.91</td>
<td>.55</td>
<td>.83</td>
</tr>
<tr>
<td>(8) Road-Map Test of Direction Sense</td>
<td>A</td>
<td>15.30</td>
<td>3.62</td>
<td>14.13</td>
<td>3.61</td>
<td>12.96</td>
<td>5.03</td>
<td>10.80</td>
<td>7.21</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>15.47</td>
<td>2.67</td>
<td>15.00</td>
<td>3.62</td>
<td>14.85</td>
<td>3.33</td>
<td>11.10</td>
<td>5.29</td>
</tr>
</tbody>
</table>
in a succeeding age level;* the presence of two extreme individuals in the nine-year-old sample accounted for the phenomenon. No general regression was evident as can be seen in the percentage distribution charts in Appendix I. The same trend toward error reduction can be observed in the mean sequences for the "Kinetic Reversals Word Reading Test," which was taken by all individuals included in the study. The average number of kinetic reversals was so low as to indicate that this type of reversal as tested on the word reading test was not common in either sampled population.

For the "Sentence Reading Test," it can be seen that no subjects in the remedial sample at the seven- and eight-year-old levels could read at the instructional level (3.1) required for this test. Even at the upper-age levels on this test and at all the levels on the "Nonsense Spelling Test" and the "Sense-Nonsense Test," the number of subjects in the remedial sample were too few to regard these data as appropriate for drawing inferences about developmental trends. In the nonremedial sample, as well, the number of subjects able to respond at a level acceptable for taking the test steadily increased at each age level. A consistent abatement of reversal errors may be seen in the two tests containing nonsense words. The "Sentence Reading Test," however, reflected an upturn in error mean in the ten-year-old category.

*Between ages eight and nine of the "Writing-Spelling Test."
Although some interesting theories might be advanced to explain this finding, it seems more prudent to shrink from any developmental inferences based on tests with levels of difficulty which screened some below average readers from earlier age levels but retained them in older groups.

Graphic presentation of the average numbers of reversal errors made by seven-, eight-, nine-, and ten-year olds should be of assistance in understanding the developmental picture of the way in which b-d reversal errors tended to subside as specific populations of remedial and nonremedial readers advanced in age. In examining these data, the reader should be cautioned that they are the result of a cross-sectional study. Such a design may be less likely to distort the results for the nonremedial than for the remedial sample. This circumstance may occur because the nonremedial sample was drawn from a population of subjects from which entrance and exit over the four-year period would have been less determined by performance in reading and spelling than would the remedial reading population. The criterion for selection and retention in the remedial population could have interacted with developmental factors examined in this study. It will be important to keep this in mind as the following material is discussed.

Median graphs were prepared only for those b-d reversal tests which were taken by all subjects in every age category.
The more difficult tests were not included because younger
subjects who were able to take these tests were probably
primarily from the upper half of their age categories in
reading achievement. Many older subjects who took these
tests undoubtedly would rank below the mean in reading
achievement. To try to present data from samples which
systematically change as age increases would present an
erroneous picture. Consequently, median graphs are pre-
sented only for the first three subtests of the "b-d
Discrimination Test," and the "Kinetic Reversal Word Read-
ing Test" which were taken by all subjects.

The "Letter Naming Test" resulted in the age medians
shown in Figure 1.

--- Remedial
----- Nonremedial

Fig. 1--"Letter Naming Test": a profile of medians of
b-d reversal errors for four age groups.
It will be remembered from the discussion of previous research in Chapter II that letter reversals are common among five- and six-year olds. What one would expect to find in testing normal groups of pupils aged seven through ten is a record of how the letter confusion tails off to an asymptote. The nonremedial sample confirmed these expectations. The difficulty appeared to be primarily overcome in letter naming by the eighth year, and asymptote seemed to have been reached in the sample by age nine. The remedial sample produced a very different result.

The unexpected convex line due to the high median for the eight-year-old sample may be explained in several ways. It could, of course, be the function of the selection and retention policies of the learning centers serving the remedial readers. On the other hand, it could reflect a chance occurrence representing little overall progress between ages seven and nine. Because the charts of percentage distribution, Appendix I, do not indicate an overall regression at succeeding ages, they would fit this latter explanation although they do not rule out the former.

Even with the lower median registered by the remedial ten-year olds, they were still far from asymptote and had not yet reached the level attained by the seven-year-old nonremedial subjects. If these findings are a picture of a developmental lag, the lag between these two samples appears considerable.
The graph of age medians from the "Word Reading Test" in some ways paralleled the findings of the "Letter Naming Test."

The nonremedial sample demonstrated the most dramatic reduction in b-d reversals between ages seven and eight, and beyond eight years of age the reversal tendency leveled out with a median of less than one. The remedial sample exhibited a pattern of erratic dips and rises from one age group to the next. The same eight-year-old sample that reflected an unexplained rise in central tendency in the reversal of isolated letters showed a decrease in b-d reversals in word reading which was not commensurate with the little overall increase evidenced between the seven- and nine-year-old groups. This pattern further supports the
explanation that chance factors may account in part for the erratic performance of the eight-year-old sample. The ten-year-old group showed less b-d reversal tendency than younger remedial pupils, though as a group their level of reversal was still considerably beyond that which could be described as random error.

The basic trends of the previous profiles were repeated by the graph of age level medians of key letter reversals on the "Writing-Spelling Test."

![Graph of age level medians of key letter reversals for four age groups.](image)

Fig. 3--"Writing-Spelling Test": a profile of medians of b-d reversal errors for four age groups.

In the nonremedial sample, successive age groups showed the characteristic tapering off of reversal errors. The remedial age-samples also showed a gradual reduction in average reversal errors. As had been observed on the
previous graphs, the steepest slope of the remedial curve occurred between the ninth and tenth year.

**Developmental comparison of b-d reversals and kinetic reversals.**—In the past, kinetic and static reversals have been treated as basically the same kinds of errors, yet some authorities have felt that they may actually represent different types of confusions. (See discussion in Chapter II.) To contrast the reduction in these types of errors at progressively older age levels, this research question was asked. How will profiles of age group changes of b-d reversal patterns in word reading compare with kinetic word reading reversal patterns for the same groups? With all the tested samples, the median number of letter sequence reversals on the "Kinetic Reversal Word Reading Test" was smaller than the average number of key letter reversals. Because of this fact, Figure 4 was given a different median scale so that smaller changes could be more easily seen.

Even though the seven-year-old nonremedial median was less than one, the same basic tapering pattern was observed with kinetic reversals as was seen in figures demonstrating the tailing off of b-d reversals. The remedial profile for kinetic reversals also assumed the characteristic but more flexible mold that typified age group changes in b-d reversals. Here, the basic patterns
in the reduction of different kinds of reversals were similar even though one type of reversal produced a significantly larger number of errors than the other (as will be seen later).

Percentage of age level samples making no reversal errors.--The aim of this portion of the study was to answer two questions. First, will the percentage of subjects who make no reversal errors tend to increase at each age level on the following tests: (a) "Letter Naming Test," (b) "Word Reading Test," (c) "Writing-Spelling Test," and (d) "Kinetic Reversal Word Reading Test"? Second, at what age will fifty percent of the nonremedial samples make no reversal errors on each test? Most studies of reversals
have involved subjects at the first-grade level or lower. The primary purpose of a developmental study of subjects aged seven through ten was to observe the way the problem disappeared at successive age levels. One of the best graphic representations for observing the elimination of the reversal problem in the two sampled populations is with charts showing the percentage of subjects in each age group who made no reversals on particular tests.

Graphs showing the percent of subjects with perfect scores are presented for all reversal tests which were administered to all subjects: the "Letter Naming Test," the "Word Reading Test," the "Writing-Spelling Test," and the "Kinetic Reversal Word Reading Test."

Fig. 5--Percent of subjects making no reversal errors of the "Letter Naming Test."
Fig. 6--Percent of subjects making no reversal errors on the "Word Reading Test."

Fig. 7--Percent of subjects making no reversal errors on the "Writing-Spelling Test."
These graphs complement the median polygons. Not only did group tendency for key letter reversals decline steadily with age in the nonremedial sample, but the percent of individuals who made no b-d substitutions with one exception (there was no change between the percent of nine- and ten-year-old nonremedial subjects who made perfect scores on the "Word Reading Test") increased at successive ages. In letter naming, more than fifty percent of the subjects were able by age eight to complete the task without a reversal error, but on the word reading and writing-spelling measures the fifty percent level was not reached until age nine. Even at the ten-year-old level more than
a third of the nonremedial subjects made occasional b-d reversals. The remedial samples produced more erratic patterns from age to age, yet a developmental trend was discernible. On none of the major b-d reversal tests, however, was fifty percent of any sample able to complete the task without committing at least one key letter reversal even through ten years of age.

The kinetic reversal chart reflected the earlier elimination of this type of error. More than fifty percent of the seven-year-old nonremedials were able to complete the test without error.

Percentage distributions by age groups.--No developmental study would be complete without examining the score distribution patterns within each age level strata. The following research question was designed for the purpose of comparing the error distributions of the two separate samples. What specific comparisons can be made between remedials and nonremedials from percentage distributions of each age level sample? A more thorough picture of the way in which the samples were distributed in the number of reversal errors is presented in Appendix I. Since the nonremedial and remedial samples did not contain equal numbers of subjects, the data were transformed from frequencies into percentages in order to facilitate comparison of the two samples. From these graphs, several things
became apparent. The distribution of nonremedials is consistently more skewed than that of the remedials. It may be assumed that any significant differences indicating the nonremedials to exceed the remedial group in reduction of b-d reversals would be descriptive of the differences in the samples in general and not merely the result of a few extreme individuals in the remedial sample. As a matter of fact, it may be seen that extreme scores were not limited to the remedial groups.

When the writing-spelling distributions are compared age for age with the word reading distribution of the non-remedial group, some differences may be noted. However, the distributions do roughly approximate one another. Although these two types of reversals may involve different variables, as will be seen from the results of later hypotheses, the schedule of reduction seemed roughly equivalent in this series of samples.

Judgment of right and left compared with reversal age patterns.--In the standardization of the Standardized Road-Map Test of Direction Sense, norms were reported for the seven-to ten-year-old category as a whole, but not for yearly age groups. Therefore, little information was actually available to indicate what might be the typical error patterns for each of the age groups involved in this study. A comparison of group distributions for nonremedials
and remedials could assist in understanding any general differences, if any, that may exist in the year by year patterns of these two groups in developing a sense of direction. In addition, these developmental patterns could be compared with those of the same groups in reversal tendencies to determine if development in the two areas was congruent. The aim of the following research question was to provide these kinds of comparisons. How will remedials and nonremedials compare on age group error-means in judgment of right and left (as measured by the Standardized Road-Map Test of Direction Sense) and how will these patterns compare with those of reversal errors? Some important observations can be made by comparing the mean scores of age level samples on knowledge of right and left with mean scores made on the reversal tests (see Table VI). A general trend toward fewer errors as age increases can be observed on both the sense of direction test and the reversal tests. However, although means of errors in judgment of right and left are lessened by the effects of age, a closer examination of the data indicates that the test may be examining a level of directional sense that is not generally characteristic of seven- to ten-year-old subjects. Since subjects had two choices for each response on the thirty-two item test, the mean which should be expected from unbiased guessing would be sixteen, yet the seven- and eight-year old nonremedial groups achieved a
mean of only 15.30 and 14.13, respectively. From the percentage distributions (Appendix I) in the seven-, eight-, and nine-year-old categories, it can be seen that there is only a small degree of reduction in errors by the group as a whole. In the nonremedial group, the diminishing means seem to be primarily the result of precocious individuals who became dramatically better than their age mates. The distribution of the ten-year-old nonremedials approximates a bimodal appearance with clumpings of individuals who seem to be approaching mastery of this rather advanced skill in directional sense removed from the bulk of the sample which assumed the form of a slightly flattened curve around the same point that had been characteristic of the central tendency of earlier age levels. The test may measure a level of distinguishing right and left that is just beginning to be established at ages nine and ten by those who are advanced in sense of direction. The early developers may cross a threshold of understanding that makes them distinctly better than their peers. However, these inferences need to be tested further since the remedial samples did not exhibit the same dichotomy between good and poor performance at the ten-year-old level.

By contrasting the developmental pattern of the reversal tests with the road-map test, it becomes obvious that the nonremedial subjects had as a group largely overcome b-d reversals by the age levels in which some were
just beginning to gain competence in the sense of direction measured by the road-map test. This observation is important for the interpretation of Hypotheses Three, Four, and Seven which investigated certain relationships between the two variables.

**Factors Related to b-d Reversal Errors**

In this section, fourteen hypotheses are examined to investigate certain aspects of b-d reversals. The hypotheses touch four basic areas: (1) differential effects of b-d reversals on remedial and nonremedial samples, (2) the relationship of age, directional sense, and strategy for distinguishing the key letters on reversals, (3) differences in occurrence of two types of reversal errors, and (4) influences of context upon b-d reversal errors.

**Hypothesis One:**—Other researchers have determined that general reversal errors are related to low level learning. No studies had been focused on b-d reversals specifically and none had examined remedials and nonremedials of the same age to discover how they may differ on reversal errors in their reaction to a battery of tests gauging skill in letter naming, word reading, writing, sentence reading, and in reading and spelling nonsense syllables. The purpose of Hypothesis One was to investigate a specific type of static reversal in these areas of performance in groups of remedial and nonremedial readers.
Since maturity has been identified as a factor which relates to the reduction in tendency to make reversal errors (see discussion in Chapter III), a proportional balance of subjects in the remedial and nonremedial groups was sought at each age level. Initially, it was postulated that the usual lag in identifying remedial readers might make it impossible to obtain an adequate number of seven-year olds in the remedial population to maintain the proportional balance and include seven-year olds in this analysis. Hence, the hypothesis restricted this study to subjects over eight years of age. Thirty nonremedial subjects were selected at each age level and twenty remedial subjects were sought. The nine- and ten-year-old categories furnished the desired number of twenty remedial subjects, but the entire population of eight-year-old remedial readers for whom parental permission for testing was obtained was only seventeen. Because of the robust nature of the \( t \) test which was to be used to test the hypothesis, it was decided to abridge the proportional balance rather than to reduce the nine- and ten-year-old categories. The balance was thus considered adequate without making any adjustments. The \( t \) test for independent samples was used to test the hypothesis in the null form. Subjects age 8.0 through 10.11 in Group B will not have a significantly higher degree (\( P \leq .05 \)) of error responses than in Group A on the following tests:
(a) "Letter Naming Test"
(b) "Word Reading Test"
(c) "Sentence Reading Test"
(d) "Writing-Spelling Test"
(e) "Nonsense Spelling Test"
(f) "Sense-Nonsense Test"
(g) "Kinetic Reversal Word Reading Test"

The results of the tests are shown in Table VII.

TABLE VII

DIFFERENCES BETWEEN NONREMEDIAL READERS (GROUP A) AND REMEDIAL READERS (GROUP B) IN REVERSAL ERRORS MADE IN VARIETIES OF SITUATIONS

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>( \bar{X} )</th>
<th>S</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Naming Test</td>
<td>A</td>
<td>1.144</td>
<td>2.608</td>
<td>146</td>
<td>6.382</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.379</td>
<td>3.548</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Word Reading Test</td>
<td>A</td>
<td>1.211</td>
<td>2.281</td>
<td>146</td>
<td>5.189</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>3.638</td>
<td>3.412</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentence Reading Test</td>
<td>A</td>
<td>.758</td>
<td>.970</td>
<td>68</td>
<td>1.541</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.375</td>
<td>1.685</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing-Spelling Test</td>
<td>A</td>
<td>1.700</td>
<td>3.495</td>
<td>146</td>
<td>3.993</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>4.328</td>
<td>4.748</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsense Spelling Test</td>
<td>A</td>
<td>1.234</td>
<td>2.433</td>
<td>103</td>
<td>1.231</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.893</td>
<td>2.409</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sense-Nonsense Test</td>
<td>A</td>
<td>1.701</td>
<td>3.031</td>
<td>101</td>
<td>4.664</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>5.731</td>
<td>5.539</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kinetic Reversal Word Reading Test</td>
<td>A</td>
<td>.157</td>
<td>.450</td>
<td>145</td>
<td>5.981</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>.862</td>
<td>.963</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sentence Reading Test*</td>
<td>A</td>
<td>1.037</td>
<td>1.400</td>
<td>113</td>
<td>4.531</td>
<td>&lt; .0001</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2.559</td>
<td>2.120</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Scores of those reading at frustration levels included.
Most of the tests produced a highly significant difference in the error scores of the remedial and nonremedial readers. The results of the "Sentence Reading Test" did not significantly differ. When scores of students reading at frustration level were included, the groups did differ significantly on the number of reversal errors on the "Sentence Reading Test." Nevertheless, on the basis of the $t$ test, the null hypothesis is rejected for all scores except those made on the "Sentence Reading Test" and the "Nonsense Spelling Test." For these two test results, the null hypothesis is retained.

An examination of the means and standard deviations will reveal that the samples were not normally distributed. However, because of the highly significant nature of the differences obtained, these differences can be considered actual. A chi square test of the same data transformed to the nominal level confirmed that the significant differences obtained from $t$ test were also all highly significant at greater than the .001 level using the nonparametric procedure.

A possible explanation for nonsignificant findings on sentence reading and nonsense spelling is that the difficulty

*The low reliability of the "Sentence Reading Test" restricts its use to a measure of random $b$-$d$ reversal tendencies in groups. It is not a good measure for evaluating individuals or for evaluating group progress in reducing reversal errors.
level of the instruments used to test these factors excluded a disproportionate number of young remedial students from this part of the study. The proportional balance which had been sought between the age levels to rule out the effects of maturity was rather seriously breached; hence, the differences between the two groups failed to reach significance. The age level frequency of subjects included in the remedial and nonremedial groups on both tests is shown below.

TABLE VIII

AGE LEVEL FREQUENCIES OF NONREMEDIAL AND REMEDIAL SUBJECTS WITH SCORES ON THE "SENTENCE READING TEST" AND "NONSENSE SPELLING TEST"

<table>
<thead>
<tr>
<th>Test</th>
<th>Group</th>
<th>Numbers in Age Level Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>8 yrs.</td>
</tr>
<tr>
<td>Sentence Reading</td>
<td>Nonremedial</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Remedial</td>
<td>0</td>
</tr>
<tr>
<td>Nonsense Spelling</td>
<td>Nonremedial</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>Remedial</td>
<td>3</td>
</tr>
</tbody>
</table>

The consistent finding of the hypothesis is that on those tests of sufficiently low difficulty to permit an approximate proportional representation of subjects in each of three age categories significant differences were found among the b-d reversal errors of nonremedials and remedials.
However, it must be added that the "Sense-Nonsense Test," a word reading test, was almost identical to the "Nonsense Spelling Test" in age level representation of the two groups; yet, significantly different means resulted in the remedial-nonremedial comparison. Likewise, in the comparison of groups of reversal errors in reading when scores produced at frustration level were included, the groups were ruled significantly different in spite of a disproportionately large number of young subjects in the non-remedial sample.

The basic findings of this hypothesis support Orton's view (10, 11) that reversal errors are common among remedial readers, but they do not necessarily lead to the causal relationship he inferred from this occurrence. The reversals could just as well be a result of the reading immaturity.

Hypothesis Two-A.--The purpose of Hypothesis Two-A was to determine if age was a significant negative correlate of the incidence of b-d reversal errors in a sample of non-remedials. A statement of the hypothesis in the null form follows:

In Group A, a correlation coefficient will not significantly differ from zero \( (p \leq .05) \) when age in months is correlated with scores on the following tests:

(1) "Letter Naming Test"
The null hypothesis is rejected for all but the "Sentence Reading Test." The basic finding of this hypothesis is that among nonremedials letter naming, word reading, and writing reversal errors are significant negative correlates of age. This relationship was established in spite of the skewed nature of the distribution examined.

These results are in agreement with previous research findings relating increased age to the reduction of general reversal tendencies (see "Maturity" in Chapter II). The
failure to establish a significant relationship between age and b-d reversals in sentence reading may be the result of two factors. First, the "Sentence Reading Test" could be read by only the better readers in the younger age groups. Since many of the subjects who had particular difficulty with static reversals may have been among the younger pupils who were unable to read the test at an acceptable level, the impact of age level differences might have been reduced to insignificance. This finding may have resulted not because the act of reading sentences tended to obscure age level differences, but because the difficulty level of the sentence reading test acted to produce basically different samples of subjects at successive age levels. A second reason for this test's failure to result in a significant relationship between age and reversal tendencies may lie in the fact that the test itself had low reliability. However, the "Kinetic Reversal Word Reading Test" did reflect a significant age level relationship, although it was not found to be a reliable measure.

Hypothesis Two-B:--This hypothesis was designed to test relationships between age and reversal tendencies in the remedial group. The null hypothesis was stated in this manner. In Group B, a correlation coefficient will not significantly differ from zero ($p \leq .05$) when age in months is correlated to the following tests:

(1) "Letter Naming Test"
(2) "Word Reading Test"
(3) "Sentence Reading Test"
(4) "Writing-Spelling Test"
(5) "Kinetic Reversal Word Reading Test"

Table X gives the resulting correlation coefficients.

TABLE X

RELATIONSHIP OF AGE TO REVERSAL ERRORS MADE BY REMEDIAL READERS

<table>
<thead>
<tr>
<th>Test</th>
<th>df</th>
<th>Correlation Coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Naming</td>
<td>73</td>
<td>-.047</td>
<td>n.s.</td>
</tr>
<tr>
<td>Word Reading</td>
<td>72</td>
<td>-.046</td>
<td>n.s.</td>
</tr>
<tr>
<td>Sentence Reading</td>
<td>6</td>
<td>-.445</td>
<td>n.s.</td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>73</td>
<td>-.144</td>
<td>n.s.</td>
</tr>
<tr>
<td>Kinetic Reversal Word Reading</td>
<td>73</td>
<td>-.166</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

In contrast to the significant negative relationships which were found between age and the letter naming, reading, and spelling reversals of the nonremedial sample, no significant relationships were found between the same variables in the sample of remedial readers. The null hypothesis was, therefore, retained. Because of the unexpected nature of these findings, a further analysis was undertaken to determine if the differences obtained from
the correlation studies in the two samples was significant. The null form of the hypothesis being tested was Group A and Group B will show no difference in correlation of age in months and scores on the following tests
(1) "Letter Naming Test"
(2) "Word Reading Test"
(3) "Sentence Reading Test"
(4) "Writing-Spelling Test"
(5) "Kinetic Reversal Word Reading Test"

This hypothesis was tested by using the test of significant difference between two correlation coefficients for independent samples (4, pp. 170-171).

TABLE XI

DEGREE TO WHICH REMEDIALS AND NONREMEDIALS DIFFER ON CORRELATION BETWEEN AGE AND SCORES ON REVERSAL TESTS

<table>
<thead>
<tr>
<th>Test</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Naming</td>
<td>1.738</td>
<td>.08 (n.s.)</td>
</tr>
<tr>
<td>Word Reading</td>
<td>2.149</td>
<td>.04*</td>
</tr>
<tr>
<td>Sentence Reading</td>
<td>.920</td>
<td>.70 (n.s.)</td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>.3866</td>
<td>.36 (n.s.)</td>
</tr>
<tr>
<td>Kinetic Reversal Word Reading</td>
<td>1.146</td>
<td>.25 (n.s.)</td>
</tr>
</tbody>
</table>

*Significant
The null hypothesis is rejected only for the "Word Reading Test" which produced significant differences between the remedial and nonremedial groups. The results of all comparisons except that of the two groups on the "Letter Naming Test" fell well within the range that might have been expected by chance. The null hypothesis is, therefore, retained for all but the comparison of the two correlations between age and word reading.

There are several possible explanations of why age did not prove a significant factor in reducing b-d and kinetic reversals of remedial subjects. Since this was a cross-sectional study, the difference may in part lie in the criteria used in selecting and releasing remedial reading students. An alternative explanation is that the developmental gradient for the disappearance of these types of reversals is so slight for some remedial readers within the four-year-age span examined that no significant age relationship could be established. Still another possibility is that some remedial teachers had through therapy successfully reduced reversal errors while other teachers had followed the advice of some authorities to ignore the problem. This possibility is mentioned because it was observed that the remedial instructor in a learning center which furnished a large number of young remedial subjects and few older ones had used several ways of assisting her pupils in overcoming the b-d reversal problem, and a
mnemonic clue which she had given them was used by some of the subjects to respond to the "Test of Articulation of b-d Strategy." If the instruction had significantly reduced the reversals of this basically young group of subjects, the significance of the relationship of age to b-d reversals in the remedial group might have been obscured.

The findings of Hypotheses Two-A and Two-B do not confirm the findings of Lyle and Goyen (9) who indicated that the differences in reversal tendencies between normal and poor readers lessened with age. Their findings would result in a conclusion that the age gradient of remedial pupils in relation to reduction of reversal errors would be sharper, especially among the older members of the sample than among the nonremedials, but the opposite was found to be true. The basic failure of the remedial subjects tested in this study to "close the gap" separating them from nonremedial readers on reversal measures can also be observed by viewing the means of successive age groups on each test shown in Table VI.

Hypothesis Three.—Hypothesis Three was used to explore the degree to which immaturity in the knowledge of right and left, as measured by the Standardized Road-Map Test of Direction Sense, was related to the problem of b-d reversal errors made by nonremedial students in various linguistic settings. Since age was a factor believed to
relate to both the development of a sense of direction and the lessening of reversal errors, it was considered important to statistically remove this factor before considering the effect of the knowledge of right and left in the reduction of reversal tendencies. The scores of the reversal tests and the Standardized Road-Map Test of Direction Sense were recorded as error scores. The question, then, was basically--Did the reduction of errors in sense of direction significantly coincide with the reduction of reversal errors? Stated in the null form, Hypothesis Three reads as follows:

In Group A with age held constant, no significant relationship will be found between knowledge of left and right as measured by the Standardized Road-Map Test of Direction Sense and scores on the following tests:

(a) "Letter Naming Test"
(b) "Word Reading Test"
(c) "Sentence Reading Test"
(d) "Writing-Spelling Test"
(e) "Kinetic Reversal Word Reading Test"

The t test was used to test the significance of the partial coefficients (4, pp. 390-392). The results of the partial correlation study are shown in Table XII.

The null hypothesis is retained. No significant relationship was demonstrated between errors in the judgment of direction and b-d reversal errors as measured by any of
TABLE XII

CORRELATION OF ERRORS MADE BY NONREMEDIAL READERS IN JUDGING RIGHT AND LEFT WITH THEIR REVERSAL ERRORS WHEN AGE IS HELD CONSTANT

<table>
<thead>
<tr>
<th>Test</th>
<th>df</th>
<th>Residual Correlation</th>
<th>t</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Naming</td>
<td>115</td>
<td>.1082</td>
<td>1.167</td>
<td>n.s.</td>
</tr>
<tr>
<td>Word Reading</td>
<td>115</td>
<td>.1121</td>
<td>1.209</td>
<td>n.s.</td>
</tr>
<tr>
<td>Sentence Reading</td>
<td>69</td>
<td>.0044</td>
<td>.036</td>
<td>n.s.</td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>115</td>
<td>.1745</td>
<td>1.900</td>
<td>n.s.</td>
</tr>
<tr>
<td>Kinetic Reversal</td>
<td>116</td>
<td>.1197</td>
<td>1.298</td>
<td>n.s.</td>
</tr>
<tr>
<td>Word Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

the listed instruments. It can be noted that all of the relationships between mistakes in judging direction and reversal errors are positive. However, these findings confirm those of Chapman and Wedell (3) who failed to demonstrate a relationship between knowledge of left and right and reversal tendencies. However, as was discovered in the developmental study discussed earlier, the validity of the road-map test as a measure of sense of direction for the age groups involved in this study may be questioned. The type of directional sense measured by this instrument appeared to be developing in only a few of the older subjects. Just where the particular skill measured by the Standardized Road-Map Test of Direction Sense fits into the hierarchy of skills leading to a mature sense of
direction is yet to be determined. Since b-d reversals were reduced to a negligible factor in reading and writing in the nonremedial sample before the sense of right and left called for in this test was largely begun, it undoubtedly could have little causal relationship to reversal errors. Perhaps some point lower in the sequence of skills involved in the development of a sense of right and left may be crucial to accurate b-d discrimination.

Hypothesis Four.--Hypothesis Four differed from the previous hypothesis only in the type of subjects being tested. By Hypothesis Four, the possibility that failure to develop adequate skill in judging between right and left may be a fundamental factor in persistent reversal errors of remedial readers was investigated. It was hypothesized that errors in judging right and left on the Standardized Road-Map Test of Direction Sense would significantly correlate with errors on reversal tests. Stated in the null form, the hypothesis read, In Group B with age held constant no significant relationship will be found between knowledge of left and right as measured by the Standardized Road-Map Test of Direction Sense and scores on the following tests:

(a) "Letter Naming Test"
(b) "Word Reading Test"
(c) "Sentence Reading Test"
(d) "Writing-Spelling Test"
(e) "Kinetic Reversal Word Reading Test"

After a $t$ test was used to gauge the significance of the findings, a partial correlation study produced the following results:

**TABLE XIII**

CORRELATION OF ERRORS MADE BY REMEDIAL READERS IN JUDGING RIGHT AND LEFT WITH REVERSAL ERRORS WHEN AGE IS HELD CONSTANT

<table>
<thead>
<tr>
<th>Test</th>
<th>df</th>
<th>Residual Correlation</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Letter Naming</td>
<td>70</td>
<td>.2526</td>
<td>2.184</td>
<td>.05*</td>
</tr>
<tr>
<td>Word Reading</td>
<td>70</td>
<td>.0423</td>
<td>.354</td>
<td>n.s.</td>
</tr>
<tr>
<td>Sentence Reading</td>
<td>5</td>
<td>.2397</td>
<td>.552</td>
<td>n.s.</td>
</tr>
<tr>
<td>Writing Spelling</td>
<td>70</td>
<td>.0041</td>
<td>.034</td>
<td>n.s.</td>
</tr>
<tr>
<td>Kinetic Reversal Word Reading</td>
<td>70</td>
<td>.1133</td>
<td>.954</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

*Significant

The null hypothesis is retained except for the "Letter Naming Test." The relationship between error scores on the **Standardized Road-Map Test of Direction Sense** and the "Letter Naming Test" reached significance even when the effects of age were held constant. The null hypothesis is, therefore, only partially rejected. Any interpretation of this one significant finding should be done with caution, since it is only one of ten $t$ tests (including those used
for Hypothesis Three) which was judged significant and the low level of significance may arouse suspicion of a type one error in declaring b-d reversals in letter naming to be significantly related to errors in sense of right and left among remedial subjects. In addition, in declaring this factor to be significant, one incurs the problem of providing a rationale for this occurrence. This is particularly difficult since the two other reversal tests with a high degree of reliability, the "Word Reading Test" and the "Writing-Spelling Test," reflected a negligible relationship between directional sense and reversal tendency among remedial readers. When the overall picture is considered, these findings cannot be construed as contradicting those of former researchers who have reported no significant relationship between poor sense of direction and reversal tendencies (3). Yet, for the same reasons discussed in Hypothesis Three, the question of the validity of the Standardized Road-Map Test of Direction Sense for the age groups in these samples makes it difficult to use these findings to support any overall conclusions concerning the knowledge of right and left and reversal tendencies.

Hypothesis Five.--The purpose of Hypothesis Five was to determine if b-d reversals occur more frequently than kinetic reversals. The results of two tests were compared.
The "Word Reading Test" was composed of a list of twenty words which contained either a b or a d. The "Kinetic Reversal Word Reading Test" was made up of a list of ten pairs of words which differed only in the order of letter placement. The words had been selected for the likelihood of reversal by young readers. This arrangement gave each subject an equal number of chances to make a b-d or a kinetic reversal. The results of the two tests were compared using a $t$ test for correlated samples (4, p. 171-172). The hypothesis was tested in this null form.

When scores on the "Word Reading Test" are compared with those of the "Kinetic Reversal Word Reading Test," no significant difference ($p \leq .05$) will result. Table XIV shows this comparison.

TABLE XIV

COMPARISON OF THE INCIDENCE OF b-d REVERSALS AND KINETIC REVERSALS IN WORD LIST PRESENTATION

<table>
<thead>
<tr>
<th>Test</th>
<th>Error</th>
<th>Standard Deviation</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Reading</td>
<td>2.505</td>
<td>2.874</td>
<td>10.457</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Kinetic Reversal</td>
<td>.536</td>
<td>.849</td>
<td>10.457</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Word Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the basis of this test, the null hypothesis is rejected at the .0001 level. Because the results of the test
demonstrated that scores on the two tests did not form a normal distribution and had thus violated the assumptions of the $t$ test, it was felt that the hypothesis should also be tested using a nonparametric method. The hypothesis was tested a second time using chi square. Four hundred eighty-one words were missed on the "Word Reading Test." This was compared with one hundred three letter sequence reversals on the "Kinetic Reversal Word Reading Test."

When the chi square formula was applied (4, pp. 173-175), a chi square value of 244.66 was obtained. Since with one degree of freedom a value of only 10.83 is required for significance at the .001 level, the difference in the number of errors produced in the two situations may be regarded as highly significant. The null hypothesis is rejected with a nonparametric procedure as well.

These findings are in direct contradiction to those of Bennet (2), who reported kinetic reversals to be more numerous and persistent than static reversals. On the other hand, the results support the observations of Kennedy (8), who found that static reversals were more common than kinetic reversals among young children and disappeared more slowly as they matured. However, the results of this comparison must be viewed as debatable evidence since the "Kinetic Reversal Word Reading Test" did not exhibit a high degree of reliability, although part of the problem in establishing a sufficiently dependable rating may have
been due to the fact that the subjects tested made very few errors on the test.

One informal observation seems worthy of mention because of the insight it lends to the possible nature of kinetic reversals. On the "Kinetic Reversal Word Reading Test," subjects who could not read a given word on the list were instructed to respond with the letter sounds or names of the first and last letters of the words. It was interesting to note that only in a single instance did the subjects (whose reading skills were not advanced enough to allow them to read the two-, three-, and four-letter words on the test) produce the sound or name of the last letter before that of the first letter. Some of these same immature readers produced kinetic reversals in producing words which they felt corresponded to the printed stimuli. This finding appears to indicate that kinetic reversals among children of the age span tested are not the result of failure of the subject to understand the consistency of left-right progression in printed material.

Hypothesis Six.--Hypothesis Six was formulated to determine if the ability of a child to express the differences between b and d would enable him to eliminate reversals in writing to a greater degree than in reading. The hypothesis was tested in the null form. Those who are able to differentiate between b and d on the "Test of
Articulation of b-d Strategy" but who make errors on either or both the "Word Reading Test" and the "Writing-Spelling Test" will not make a significantly smaller number of errors on the "Writing-Spelling Test." This hypothesis was tested with a *t* test for correlated samples (4, pp. 153-155).

**TABLE XV**

**COMPARISON OF ERROR RATE MADE ON WORD READING AND WRITING TESTS BY SUBJECTS ABLE TO ARTICULATE THE DIFFERENCES BETWEEN b AND d**

<table>
<thead>
<tr>
<th>Test</th>
<th>Error Mean</th>
<th>Standard Deviation</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Reading</td>
<td>2.226</td>
<td>2.544</td>
<td>.770</td>
<td>.443 (n.s.)</td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>2.061</td>
<td>2.755</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

On the basis of this test, the null hypothesis is retained. The ability to explain or demonstrate the difference between the letters b and d did not significantly reduce writing reversals as opposed to reading reversals.

Perhaps the most important finding to emerge from this part of the investigation had nothing to do with the original hypothesis. In the reliability study of the "Test of Articulation of b-d Strategy," subjects in this study were found unreliable in their responses to the question posed in the test. They were unable to explain
consistently without error the differences between b and d. As was reported in Chapter III, only sixty-nine percent of the subjects were ranked identically on two separate examinations. This gave the test a reliability coefficient of only .34. The percent of subjects who gave consistent answers was not greater in the nonremedials (sixty-eight percent) than in the remedials (seventy percent). The finding of greatest consequence resulting from this hypothesis is that nearly one-third of the subjects from age seven through ten in the sampled populations cannot be depended upon to respond consistently to a question asking them to explain or demonstrate a strategy for distinguishing b and d.

**Hypothesis Seven.**--The aim of Hypothesis Seven was to determine if errors in judgment of right and left would be significantly different in those subjects who received various rankings in relating a strategy to distinguish between b and d. Pupils were grouped according to those who correctly differentiated between the two letters, those who were uncertain but corrected themselves, and those who could not correctly explain the differences between the two letters. A one-way analysis of variance was used to test the null hypothesis. Pupils who are grouped by rankings on the "Test of Articulation of b-d Strategy" will not significantly differ (p ≤ .05) on
knowledge of left and right as measured by the Standardized Road-Map Test of Direction Sense.

**TABLE XVI**

COMPARISON OF GROUPS WITH DIFFERENT RATINGS ON ABILITY TO ARTICULATE THE DIFFERENCES BETWEEN b AND d ON THEIR ERRORS IN DIRECTIONAL JUDGMENT

<table>
<thead>
<tr>
<th>Source of Variance</th>
<th>Sums of Squares</th>
<th>df</th>
<th>Variance Estimate</th>
<th>f</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>124.307</td>
<td>2</td>
<td>62.153</td>
<td>2.629</td>
<td>.075</td>
</tr>
<tr>
<td>Within</td>
<td>4639.180</td>
<td>191</td>
<td>23.638</td>
<td></td>
<td>(n.s.)</td>
</tr>
</tbody>
</table>

The level of significance did not meet the required level of .05 or less; therefore, the null hypothesis is retained. Pupils ranked differently on ability to relate a strategy for differentiating between b and d did not significantly differ in their tendency to make errors in right-left discrimination.

As was explained in the discussion of Hypothesis Six, the unreliability of the "Test of Articulation of b-d Strategy" calls into question any statistical test based on its rankings. Therefore, no conclusion will be made concerning this finding.

**Hypothesis Eight-A.**—The purpose of Hypothesis Eight-A was to explore how the appearance of b and d in a particular type of context may influence reversal errors of
nonremedial readers. The aim was to determine if reversal errors would be more numerous in words that would be transformed into a meaningful word when a \textit{b-d} reversal is made than in those in which such an error would produce a nonsense word. Because of the possibility that meaningfulness may not operate equally in reading and spelling to influence \textit{b-d} reversals, these two activities were tested separately.

Subjects were tested on responses to words which were equally divided between those which would produce meaningful words when a reversal error was made and those which had no meaningful counterpart. The number of reversal errors made when reading and spelling these two types of words were tested to see if the proportion of errors made in the words with meaningful counterparts significantly differed from that proportion of errors which would be expected if possession of a meaningful counterpart were not a factor in producing \textit{b-d} reversals (5, pp. 321-324).

On the "Word Reading Test," subjects were allowed to produce letter sounds or letter names if they could not read the words. Key letter reversals made while sounding or naming letters were counted when these scores were used for some purposes. These types of errors were ignored for the examination of this hypothesis. Only those \textit{b-d} reversals which occurred when a word or word-like sound was made (i.e., a Gestalt with two or more phonemes) were
included in this analysis. Likewise, the results of the "Writing-Spelling Test" when analyzed for other purposes included reversal errors made by subjects who could not spell the words, but who could write the letters when the words were spelled orally by the examiner. Responses to dictated letters were ignored in this analysis of meaningful counterparts because it was felt that the level of achievement of subjects who could not spell the words themselves was at a stage too immature for meaningfulness to be a factor. Also, errors which were corrected before the entire word was produced were also disregarded. The intent, then, was to measure to what extent the reproduction of a meaningful (English) Gestalt may have upon written reversals of b and d. The analysis was also restricted to subjects under nine years of age because the difficulty level of both tests used was felt to be more appropriate for the younger subjects in the sample.

The hypothesis to be tested was stated in the null form.

In Group A, subjects under age 9.0 years of age will not make significantly more b-d reversal errors (p ≤ .05) in words which form actual words when the error is made than in those words which have no meaningful counterpart on the following tests:

(1) "Word Reading Test"

(2) "Writing-Spelling Test"
TABLE XVII

DEGREE TO WHICH WORDS WITH MEANINGFUL COUNTERPARTS INFLUENCE THE OCCURRENCE OF b-d REVERSALS OF YOUNG NONREMEDIAL READERS

<table>
<thead>
<tr>
<th>Test</th>
<th>Word Type</th>
<th>Number of Errors</th>
<th>Proportion of Errors</th>
<th>z</th>
<th>p     (one-tailed test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Reading</td>
<td>C*</td>
<td>74</td>
<td>.725</td>
<td>4.54</td>
<td>&lt;.001</td>
</tr>
<tr>
<td></td>
<td>NC**</td>
<td>28</td>
<td>.275</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>C*</td>
<td>67</td>
<td>.528</td>
<td>.620</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>NC**</td>
<td>60</td>
<td>.472</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Words having a meaningful counterpart when b or d is reversed.

**Words having no meaningful counterpart when b or d is reversed.

The null hypothesis is rejected for the "Word Reading Test" and retained for the "Writing-Spelling Test." The production of more than seventy-two percent of the total b-d reversal errors in reading of young nonremedial subjects by words that had meaningful counterparts was significantly greater (<.001 level) than what might have been expected purely by chance. To the contrary, with these same subjects the nearly fifty-three percent of spelling b-d reversals generated by the words possessing meaningful counterparts was not significantly different from chance expectations.

Insofar as is known, these findings are without precedence in educational research. The nonremedial subjects
demonstrated that if the English language contained two words believed to be familiar to young children which differed only in that where one contained a b the other had a d, or vice versa, a b-d reversal was more than twice as likely to occur in reading than if the word had no such counterpart. However, in spelling, the existence of a meaningful counterpart when b and d are reversed produced no more reversal errors than might be expected through chance occurrence. The fact that possession of a meaningful counterpart significantly influenced the number of b-d errors likely in word reading, but not in spelling, prompted a further analysis. Was the difference in the subjects' reaction to such words in reading and spelling significantly different? The null hypothesis tested was--

In Group A the "Word Reading Test" and the "Writing-Spelling Test" will not significantly differ on the number of b-d reversal errors made by subjects under 9.0 years of age on words which form actual words when b and d are reversed than on words which have no meaningful counterparts. When a chi square test was applied, the difference between reading and spelling was found to be significant at the .01 level.

These findings might be interpreted as indicating that meaningfulness of a response is more of a factor in reading than in spelling. However, since some responses contained more errors than merely a b-d reversal, this
interpretation, though logical, may not necessarily follow. For this interpretation to be valid, an analysis of meaningfulness of words actually produced would be necessary.

**Hypothesis Eight-B.**--The same factors that were examined in the Hypothesis Eight-A were tested to determine what influence they might have on the b-d confusions of young (seven- and eight-year old) remedial readers. The data included in this part of the study were subject to the identical restrictions required for the analysis of errors made by nonremedial readers.

The hypothesis under test was as stated below.

In Group B, subjects under 9.0 years of age will not make significantly more b-d reversal errors \( (p \leq .05) \) in words which form actual words when the error is made than in those words which have no meaningful counterpart on the following tests:

1. "Word Reading Test"
2. "Writing Spelling Test."

The proportion of errors produced in response to words having counterparts was tested to see if this error rate differed significantly from that which might be expected if this factor exerted no significant influence on the production of b-d reversal errors. See Table XVIII.

The null hypothesis is rejected for the "Word Reading Test" and retained for the "Writing-Spelling Test."
TABLE XVIII

DEGREE TO WHICH WORDS WITH MEANINGFUL COUNTERPARTS INFLUENCE THE OCCURRENCE OF b-d REVERSALS OF YOUNG REMEDIAL READERS

<table>
<thead>
<tr>
<th>Test</th>
<th>Word Type</th>
<th>Number of Errors</th>
<th>Proportion of Errors</th>
<th>z</th>
<th>P (one-tailed test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Word Reading</td>
<td>C*</td>
<td>47</td>
<td>.595</td>
<td>1.679</td>
<td>&lt;.05</td>
</tr>
<tr>
<td></td>
<td>NC*</td>
<td>32</td>
<td>.405</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing-Spelling</td>
<td>C*</td>
<td>42</td>
<td>.462</td>
<td>.735</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>NC*</td>
<td>49</td>
<td>.538</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Words having a meaningful counterpart when b or d is reversed.

**Words having no meaningful counterpart when b or d is reversed.

In a sample of young remedial readers, as in the nonremedial samples, words with meaningful counterparts when b and d are reversed produced a significantly greater proportion of errors in reading than would be expected by chance but not in spelling.

Although this finding parallels that of the young nonremedial readers, the level of significance is not nearly so great. The nonremedials appeared to be more profoundly influenced by this factor than were remedials. In order to determine if the remedials and nonremedials differed significantly on the proportion of b-d reversals made in words with counterparts, a further analysis was made.
The test of significant difference between two independent proportions was used to make the comparison. Although the difference between the two groups was rather large, the proportion of errors made by the nonremedial readers in reading words with counterparts was not significantly different from the proportion of errors made in reading the same words by the remedial sample. The level of probability reached on a two-tailed test was equal to .0658.

**Hypothesis Nine.**—Hypothesis Eight had been designed to show how subjects under age nine were influenced in key letter reversals by words which produced meaningful counterparts when such errors were made. In Hypothesis Nine, the "Sense-Nonsense Test" is used to examine the impact of basically the same factor on the reversal errors of some of the older and/or more capable readers in both samples. Only subjects who had exhibited a sufficient degree of facility in working with lower-level subtests on the "b-d Discrimination Test" were tested on the "Sense-Nonsense Test" and, therefore, included in this part of the study. The sample size which resulted for the nonremedial group was ninety-three; and for the remedial group, subjects numbered twenty-seven for this analysis.

The "Sense-Nonsense Test" was composed of forty words. Half of these were real words and half were nonsense words.
Of the real words, ten would have remained real words if a b or d were reversed, whereas ten others would be transformed into a meaningless sound sequence if the key letters were exchanged. Similarly, the twenty nonsense words were equally divided between those which had sensible counterparts and those which had meaningless counterparts after a b-d reversal. The null hypothesis was worded as follows:

No significant differences [(p ≤ .01), a higher level of significance was required because of the skewed nature of the distribution] will be found on the number of b-d reversal errors committed on the four-word types of the "Sense-Nonsense Test" by the following groups:

(a) Group A
(b) Group B.

To analyze the data, a two-way analysis of variance was employed. Table XIX is the result of that procedure. The interaction was less than the required .01 level so that it was declared insignificant. This decision to rule interaction insignificant was believed to be correct, because an inspection of cell means (Table XX) revealed the degree of interaction reflected was of an ordinal nature. In addition, when the data was transformed to the nominal level and chi square test for goodness of fit applied, no significant difference was found.

Since under these circumstances it seems proper to examine the main effects, it can be observed from Table XIX
TABLE XIX

COMPARISON OF FOUR ERROR TYPES MADE BY CONTRASTED GROUPS OF NONREMEDIAL AND REMEDIAL READERS

<table>
<thead>
<tr>
<th>Sources of Variance</th>
<th>df</th>
<th>Sums of Squares</th>
<th>Mean Squares</th>
<th>f</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rows (Difference between Groups A and B)</td>
<td>1</td>
<td>64.017</td>
<td>64.017</td>
<td>37.305</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Columns (Differences in Error Types)</td>
<td>3</td>
<td>61.217</td>
<td>20.406</td>
<td>11.859</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Interaction</td>
<td>3</td>
<td>16.487</td>
<td>5.496</td>
<td>3.194</td>
<td>.0234</td>
</tr>
<tr>
<td>Within</td>
<td>472</td>
<td>812.146</td>
<td>1.721</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant.

that the nonremedials significantly differed from the remedials (at the .0001 level) on the average number of b-d reversal errors made. In addition, there was a significant difference (.0001 level) in the number of errors produced by various error types. The cell means in Table XX may be of assistance in understanding the nature of these differences.

By visual inspection and quick calculations, several factors can be easily determined. First, on any given error type, the remedials as a group did less well than the nonremedials. But not all of the nonremedial error
averages were less than all remedial error averages. The exception was in the category of real words which have no counterparts. This point is obviously the source of most of the interaction that resulted from the two-way analysis of variance. Real words without counterparts so retarded b-d reversals that remedials made fewer average errors on these types of words than did nonremedials on real words or nonsense words which have counterparts.

It can also be noted that within the respective samples words that possessed counterparts produced b-d reversals at essentially the same rate regardless of whether the printed stimulus was a real word or a nonsense word, but in both samples, nonsense words without counterparts produced approximately twice as many errors as did real words with

### TABLE XX

**MEAN b-d REVERSAL ERRORS MADE BY REMEDIAL AND NONREMEDIAL SUBJECTS ON THE FOUR WORD TYPES OF THE SENSE-NONSENSE TEST**

<table>
<thead>
<tr>
<th>Group</th>
<th>Real Words</th>
<th>Nonsense Words</th>
<th>Test Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C* NC**</td>
<td>C* NC**</td>
<td></td>
</tr>
<tr>
<td>Nonremedials</td>
<td>.796 .204</td>
<td>.828 .452</td>
<td>.570</td>
</tr>
<tr>
<td>Remedials</td>
<td>2.037 .482</td>
<td>2.185 1.074</td>
<td>1.444</td>
</tr>
<tr>
<td>All Subjects</td>
<td>1.075 .267</td>
<td>1.133 .592</td>
<td>.767</td>
</tr>
</tbody>
</table>

*Counterpart.  
**No counterpart.
counterparts. In real words, the ratio of errors for words with counterparts to those without them was roughly four to one, while for the nonsense words the same comparison produced a ratio of about two to one. With these relationships in mind, it is easier to understand the results of the Scheffe test which was used to make the multiple comparisons within each sample.

**TABLE XXI**

F RATIOS FOR THE MULTIPLE COMPARISONS OF THE EFFECTS OF FOUR TYPES OF b-d REVERSAL ERRORS OF SOME NONREMEDIAL AND REMEDIAL SUBJECTS

<table>
<thead>
<tr>
<th>Group</th>
<th>Word Types*</th>
<th>RNC</th>
<th>NC</th>
<th>NNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonremedial</td>
<td>RC</td>
<td>9.452</td>
<td>.028</td>
<td>3.200</td>
</tr>
<tr>
<td></td>
<td>RNC</td>
<td>.</td>
<td>10.512</td>
<td>1.653</td>
</tr>
<tr>
<td></td>
<td>NC</td>
<td>.</td>
<td>.</td>
<td>3.828</td>
</tr>
<tr>
<td></td>
<td>RC</td>
<td>18.986**</td>
<td>.172</td>
<td>7.276</td>
</tr>
<tr>
<td>Remedial</td>
<td>RNC</td>
<td>.</td>
<td>22.775**</td>
<td>2.755</td>
</tr>
<tr>
<td></td>
<td>NC</td>
<td>.</td>
<td>.</td>
<td>9.687</td>
</tr>
</tbody>
</table>

*RC--real words with counterparts.
RNC--real words with no counterparts.
NC--nonsense words with counterparts.
NNC--nonsense words with no counterparts.

**Significant at the .01 level or better.

It will be seen that in the nonremedial group no significant differences were observed between word types. Word types did not significantly differ in the production of b-d reversal errors in the nonremedial sample. However, it is important to observe that by far the largest ratios resulted when words with counterparts were compared to words without counterparts.
For Group B (the remedial group), the null hypothesis is partially rejected. Significant differences in error production at the .01 level were observed between real words with counterparts and real words without counterparts and also between real words without counterparts and nonsense words with counterparts. The null hypothesis is retained for all other comparisons, although the comparison of nonsense words with counterparts and nonsense words without counterparts reached the .05 level. As can be seen, the significant differences and nonsignificant though inflated f ratios in both remedial and nonremedial samples occurred when words with counterparts (whether they were real or nonsense words) were being compared to words without counterparts.

The potency of this factor is magnified to significance for both nonremedials and remedials if the real word and nonsense word categories are eliminated and pairwise comparisons made between words with counterparts and words without counterparts. Table XXII shows this comparison using the Shaffé test to determine significance.

On this test, both remedial and nonremedial subjects who made b-d reversals made significantly more of these types of errors in reading words which form sensible words when b and d are interchanged. These findings are in basic agreement with the findings of the Hypotheses Eight-A and Eight-B which gave evidence that nonremedials and remedials
TABLE XXII
A COMPARISON OF THE EFFECTS OF TWO WORD TYPES ON THE b-d REVERSAL ERRORS OF NONREMEDIAL AND REMEDIAL READERS

<table>
<thead>
<tr>
<th>Group</th>
<th>Word Type</th>
<th>Combined Mean</th>
<th>f</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonremedial</td>
<td>C*</td>
<td>.812</td>
<td>26.155</td>
<td>&lt;.01</td>
</tr>
<tr>
<td></td>
<td>NC**</td>
<td>.218</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remedial</td>
<td>C*</td>
<td>2.111</td>
<td>20.922</td>
<td>&lt;.01</td>
</tr>
<tr>
<td></td>
<td>NC*</td>
<td>.778</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Real and nonsense words with counterparts.

**Real and nonsense words with no counterparts.

under nine years of age made significantly more b-d reversals in reading words which produced real words when these letters were confused.

Hypothesis Ten-A.—The purpose of Hypothesis Ten-A was to determine if the presence of b or d in an unfamiliar Gestalt significantly influenced b-d discrimination of nonremedial readers. To test this fact it was assumed that real words would have been more commonly encountered as units and hence more "familiar" than nonsense words. The question that was actually being investigated, then, was this: Would nonremedial subjects make a significantly higher number of b-d reversals on nonsense words than on real words? The "Sense-Nonsense Test" was used to test
this factor in reading. Half of the words on this test were real and half were nonsense syllables. For spelling responses, the "Writing-Spelling Test," composed of real words, was contrasted to the results of the "Nonsense Spelling Test," made up of synthetic words. Since there were twenty-three key letters on the "Writing-Spelling Test" and only twenty on the "Nonsense Spelling Test," the anticipated error rate for real words was .5349 for the real words and .4651 for the nonsense words.

The proportion of b-d reversal errors made on nonsense words was tested to see if they were significantly greater than could be reasonably expected if chance were the lone factor operating.

The hypothesis being tested was--In Group A, those who complete all subtests of the "b-d Discrimination Test" and who make at least one error will not make a significantly higher proportion of errors (≤.05 level) on the following comparisons:

(1) Real words to nonsense words on the "Sense-Nonsense Test"

(2) "Writing-Spelling Test" to "Nonsense Spelling Test."

The hypothesis was tested with the test for significance of a proportion within a population (5, pp. 321-324).

The null hypothesis is rejected at the .05 level. Non-remedial readers committed significantly more b-d reversal
errors in nonsense words than in real words on both reading and writing tests.

TABLE XXIII

COMPARISON OF b-d REVERSAL ERRORS MADE BY NONREMEDIAL SUBJECTS ON REAL WORDS AND ON NONSENSE WORDS IN READING AND WRITING

<table>
<thead>
<tr>
<th>Process Tested</th>
<th>Word Type</th>
<th>Number of Errors</th>
<th>Proportion of Errors</th>
<th>Proportion of Errors Expected</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Real</td>
<td>90</td>
<td>.429</td>
<td>.500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsense</td>
<td>120</td>
<td>.571</td>
<td>.500</td>
<td></td>
<td>2.069</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Spelling</td>
<td>Real</td>
<td>122</td>
<td>.467</td>
<td>.535</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsense</td>
<td>139</td>
<td>.533</td>
<td>.465</td>
<td></td>
<td>2.185</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

No previous record was found indicating that this factor had ever been formerly tested. This finding adds to Hildreth's (7) contention that the unfamiliar is likely to produce more confusion in spatial orientation than the familiar. However, her argument seemed primarily to center around familiarity with the reversed item itself. The letters b and d would be equally familiar whether embodied in real or nonsense words. This finding supports an expanded concept that unfamiliarity with the context in which a confusing letter is situated also may tend to produce b-d reversals among some nonremedial readers.
Hypothesis Ten B.--Hypothesis Ten-B was to examine key letter reversal errors made by remedial readers in familiar and unfamiliar contexts. The tests used with these subjects and the statistical procedures employed were identical to those utilized in the investigation of nonremedial readers just discussed. Since these tests were too difficult for many in the remedial sample, the population of errors examined by this hypothesis were the product of some of the better readers in the remedial sample. Only twenty-five of the seventy-four remedial subjects took all of the tests required for inclusion in this part of the study.

The form of the hypothesis used for statistical testing was worded as follows: In Group B, those who complete all subtests of the "b-d Discrimination Test" and who make at least one error will not make a significantly higher proportion of errors on the following comparisons:

(1) Real words to nonsense words on the "Sense-Nonsense Test,"

(2) "Writing-Spelling Test" to "Nonsense Spelling Test."

The null hypothesis is retained. See Table XXIV. The upper level readers in the remedial sample did not produce a significantly higher number of b-d reversal errors in nonsense words than in real words. This finding was true on both reading and writing tests. Although this finding based on the responses of remedial subjects differs from the findings that resulted from b-d error patterns of
TABLE XXIV

COMPARISON OF b-d REVERSAL ERRORS MADE BY REMEDIAL
SUBJECTS ON REAL WORDS AND ON NONSENSE WORDS
IN READING AND WRITING

<table>
<thead>
<tr>
<th>Process Tested</th>
<th>Word Type</th>
<th>Number of Errors</th>
<th>Proportion of Errors</th>
<th>Proportion of Errors Expected</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading</td>
<td>Real</td>
<td>65</td>
<td>.442</td>
<td>.500</td>
<td>1.402</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>Nonsense</td>
<td>82</td>
<td>.558</td>
<td>.500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spelling</td>
<td>Real</td>
<td>57</td>
<td>.500</td>
<td>.535</td>
<td>.747</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>Nonsense</td>
<td>57</td>
<td>.500</td>
<td>.465</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

nonremedial readers, the tendency of the remedial sample
(though not significant) was to produce a higher proportion
of errors in nonsense words than had been anticipated, as
had the nonremedial group. When the proportions of errors
made by remedial readers in real words on both reading
and writing tests were tested against those of nonremedial
readers, the proportions were not found to differ signifi-
cantly. If there were any factors other than chance that
produced the differences between the remedial and non-
remedial samples, they may relate to a reduced capacity of
remedial readers to learn from experiences with words.

Hypothesis Eleven.--The purpose of this hypothesis
was to discover if sentence context influences the inci-
dence of b-d reversal errors. The "Sentence Reading Test"
which was designed to test this hypothesis contained twenty sentences, ten of which produced sensible sentences if a b-d reversal error was made in the key word. The remaining sentences each contained meaning prior to the placement of the key word which would result in a non-sense statement if a b-d reversal were made in the key word. The key words in the sentences with no prior meaning clues were paired with the key words in the sentences with meaning determinants prior to the key word. The paired words were either the same word or the alternate word produced by the exchange of a b or d with its confusing counterpart. It should be noted that the test was not found to be highly reliable. (See discussion in Chapter III.) Since the test was found to have a difficulty level of 3.1, as measured by the Spache Readability Formula, its use was primarily restricted to subjects who had developed reading skills at a level not highly associated with reversal errors. What the test did produce were random errors of generally the average or better than average readers in both samples. Only those subjects who responded with facility to easier tests were asked to read this test. The errors made by those who were able to read the test sentences at or below their instructional reading level were included in the observations used to test the hypothesis. What the results of this hypothesis will show will be the nature of random
reversals made by students able to read successfully at or above the 3.1 level.

The hypothesis was tested to determine if the proportion of random b-d reversal errors made on sentences with prior meaning clues was significantly less than that which could be the result of chance. The test of significance of the proportion within a population was used (5, pp. 321-324) to test the null form of the hypothesis.

On the "Sentence Reading Test," a smaller proportion of b-d reversal errors made in key words preceded by prior meaning determinants than in words where no prior meaning clues are present will not be significant in the following samples:

(a) Group A
(b) Group B

| TABLE XXV |

THE EFFECT OF SENTENCE CONTEXT ON RANDOM b-d REVERSAL ERRORS OF REMEDIAL AND NONREMEDIAL READERS

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects</th>
<th>Location of Errors</th>
<th>Number of Errors</th>
<th>Proportion of Total Errors</th>
<th>z</th>
<th>p(one-tailed test)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonremedial</td>
<td>72</td>
<td>PM*</td>
<td>10</td>
<td>.169</td>
<td>-5.077</td>
<td>&lt; .001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NPM**</td>
<td>49</td>
<td>.831</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Remedial</td>
<td>8</td>
<td>PM*</td>
<td>1</td>
<td>.091</td>
<td>-2.713</td>
<td>&lt; .005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NPM**</td>
<td>11</td>
<td>.909</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Prior meaning determinant given before key word.
** No prior meaning determinant given before key word.
The null hypothesis is rejected at the .001 level for the nonremedial group and at the .005 level for the remedial group. After prior meaning clues in sentence reading, nonremedial and remedial subjects made significantly fewer b-d reversal errors than would be expected by chance. Conversely, when context did not provide prior meaning determinants, random b-d reversals exceeded chance expectations.

This finding would tend to support Hildreth's observation that reversals appeared to be meaningful substitutions for the printed words they replaced. The finding does not confirm a difference in the way context influences the b-d reversals of remedial and nonremedial readers who can read acceptably at the third-grade level.

Hypothesis Twelve.—Hypothesis Twelve was propounded to determine if there was a significant relationship between the tendency of subjects to make b-d reversal errors in reading and writing. The Pearson product-moment correlation coefficient was used to determine the relationship between the two factors and significance was tested by use of a table of critical values of the correlation coefficient (4, p. 457).

The following hypothesis was tested: When scores of the "Word Reading Test" are compared with scores of the
"Writing-Spelling Test," no significant relationship 
(p ≤ .05) will be found.

TABLE XXVI

RELATIONSHIP OF SCORES ON THE "WORD READING 
TEST" AND THE "WRITING-SPELLING TEST"

<table>
<thead>
<tr>
<th>Correlation Coefficient</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>.5089</td>
<td>191</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

The null hypothesis is rejected at the .01 level and 
the research hypothesis is retained. A correlation coef-
ficient of .5089 between error scores of the "Word Reading 
Test" and the "Writing-Spelling Test" shows a significant 
relationship between the number of b-d reversals made on 
both tests. Corrected for attenuation, the true correla-
tion coefficient between the two factors may be as high 
as .5786.

These findings complement the findings of Asso and 
Wyke (1) who investigated static reversals in young chil-
dren. They determined a high correlation (.92) between 
ability to write spatially confusing letters to dictation 
and ability to correctly name such letters. Although, as 
was seen from the results of Hypotheses Eight-A and Eight-B 
some factors significantly differ in the degree to which 
they may influence reading and writing reversals, the
findings of this hypothesis revealed a significant degree of common variance between b-d reversals in reading and writing.

**Hypothesis Thirteen.**—The purpose of this hypothesis was to determine if the location of a letter within a word influenced the type of reversal error made in reading and writing. To investigate this possibility, subjects read or spelled lists composed of words with a rather closely balanced number of b's and d's in both initial and final positions (see Appendix A). On the reading test, only errors made in the production of word or word-like entities were involved in this analysis. That is to say, when subjects could not read a word, but produced only initial and final letter sounds or spelled the word orally, their errors were ignored for this part of the study. On the spelling test, errors made to dictation of letter names were ruled out. Only errors made when the subject wrote the entire word without assistance from the examiner were used for the spelling reversals. The object was to determine if errors made in the initial or final position differed significantly in the incidence of shifts of b to d, or d to b. Chi square (4, pp. 182-186) was used to test this hypothesis. In comparing types of errors (b for d and d for b), initial errors will not differ significantly (p ≤ .05) from terminal errors in the following tests:
(a) "Word Reading Test"
(b) "Writing-Spelling Test."

**TABLE XXVII**

DIFFERENCES IN TYPES OF b-d REVERSAL ERRORS MADE IN INITIAL AND FINAL POSITIONS IN READING AND SPELLING

<table>
<thead>
<tr>
<th>Process Tested</th>
<th>Error Types*</th>
<th>Errors in Initial Position</th>
<th>Errors in Final Position</th>
<th>df</th>
<th>Chi Square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>O</td>
<td>E</td>
<td>O</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td>b-d</td>
<td>28</td>
<td>54.875</td>
<td>149</td>
<td>122.125</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>d-b</td>
<td>74</td>
<td>47.125</td>
<td>78</td>
<td>104.875</td>
<td></td>
</tr>
<tr>
<td>Spelling</td>
<td>b-d</td>
<td>47</td>
<td>102.520</td>
<td>179</td>
<td>125.480</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>d-b</td>
<td>143</td>
<td>89.480</td>
<td>56</td>
<td>109.520</td>
<td></td>
</tr>
</tbody>
</table>

*b-d designates a b that was erroneously replaced by a d, while d-b designates a d that was erroneously replaced by a b.

Since only a 10.83 chi square value is required for significance at the .001 level, the null hypothesis is rejected. There is a highly significant difference between the types of error shifts made in initial and final positions.

From Table XXVII, it can be seen that in the sampled groups d was much more likely (at nearly a three to one ratio) than b to be reversed at the beginning of a word, while in the final position b was more likely (at a combined ratio of about two and one-half to one) than d to be
subject to reversal errors. This trend was similar in both reading and writing.

One possible explanation for this finding is that direction of the reversal shift at the beginning or end of a word may be influenced by the letters which appear more typically in those positions in high frequency words. When a list of commonly used words (12) was examined, it was found that b's exceeded d's at the first of words by a three to one margin. Interestingly, when b-d reversal errors were made in the initial position, b's replaced d's at nearly a three to one ratio over the d to b shift. An inspection of the same word list (12) also revealed that b's rarely occur at the ends of words. In the final position, d's outnumbered b's at a rate of more than seventeen to one. It was not surprising then that when reversal errors were made on key letters at the ends of words, d's more often replaced b's than the converse. However, the proportion of b to d error shifts as opposed to d to b shifts at word endings did not at all resemble the magnitude of the proportion by which d's exceed b's at the ends of common words. The ratio of the difference was only two and one-half to one.

If there is a causal relationship between the types of b-d reversals that are most characteristic at beginnings and ends of words and the typical placement of these letters in high incidence words, it may mean that the subjects'
response to confusing letters within words may have been
governed in part by force of habit. In other words, cer-
tain "rules" or "odds" concerning the likelihood of the
appearance of the particular letters could have been
gathered from experience with words and this subconscious
knowledge applied to responses to the letters. The possi-
bility of the operation of this inductive process influenc-
ing letter reversals among immature readers and spellers
would be parallel to the substitution of a regularized
verb form for irregular verbs by immature speakers of a
language. In other words, b-d reversal errors may be
accounted for in part by a basic inductive process that is
common in the learning of language.

**Hypothesis Fourteen.**—Hypothesis Fourteen was proposed
to test if b-d reversal errors occur more commonly at the
beginnings or ends of words in reading and spelling.
Subjects' responses to lists of words were tabulated. The
data examined in this hypothesis is the same as that
analyzed in hypothesis thirteen. In this analysis, both
types of b-d reversals (i.e., b to d and d to b) were com-
bined and divided only into those occurring at the begin-
nings and ends of words. These observed frequencies were
tested against the expected frequencies which were deter-
mained from the number of times b and d actually occurred
in the test words at the initial and final positions. Chi
square was used to test this null hypothesis (4, pp. 173-177). The proportion of b-d reversal errors made in the initial position of a word will not significantly differ \((p \leq .05)\) from the proportion of errors made in final positions on the following tests:

(a) "Word Reading Test"
(b) "Writing-Spelling Test."

TABLE XXVIII

DIFFERENCES IN b-d REVERSAL ERRORS MADE IN INITIAL AND FINAL POSITIONS OF WORDS IN READING AND SPELLING

<table>
<thead>
<tr>
<th>Process Tested</th>
<th>Errors in Initial Position</th>
<th>Errors in Final Position</th>
<th>df</th>
<th>Chi Square</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>O</td>
<td>E</td>
<td>O</td>
<td>E</td>
<td></td>
</tr>
<tr>
<td>Reading*</td>
<td>102</td>
<td>156.669</td>
<td>227</td>
<td>172.330</td>
<td>1</td>
</tr>
<tr>
<td>Spelling**</td>
<td>192</td>
<td>204.217</td>
<td>235</td>
<td>222.782</td>
<td>1</td>
</tr>
</tbody>
</table>

*Percent of occurrence of key letters in test words was 47.6 in the initial position and 52.4 in the final position.

**Percent of occurrence of key letters in test words was 47.8 in the initial position and 52.2 in the final position.

On the basis of the chi square test, the null hypothesis is rejected for the "Word Reading Test" at the .001 level, but retained for the "Writing-Spelling Test." More than two-third of the b-d reversal errors made in reading
isolated words were made at the end of the word, and this proportion of occurrence is highly significant. The fact that fifty-five percent of the key letter reversals was made at the ends of words on the spelling test was not found to be significantly different from the fifty-two percent expected from the incidence of b's and d's in the stimulus words.

Any interpretation of these findings must also take into account the fact that the words used in this test were balanced to equate as nearly as possible the number of b's and d's in both the initial and final position. This is not the incidence of their occurrence in commonly used words, as was noted earlier. If children are biased in their responses to b and d by the frequency with which these letters appear at particular positions in commonly used words (see discussion of findings from Hypothesis Thirteen), then the findings of this study may not represent a picture that would be encountered in a normal reading situation. That is to say, there were more d's in the initial position and more b's in the final position than is usual among frequently used words. This circumstance could have inflated the number of errors made at either or both the beginnings and ends of words over that which would have been produced had the representation been more normal and could have interacted with these results. Therefore, the following discussion should be regarded as
a tentative explanation of the reasons for the findings resulting from Hypothesis Fourteen.

The fact that more than sixty-eight percent of the key letter reversals in word reading occurred at the ends of words would support the view that reversal errors may be due to an inattention factor. These were the conclusions reached by Hildreth (6) and Kennedy (8) in regard to kinetic reversals. Since, in reading, the end of a word is less likely than the beginning of a word to be the focus of a reader's attention (see discussion in Chapter II), it may be that b-d reversals may in part be the product of failure to attend carefully to the letters rather than to visual distortion, as had originally been suggested by Orton (10). This view would also help explain why no significant difference was found between the number of b-d reversal errors made at different word positions in spelling. Presumably the amount of time (and hence degree of attention) spent with each letter in the reproduction of the written word would be the same regardless of its positional location. However, it may be noted that the increase in time spent with the key letters in spelling did not decrease reversal errors. In fact, b-d reversals were more numerous in spelling than in reading. In computations beyond those required by the present hypothesis, this difference was found to be significant at the .05 level. Obviously, there are a great many factors operating to differentiate between
reading and spelling than were accounted for in this study, and further study would be needed to explain the increased occurrence in reversals in spelling. Some tentative suggestions may be (1) spelling is less guided by the already established linguistic competence of the individual to result in a meaningful product and (2) spelling depends on recall and reproduction of form and not mere recognition of form and association of proper labels.

Phase II

One of the basic purposes of this study was to identify a group of subjects who have extreme difficulty in distinguishing b from d. The rationale used in defining extreme cases is more thoroughly described in Appendix H. Briefly, those who had an unusually high pattern of reversing b and d were determined by their total score on the first three tests of the "b-d Discrimination Test" ("Letter Naming Test," "Word Reading Test," and "Writing-Spelling Test"). The individuals were identified because the number of errors they committed on these tests differed significantly from the average number of errors committed by their age group. The nonremedial groups were used as norming samples for seven-, eight-, nine-, and ten-year-old-age levels. Subjects whose number of errors were beyond the standard deviation limits which would theoretically place them statistically in the highest one percent of those committing
reversal errors were considered to have b-d reversal problems. For the nine-year-old category, a special adjustment was necessary. As has been discussed earlier (and in Appendix H), most indicators supported the conclusion that the overcoming of b-d reversal errors was a continuous developmental process, yet the inclusion of two very extreme individuals in the nine-year-old norming sample so affected the mean and standard deviation of the nine-year-old sample as to make the criterion for selection as an extreme case in that age group more stringent (that is to say, requiring more reversal errors) than was required of eight-year olds. In order to eliminate the appearance of a developmental regression in the criterion for identifying extreme b-d reversers, a different statistical level was used for nine-year olds. Since the distortion of the mean and standard deviation appeared higher than normal, a lower level of significance was employed. Those subjects nine years of age whose error score would theoretically place them in the upper five percent of b-d reversers were defined as having a b-d reversal problem. This adjustment was considered a conservative one, since the score level identifying extremes in the nine-year-old groups was identical to that of the eight-year olds and not less as would be expected in a consistent developmental progression. In addition, this criterion did not result in the identification of more extreme cases in the nine-year-old
category than was made among the eight- and ten-year-old subjects. Still further evidence of the conservative nature of this adjustment was a circumstance which occurred during the retest of subjects in investigating the reliability of one of the tests. A subject whose score narrowly missed qualifying her in the extreme category under the adjusted criterion related that her confusion of b and d created an educational problem for her. In conversation just prior to the retest, the subject stated that she was to have a spelling test that day and that her mother wanted her to make "a hundred." When asked if she thought that she would make a hundred, she replied negatively, saying, "I keep getting my b's and d's mixed up."

This conservative adjustment was preferred over a more liberal one that would have included this subject and would have placed the error level required for identification as a nine-year-old extreme reverser between that required of an eight- and ten-year old rather than at the same level used to identify eight-year olds, because the purpose of the identification was to describe extreme cases. Thus, chances of a false positive identification which would include individuals who were not actually extreme cases was reduced. If this test were to be used to identify individuals who may need special assistance in overcoming the difficulty, renorming may be advised or a different adjustment for nine-year olds may be considered.
When these criteria were applied to the one hundred ninety-four subjects included in this study, twenty-three subjects were found to have extreme problems with the reversal of b and d. The following chart details the number of subjects identified in each category.

**TABLE XXIX**

NUMBER OF INDIVIDUALS WITH b-d REVERSAL PROBLEMS IN AGE LEVEL SAMPLES

<table>
<thead>
<tr>
<th>Age</th>
<th>Nonremedial</th>
<th>Remedial</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>

It should be noted that the agreed upon definition actually identified nearly six percent of the norming population (nonremedial group) and nearly twenty-two percent of the remedial sample as having b-d reversal problems. The nearly six percent identification rate in the nonremedial sample occurred even though statistical projections for a normal curve (using a one-tailed test) were for one percent of the population to be identified in the seven-, eight-, and ten-year-old categories and in spite of the fact that
subjects who were involved in the remedial reading program were systematically eliminated from the random sample of the norming population. A probable factor in producing this result is the high degree of positive skew that progressively developed in the error scores as age increased. As a result, an unusually high percentage of individuals scored at statistically extreme positions when normal curve standards were applied. Many of the extreme individuals actually scored well beyond the projected .01 level from the mean. Conversely, relatively few subjects would have been added to the extreme group if the point of identification had been lowered to the .05 level for all age groups. This is especially true for remedials and nonremedials over seven-years of age. With these types of distributions, it seems safe to conclude that the group identified here as having b-d reversal problems compiled scores that were considerably removed from the scores made by the bulk of individuals in their age group.

It might be expected, from the already reported findings of a significantly higher number of b-d reversal errors among the remedial groups than among the nonremedial samples, that a significantly higher proportion of subjects with extreme difficulty in discriminating between b and d were found in the remedial reading classes. When the data was arranged in a chi square contingency table, the following results were produced.
**TABLE XXX**

A COMPARISON OF THE NUMBER OF EXTREME REVERSERS IN NONREMEDIAL AND REMEDIAL SAMPLES

<table>
<thead>
<tr>
<th>Group</th>
<th>Number with b-d Reversal Problem</th>
<th>Number without b-d Reversal Problem</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nonremedial</td>
<td>7</td>
<td>113</td>
<td>120</td>
</tr>
<tr>
<td>Remedial</td>
<td>16</td>
<td>58</td>
<td>74</td>
</tr>
<tr>
<td>Totals</td>
<td>23</td>
<td>171</td>
<td>194</td>
</tr>
</tbody>
</table>

Chi square = 10.918  \( p = .001 \)  \( df = 1 \)

The remedial samples did contain a significantly greater number of subjects with extreme difficulty in responding correctly to the letters b and d than did the nonremedial samples.

**Description Based on School Records**

The school records provide only sketchy data for describing the subjects with b-d reversal problems. Standardized test data was not uniformly available on all subjects; thus, many of the observations must be interpreted cautiously, and conclusions regarded as only tentative.

**Mental Maturity.**--Data for assessing the general intelligence of the group with b-d reversal problems is meager. Scores from the California Test of Mental Maturity were available for only eleven of the twenty-three subjects.
The mean of these eleven scores was 91.46. The range was 113-69. Subjects' scores on the language section of the California Test of Mental Maturity (13) were compared with those of the nonlanguage section. By using the \( t \) test for correlated samples (4, pp. 153-155), the following results were obtained.

\[
\begin{array}{|c|c|c|c|c|}
\hline
D & D^2 & df & t & p \text{ (two-tailed test)} \\
\hline
-59 & 1,082 & 10 & 2.032 & .10 \text{ (n.s.)} \\
\hline
\end{array}
\]

Although the scores were not found to be significantly different, the results might support further research into this factor using a larger sample and an individual intelligence test. The tendency was toward a lower score on the language factor than on the nonlanguage component. The degree of differences that did result may reflect in part the lower reading achievement of this group that will be discussed later.

Educational levels.—The indicators of educational achievement that were available in the school records tended to support a hypothesis that individuals who have
extreme difficulty distinguishing \( b \) from \( d \) tend to achieve at subnormal levels in academic areas. Records of the Metropolitan Readiness Test (7) were obtainable for seventeen of the twenty-three subjects in the extreme reversal group. A distribution of the letter grades assigned to each of the seventeen when they were in the first grade are shown below.

**TABLE XXXII**

FIRST GRADE METROPOLITAN READINESS TEST SCORES OF SUBJECTS WITH \( b-d \) REVERSAL PROBLEMS

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Superior)</td>
<td>0</td>
</tr>
<tr>
<td>B (High Normal)</td>
<td>1</td>
</tr>
<tr>
<td>C (Average)</td>
<td>7</td>
</tr>
<tr>
<td>D (Low Normal)</td>
<td>2</td>
</tr>
<tr>
<td>E (Low)</td>
<td>7</td>
</tr>
</tbody>
</table>

It can be observed that the median for the group would fall below average within these categories and that only one subject was rated above average. Nevertheless, it should be noted that nearly half of the group ranked as average or above.

Scores for the California Achievement Test (14) were recorded for twelve subjects. Ten of these were administered when the subjects were in the second grade; two subjects were given the test at the end of the first grade.
None of the twelve attained reading scores that equaled those of their grade placement. When the test was taken, the average grade placement of the subjects was 2.175 and the average achievement level in reading was 1.0, a level that statistically represents that of a beginning first grader. To determine if the reading achievement level significantly differed from the grade level assignment, the test for significant difference of correlated means (4, pp. 153-155) was employed.

TABLE XXXIII

COMPARISON OF READING ACHIEVEMENT AND GRADE LEVEL ASSIGNMENT OF TWELVE SUBJECTS WITH b-d REVERSAL PROBLEMS

<table>
<thead>
<tr>
<th>Mean Grade Level</th>
<th>Mean Reading Achievement Score</th>
<th>( \xi_D )</th>
<th>( \xi_D^2 )</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.175</td>
<td>1.0</td>
<td>14.1</td>
<td>238.68</td>
<td>11</td>
<td>3.162</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

The reading levels as measured by the California Achievement Test did differ significantly from the grade level assignments of the subjects. On the average, these subjects with b-d reversal problems were more than one year retarded in reading achievement near the beginning of their second year in school.

As an indicator of achievement, grades assigned by teachers can neither be regarded as standard nor objective
scores. Yet, since these scores were the only measures of student achievement that were available for nearly all subjects (grade averages were not available for one subject who moved before the collection of data for Phase II), it was decided to determine if these evaluations would tend to support the findings based on standardized test data which was obtained for only half of the extreme group.

In the grading scheme of the sampled school district, a grade of one (1) is considered a high grade and four (4) is regarded as the lowest. Specifically, the verbal label assigned to each grade is, 1--rapid progress, 2--satisfactory, 3--acceptable progress, 4--little or no progress. For the purpose of this investigation, each subject's six grades for the year in each of four academic areas were reduced to a single representative grade in each academic area. The grade was determined by the following process: grades separated by more than one step were transformed into intermediate scores. For example, if a subject had a two and a four in a subject category, both were considered the same as a three. A one, however, would raise a four to a three but be reduced only to a two. Once all the transformations were made, the modal ranking was accepted as the yearly grade. In bimodal situations (these were always contiguous), the lower mode was used in accordance with the district's policy in averaging grades. The following figure shows
the frequency distribution of yearly grades of the subjects with b-d reversal problems.

Fig. 9--Frequency distribution of yearly grades received by students with b-d reversal problems.

If the grading scale is thought of in terms of a dichotomy of high and low grades, with the high grades represented by ones and twos and the low grades defined as threes and fours, it may be said that the general tendency of students
with b-d reversal problems was to make low grades in all academic subjects. The subject area that produced the highest number of low grades was language arts. On the other hand, health-science produced the most high grades. Only one yearly grade out of the eighty-eight received by the group was at the highest grade level.

Another indicator of low academic achievement was the number of retentions and advised retentions among the subjects identified as having difficulty distinguishing the letters b and d. Of the twenty-two subjects for whom complete records of previous grades were available, two had been retained, one was to be retained the following year, and a fourth had been promoted on request of the parent against the advice of the teacher and the school principal. Nearly fourteen percent of these subjects were retained, while approximately eighteen percent should have been retained in the judgment of school officials. This must be regarded as a higher rate than is normal within the district, for the school system's guide lines define ten percent failure as so excessive that a teacher who issues more than one failing grade in ten must write a justification of the situation for the district's central administrative authorities.

Sex.--The subjects who exhibited a b-d reversal problem were about equally divided by sex. Twelve were boys
and eleven were girls. This sex balance is in contrast to the significantly high proportion of boys that is usually found in populations of remedial readers and that characterized the remedial sample in this study. However, the fact that .757 of the remedial sample was male was offset somewhat by the higher proportion of females (.583) in the nonremedial sample. The sexual composition of the various samples is shown in the following table. Analysis was made by using the test for significance of a proportion within a population (5, pp. 321-324). Fifty percent was assumed to be normal for each sex.

TABLE XXXIV
ANALYSIS OF SEXUAL COMPOSITION OF SEVERAL DEFINED GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>Male</th>
<th>Female</th>
<th>Totals</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Nonremedial</td>
<td>50</td>
<td>41.7</td>
<td>70</td>
<td>58.3</td>
<td>-1.820</td>
</tr>
<tr>
<td>Remedial</td>
<td>56</td>
<td>75.7</td>
<td>18</td>
<td>24.3</td>
<td>4.416</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>54.6</td>
<td>88</td>
<td>45.4</td>
<td>1.281</td>
</tr>
<tr>
<td>b-d Reversal</td>
<td>12</td>
<td>52.2</td>
<td>11</td>
<td>47.8</td>
<td>.211</td>
</tr>
<tr>
<td>Extremes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

According to the above table, none of the samples contained a male component that significantly differed from chance expectations except the remedial group in which the sex bias was highly significant. It can also be seen that
the proportion of males and females in the combined samples of remedials and nonremedials closely resembles the sexual composition of the group which exhibited b-d reversal problems. Chi square goodness of fit (4, pp. 182-186) was used to test the relationship of these two proportions. The results of this test are reported in the table below. Expected frequencies were based on the composition of the combined samples (remedials plus nonremedials).

**TABLE XXXV**

COMPARISON OF THE SEXUAL COMPOSITION OF ALL SUBJECTS WITH THAT OF THE GROUP WITH b-d REVERSAL PROBLEMS

<table>
<thead>
<tr>
<th>Group</th>
<th>Observed</th>
<th>Expected</th>
<th>(\frac{(O-E)^2}{E})</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>12</td>
<td>12.558</td>
<td>.025</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
<td>10.442</td>
<td>.030</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>23</td>
<td>23.000</td>
<td>Chi square = .055</td>
<td>&lt;.90</td>
</tr>
</tbody>
</table>

The exceedingly small chi square value is well within the range of probable chance occurrence indicating little difference between the expected distribution computed from the actual sex proportions in the population from which the extreme group was identified and the extreme sample itself. These findings support the conclusion that there is not a sexual bias among those who have a b-d reversal problem.
Handedness.--Although left-handedness was at one time thought to be related to reversal problems, the findings of this study seem to support the growing body of research evidence (see discussion in Chapter II) that indicates little association between the two factors. Only four of the twenty-three subjects designated as extreme reversers wrote with their left hand. The fact that more than eighty percent of the group were right-handed seems to rule out the probability of a causal link between b-d reversals and left-handedness.

Performance on reversal tests.--The responses of the subjects identified as having problems in distinguishing b from d contribute some important information which is descriptive of the group. The twenty-two individuals who completed all three subtests used to determine if students could adequately handle the key letters committed a mean number of 26.682 errors out of the sixty-four opportunities for error presented to each. Stated another way, the extreme subjects as a group erred 41.69 percent of the instances in which they were confronted with the key letters. This figure was assessed with the test for significance of a population proportion (5, pp. 321-324) to determine if their responses differed from the proportion that might reasonably have been produced by chance alone. The z value of .780 which resulted was not significant. The group as
a whole did not possess enough skill in responding to the key letters to exceed the chance expectation of random guessing.

Several aspects of the performance of the group that exhibited an extreme tendency to reverse \( b \) and \( d \) were indicative of the basic immaturity of the group in basic language skills. On the "Letter Naming Test," the extreme reversers made an average number of 3.412 errors in identifying letters other than \( b \) or \( d \), whereas the average number of miscalled letters (excluding \( b \) and \( d \)) among those who were above average in identifying the key letters averaged only 1.181 errors. The \( t \) test for independent samples was applied to determine if these means significantly differed. The Cochran and Cox adjustment was used because of the variance inequality.

### Table XXXVI

**Comparison of Letter Naming Errors of \( b-d \) Reversers and an Above Average Group**

<table>
<thead>
<tr>
<th>Group</th>
<th>( \bar{X} )</th>
<th>SD</th>
<th>( \xi(x-x)^2 )</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Average in ( b-d )</td>
<td>1.181</td>
<td>1.383</td>
<td>177.926</td>
<td>93</td>
<td>-3.255</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Reversals in ( b-d )</td>
<td>3.522</td>
<td>3.432</td>
<td>227.271</td>
<td>22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The group which exhibited difficulty in distinguishing \( b \) and \( d \) had a significantly greater incidence of errors in
naming other letters of the alphabet than did those whose accuracy was above average in b-d identification. However, as may be inferred from the elevated standard deviation, this increased error rate was not true of all in the extreme reversal group. Nearly twenty-two percent of the group (five subjects) made no letter identification errors other than b-d reversals. It cannot be said, therefore, that a b-d reverser will necessarily have trouble with other letters as well.

On the "Word Reading Test," subjects who were unable to read a word were allowed to respond by producing the sound or name of the first and last letters of the word. Among those who made an extreme number of key letter reversals, an average of 9.304 of the twenty words were unread and handled as letter naming or sounding task. For those who committed fewer errors than was average for their age group, the mean number of unread words for the same test was .775. A t test was used to compare these two independent means. Unequal variances necessitated the use of the Cochran and Cox adjustment (4, pp. 155-157).

In Table XXXVII, the adjusted t score represents a highly significant difference between average number of unread words. Those with extreme reversal tendencies were able to attempt to decode fewer words than were those who had a better than average record in responding to b and d. However, it would be a mistake to assume that all b-d
TABLE XXXVII

COMPARISON OF b-d REVERSERS AND AN ABOVE AVERAGE GROUP IN AVERAGE NUMBER OF UNREAD WORDS

<table>
<thead>
<tr>
<th>Group</th>
<th>( \bar{X} )</th>
<th>SD</th>
<th>( \varepsilon(x-\bar{X})^2 )</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Average in b-d Response</td>
<td>0.755</td>
<td>2.924</td>
<td>795.372</td>
<td>93</td>
<td>-4.884</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>9.304</td>
<td>8.293</td>
<td>1504.264</td>
<td>22</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

reversers were unable to decode words. Just over one-third of the extreme reversers "read" all of the test words.

On the "Writing-Spelling Test," subjects who were unable to spell a given word were permitted to write the word as the letters were dictated by the examiner. The number of times an individual required the examiner's assistance in the form of dictating the proper letter sequence was regarded as a crude index of academic immaturity and insecurity. The group who made excessive b-d reversals on the average required the dictation of about one word in three, while the group who ranked above average in b-d responses averaged slightly fewer than one dictation per twenty.

According to the comparison (using the t test with the Cochran and Cox modification to compensate for the dissimilar variances), the group with b-d reversal problems significantly differed from the aggregate of subjects who were above average in reacting to the key letters in the amount
TABLE XXXVIII

COMPARISON OF NUMBER OF DICTATIONS REQUIRED ON THE "WRITING-SPELLING TEST" BY TWO GROUPS

<table>
<thead>
<tr>
<th>Group</th>
<th>$\bar{X}$</th>
<th>SD</th>
<th>$\xi(x-\bar{X})^2$</th>
<th>df</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Average in b-d Response</td>
<td>0.777</td>
<td>1.797</td>
<td>332.339</td>
<td>93</td>
<td>-3.980</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>7.261</td>
<td>7.424</td>
<td>1153.701</td>
<td>22</td>
<td>-3.980</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

of letter dictation required on the "Writing-Spelling Test."

Yet, as has been mentioned in the discussion of other ad hoc immaturity indexes, the dependence on dictated letter sequences did not describe all of the extreme letter reversers. Nearly one-third of the group (seven subjects) completed the test without any letter dictations.

Other comparative factors.--In the literature, many other confusions have been lumped together with b-d reversals under the general category known as static reversals. One such pair of mutually confusing symbols are the letters b and p. Although the "b-p Discrimination Test" was not specifically designed to measure b-p substitutions, data were tabulated to determine if the confusion of b and p might also be characteristic of subjects who had extreme difficulty in handling b and d. A comparison of the incidence of the two error types by those with high b-d reversal
tendencies as against those who were above average in b-d discrimination produced some interesting results.

The percentage of individuals for whom b-p substitutions were recorded was approximately equal in both groups—nearly thirty-three percent in the above average group and thirty-nine percent in the group which found b and d highly confusing. A chi square contingency table was used to test if the two types of errors occurred with the same proportion of frequency in samples of extreme reversers and those above average in b-d response.

**TABLE XXXIX**

**RELATIONSHIP OF b-d WITH b-p ERRORS IN TWO SAMPLES**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Errors of Each Type</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b-d</td>
<td>b-p</td>
</tr>
<tr>
<td>Above Average in b-d Response</td>
<td>198</td>
<td>56</td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>587</td>
<td>11</td>
</tr>
<tr>
<td>Totals</td>
<td>785</td>
<td>67</td>
</tr>
</tbody>
</table>

df=1    Chi square=100.477   p<.001

Groups which radically differed on their ability to distinguish between b and d committed b-d and b-p errors at rates that differed to a highly significant degree. Subjects who profoundly confused b and d did not produce a
correspondingly high number of b-p substitutions. The two most extreme individuals in the group confusing b and p (six and twelve errors each) were both above average in their ability to discriminate between b and d.

**Production of real words.**—Did the extreme group differ from the above average subjects in their production of meaningful words (as opposed to nonsense words) when the key letters were reversed? Both responses to the "Word Reading Test" and the "Writing-Spelling Test" were evaluated. On the former, only responses which resulted in multiphonemic Gestalts (not isolated letter sounds or names) were analyzed. In the latter, only words which were spelled without letter dictation from the examiner were examined. The results of the chi square comparison (4, pp. 182-192) were as follows.

**TABLE XL**

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Word Types Produced</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real</td>
<td>Not Real</td>
</tr>
<tr>
<td>Above Average in b-d Response</td>
<td>67</td>
<td>12</td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>52</td>
<td>14</td>
</tr>
<tr>
<td>Totals</td>
<td>119</td>
<td>26</td>
</tr>
<tr>
<td>df=1</td>
<td>Chi square=.886</td>
<td>p&lt;.50 (n.s.)</td>
</tr>
</tbody>
</table>
In neither word reading nor writing-spelling did the groups significantly differ in the degree of real word production when reversal errors were made. Both groups tended to produce meaningful words in spite of reversal errors when reading, but in writing-spelling, subjects in both groups tended to produce a higher percentage of nonsense words than real words when key letter reversals were made.

**Location of b and d.**—In Hypothesis Fourteen of Phase I, it was found that the position of b and d in the word did significantly influence the likelihood of a reversal error in word reading, but not in writing-spelling. It will be remembered that on the "Word Reading Test," errors that were made when naming or sounding initial and final letters were
ignored for this analysis. Only errors made when subjects were producing "words" (i.e., multiphonemic Gestalts) were the responses included in the comparison. On the "Spelling-Writing Test," only responses made without assistance from the examiner in the form of letter dictation were tabulated. In order to determine if the subjects who had great difficulty in discriminating between b and d were influenced differently by letter location than were those better than average in responses to the confusing letters, chi square (4, pp. 182-186) was used. The degree to which the two groups differed in the positional patterns of the incorrect key letter responses is presented in Table XLII and Table XLIII.

**TABLE XLII**

**COMPARISON OF TWO GROUPS ON THE LOCATION OF b-d REVERSALS WITHIN WORDS BEING READ**

<table>
<thead>
<tr>
<th>Group</th>
<th>Position of Reversal</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Above Average in b-d Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>22</td>
<td>65</td>
</tr>
<tr>
<td>Totals</td>
<td>54</td>
<td>105</td>
</tr>
<tr>
<td>df=1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi square</td>
<td>6.447</td>
<td></td>
</tr>
<tr>
<td>p</td>
<td>&lt;.02</td>
<td></td>
</tr>
</tbody>
</table>

While the extreme reversers did not significantly differ from the above average group in the positional location of
TABLE XLIII
COMPARISON OF TWO GROUPS ON THE LOCATION OF b-d REVERSALS WITHIN WORDS BEING SPelled

<table>
<thead>
<tr>
<th>Group</th>
<th>Position of Reversal</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
</tr>
<tr>
<td>Above Average in b-d Response</td>
<td>22</td>
<td>38</td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>78</td>
<td>79</td>
</tr>
<tr>
<td>Totals</td>
<td>100</td>
<td>117</td>
</tr>
</tbody>
</table>

df=1
Chi square=2.9576
p<.10 (n.s.)

b-d reversals while spelling, they did differ to a significant degree (<.02 level) in the positional patterns of key letter reversals in word reading.

There is at least one possible explanation for the difference between the two groups. The positional influence may have more profoundly affected the word reading reversal errors of the above average group than the extreme reversers because, although the above average subjects can basically distinguish between the key letters, their occasional errors may be intensified if the commonly confused letters are not at the point of primary focus, which (as had already been discussed) tends to be the initial part of a word. On the other hand, the extreme reverser may be so thoroughly confused by the two letters that he is doing little more than
guessing. It is unlikely that focus or concentration would have any impact if guessing were the primary basis of his response.

Types of letter shifts.--Still another factor may be operating to produce a difference in the groups' responses to \( b \) and \( d \) in initial and final positions. The type of error shift, whether \( b \) to \( d \) or \( d \) to \( b \) in each of those positions, may influence the situation. In Phase I, Hypothesis Thirteen, it was found that at the beginning of a word a \( b \) was three times as likely to replace a \( d \) than the converse and at the end of a word \( d \)'s were substituted for \( b \)'s two and one-half times as often as \( b \)'s replace \( d \)'s. This bias in the type of shift common in initial and final positions was found to be highly significant. To determine if this factor operated with equal influence among the above average key letter discriminators and those with \( b-d \) reversal problems, the chi square test of independence (4, pp. 182-186) was employed in Table XLIV and Table XLV.

In word reading errors, the groups did not significantly differ in the types of shifts made in beginnings and ends of words. In writing-spelling errors, the groups did differ significantly. Although it will be noted that the group with extreme \( b-d \) reversal problems was biased as to types of errors in the same direction as was the above average group, the relationship of location to type of shift was not
### TABLE XLIV

A COMPARISON OF TWO GROUPS AS TO THE TYPES OF b-d REVERSALS MADE IN WORD READING

<table>
<thead>
<tr>
<th>Group</th>
<th>Shifts in Initial Position</th>
<th>Shifts in Final Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b to d</td>
<td>d to b</td>
</tr>
<tr>
<td></td>
<td>0 E</td>
<td>0 E</td>
</tr>
<tr>
<td>Above Average</td>
<td>7 9.9</td>
<td>15 19.8</td>
</tr>
<tr>
<td>in b-d Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>11 8.1</td>
<td>21 16.2</td>
</tr>
<tr>
<td>df=3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi square=6.889</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE XLV

A COMPARISON OF TWO GROUPS AS TO THE TYPES OF b-d REVERSALS MADE IN WRITING-SPELLING

<table>
<thead>
<tr>
<th>Group</th>
<th>Shifts in Initial Position</th>
<th>Shifts in Final Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b to d</td>
<td>d to b</td>
</tr>
<tr>
<td></td>
<td>0 E</td>
<td>0 E</td>
</tr>
<tr>
<td>Above Average</td>
<td>6 9.815</td>
<td>20 22.576</td>
</tr>
<tr>
<td>in b-d Response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b-d Reversal Problems</td>
<td>24 20.184</td>
<td>49 46.424</td>
</tr>
<tr>
<td>df=3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chi square=13.464</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

as potent with this group. Assuming the "induction from practices theory" is correct (discussed with Hypothesis
Thirteen, Phase I), the explanation for the significantly different reactions of the b-d reversers and the above average group to these error types may be due to one or a combination of several factors. First, the extreme subjects may not read or spell as often as the other group and hence have less opportunity to induct the pattern from practice. Second, the extreme group may profit less from practice than does the above average section, or the confusion of the b-d reversers may be so profound and may result in such inaccurate practice as to muddle the inductive process.

Summary

The findings of this study confirm a general phase-out of b-d reversals among nonremedial subjects between ages seven and ten. The greatest reduction in b-d reversals in the four-year age span occurred for the nonremedial sample between ages seven and eight. The remedial samples furnished a more erratic picture of a delayed reduction in reversal tendency with the greatest improvement indicated between the ninth and tenth year. The basic patterns of reduction in b-d reversal error as age progressed appeared similar in a variety of processes, such as letter naming, word reading, and writing-spelling. Kinetic reversals in word reading produce a profile of reduction that approximated those of the b-d reversals, but the number of such reversals was dramatically less than key letter confusions.
When a nonremedial sample was compared with a remedial sample which was roughly proportional in age level representation, the remedial group produced a significantly higher number of reversal errors than did the nonremedial group. In the nonremedial group (except for the "Sentence Reading Test" that proved too difficult for fair age level representation), b-d reversals were found significantly related to age. In the remedial group, however, age was not found to be a significant correlate of reversal errors. In the nonremedial sample, knowledge of right and left, as measured by the Standardized Road-Map Test of Direction Sense, was not a significant correlate of reversal errors when age was held constant. In a similar test with the nonremedial sample, basically the same finding resulted, though a mildly significant relationship was indicated between b-d reversals in letter naming and knowledge of right and left.

When the number of b-d reversals was compared with the number of kinetic reversals, a highly significant difference was found. Key letter reversal was the more common of the two.

Neither the remedial nor the nonremedial samples could reliably explain or demonstrate the differences between b and d. Those subjects who on initial testing did correctly explain or demonstrate the differences between the two letters or who gave a correct strategy for differentiating
between them, did not show significantly fewer errors in writing-spelling than in word reading. Likewise, no significant difference was found in the knowledge of right and left of those who ranked differently on their ability to express differences between \( b \) and \( d \).

In a nonremedial sample under nine years of age, words which form meaningful counterparts when \( b \) and \( d \) are reversed produced a significantly higher number of \( b-d \) reversal errors than did words which did not have meaningful counterparts after \( b-d \) reversals on a word reading test but not on written spelling. When the two processes (reading and spelling) were compared, they were found to significantly differ on the number of \( b-d \) reversals made on words with meaningful counterparts and those without meaningful counterparts when key letters are exchanged. In word reading, the remedial group under nine years of age showed the same significant tendencies to reverse more letters in words with meaningful counterparts than in those without them. In writing-spelling, these two word types did not produce a significantly different number of errors among remedial subjects.

When nine- and ten-year-old remedials were compared on word reading with nonremedials, no significant interaction was found between the group and the responses on four different word types. The significant finding was that if a test word had a meaningful counterpart (regardless of whether
the original stimulus had been a real or nonsense word) more errors were made than if the test word had no meaningful counterpart. Nonremedial subjects were found to produce significantly more b-d reversal errors in nonsense words than in real words. This tendency was significant in both word reading and writing-spelling. On the other hand, remedial subjects did not produce significantly more reversal errors in nonsense words than in real words in either reading or spelling.

In reading sentences, prior meaning clues were found to significantly reduce b-d reversals of both remedial and nonremedial subjects when compared with contexts which included no prior meaning determinants. Key letter reversals in word reading were found significantly related to those made in writing-spelling.

The location of b or d in the word was demonstrated to significantly influence the type of reversal shift. Significantly more reversals resulted when d's occurred at the beginnings of words and also when b's occurred at the ends of words. In addition, in word reading it was determined that significantly more reversal errors occurred at the ends of words than at the beginnings. In spelling, however, positional location did not appear to affect significantly the number of key letter reversals.

Based on sketchy school data, subjects who committed an extreme number of b-d reversals were not found to
differ significantly on the language and nonlanguage factor on group intelligence tests. Indexes of academic readiness and achievement consistently indicated that the extreme cases performed at a low level. The group was found to be predominantly right-handed and about equally divided by sex.

When the extreme reversers were compared to the group that was above average in b-d responses, the extreme group was found to make significantly more errors on letters other than b and d in letter naming tasks. They also attempted to read significantly fewer words than did the above average group and were more dependent on the examiner's verbal assistance when writing. These two groups did not significantly differ in proportion of real words produced when reversal errors were made in reading or in writing. They did significantly differ on the position of b-d reversals within words while reading, although position did not significantly differentiate between the groups in written reversals. Conversely, the extremes and the above average groups significantly differed on the types of b-d reversals made at the beginnings and ends of words in writing-spelling but not in reading.

An important finding resulted from a comparison of extreme reversers and those above average in b-d responses on the incidence of b-d and b-p reversals. The two reversal types were found to occur in significantly different proportions in these two samples.
CHAPTER BIBLIOGRAPHY


215


CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, IMPLICATIONS
AND RECOMMENDATIONS FOR FURTHER STUDY

This chapter contains a summary of the study findings based on both the descriptive and statistically tested data. Both conclusions based on these findings and educational implications are presented. In addition, some suggestions for further study are listed.

Summary of the Study

A review of educational literature revealed that too little was known about the way in which confusion of the letters b and d is overcome in specific types of activities such as letter naming, reading, and writing. Further study was also needed to relate static reversals to both kinetic reversals and sense of direction. In addition, no etiological description of a sufficiently large group of subjects with extreme difficulty with reversals had been made so that characteristics common to the group could be examined.

The two basic purposes of the study were (1) to investigate b-d reversal errors, kinetic reversal errors, and knowledge of left and right in a cross section of age groups of two populations—a population of remedial readers and one of nonremedial readers and (2) to identify and
describe a group of subjects having extreme difficulty with 
\textit{b-d} reversals. Phase I consisted of both a cross-
sectional developmental study and an examination of hypoth-
esized findings. For Phase II "extreme" \textit{b-d} reversal 
problems were operationally defined and subjects were 
identified and described.

Ten schools in a large metropolitan school district 
were randomly selected from those schools which contained 
learning centers staffed with diagnostic reading specialists. 
The nonremedial sample was randomly drawn in each school 
from students in seven-, eight-, nine-, and ten-year-old 
age categories who were not in special education classes or 
involved in remedial reading instruction. In each school 
of those who obtained parent permission for testing, the 
three in each age category which were chosen first in order 
of random selection were tested with a battery of tests and 
included in the nonremedial sample. The remedial group 
consisted of the population of remedial reading students in 
each age category who received parental permission except 
in the nine-year-old level in which several subjects were 
randomly removed in order to approximate a proportional 
balance at each age level between the remedial and non-
remedial populations.

For Phase II, extreme cases were identified from both 
the remedial and nonremedial populations by using the com-
combined scores of the first three subtests of the \"b-d\"
Discrimination Test." The nonremedial sample consisted of one hundred twenty subjects; the remedial, seventy-four; and the extreme group, twenty-three.

Four instruments were used; the first three were specifically designed for the study. The "b-d Discrimination Test" was composed of six subtests: "Letter Naming Test," "Word Reading Test," "Writing-Spelling Test," "Sentence Reading Test," "Nonsense Spelling Test," and "Sense-Nonsense Test." Each of these tested the reversal of b and d in different settings. The "Kinetic Reversal Word Reading Test" measured confusion of short words that differed only in letter order. To test the subject's ability to explain the difference between b and d, the "Test of Articulation of b-d Strategy" was used. A Standardized Road-Map Test of Direction Sense was used to gauge knowledge of right and left. Table XLVI shows the statistical procedures used to test each of the hypotheses in Phase I of the study.

Because the distributions of the samples were not normal, the .01 level was required for significance for the two-way analysis of variance. For other tests, the .05 level was the required level of significance. For Phase II, chi square, the tests of significance for a proportion in a population, the t test for correlated samples, and the Cochran and Cox adjusted t test were performed.
TABLE XLVI

STATISTICAL PROCEDURES FOR PHASE I

Test | Hypothesis
--- | ---
Two-way analysis of variance. | 9
One-way analysis of variance. | 7
\( t \) test for independent samples. | 1
\( t \) test for correlated samples | 5,6
Chi square test for independence. | 13,14
Chi square test for goodness of fit | unhypothesized comparison on 9

Test of significance of a proportion in a population | 8,10,11
Pearson product-moment correlation. | 2,12
Test of significant difference between two correlation coefficients | unhypothesized comparison on 2
Partial correlation procedure | 3,4

Findings: Phase I

The findings of the developmental study were responses to five experimental questions and were based on tabulated observations and graphic presentation of the data on remedial and nonremedial groups. For the second half of Phase I, fourteen hypotheses were tested as a basis for the findings.

Developmental Study

An examination of data from remedial and nonremedial samples divided into yearly age levels from seven through ten resulted in the following findings:
1. The greatest yearly decrease in b-d reversals in the nonremedial samples occurred between ages seven and eight in letter naming, word reading, and writing-spelling activities. For the nonremedial group, a general low level of median number of errors was achieved at the eight-year-old level and little reduction in the median was noted thereafter.

2. The greatest yearly decrease in b-d reversals in the remedial samples occurred between ages nine and ten in letter naming, word reading, and writing-spelling activities. The profiles of reduction of letter naming and writing-spelling were similar, but the word reading profile differed at the eight-year-old level.

3. Although the kinetic reversal profile was based on fewer average errors than was the b-d word reading test, the basic profiles for error reduction were similar for the nonremedial series of samples. The age profiles of remedial readers differed only at the eight-year-old level.

4. The percent of nonremedial readers who made no reversal errors either increased or remained the same on each test at each successive age level. The remedial groups followed basically the same pattern, the one exception being in the "regression which occurred in nine-year-old letter naming.

5. For nonremedials on kinetic reversals, more than fifty percent of seven-year-old subjects made no kinetic
reversal errors. For b-d reversals of nonremedial subjects, the fifty percent level on letter naming was reached at age eight, but for word reading and writing-spelling, the nine-year-old sample was the youngest group which reached or exceeded the fifty percent level.

6. On age level profiles of knowledge of right and left (as measured by the Standardized Road-Map Test of Direction Sense), the profiles of the remedial group roughly approximated those of the nonremedial sample, except at the oldest level. The ten-year-old error distribution of nonremedials produced a bimodal trend with the second mode developing at a position representing few errors. In the ten-year-old remedial group, the error distribution was not bimodal, but represented a gradual sample shift toward fewer errors.

**Hypothesized and Related Findings**

These findings resulted from statistical tests of fourteen hypotheses. The related findings were the product of further tests needed to interpret some of the initial findings.

1. When the remedial and nonremedial groups remained in a rough proportional balance in age level representation, the remedial sample committed significantly more b-d reversals than did the nonremedial group.
2. In the nonremedial group, b-d reversal errors in letter naming, word reading, and writing, as well as kinetic reversals in word reading were all significant negative correlates of age.

3. In the remedial group, neither b-d reversal errors nor kinetic reversals were significantly related to age.

4. In the nonremedial group with age held constant, no significant relationship was found to exist between errors in judgment of right and left and b-d reversals or kinetic reversals.

5. In the remedial group with age held constant, b-d reversals and kinetic reversals were generally found not to be significantly related to errors in judgment of right and left, although a significant relationship was established between errors in sense of direction and the confusion of b and d in letter naming.

6. In word reading, the mean number of b-d reversals significantly exceeded the mean number of kinetic reversals.

7. The subjects who could correctly express the differences between b and d did not make significantly fewer errors in writing-spelling than in word reading.

8. Only sixty-nine percent of subjects ages seven through ten were consistent in their ability to explain the differences between b and d.

9. Pupils ranked differently on ability to relate a strategy for differentiating between b and d did not
significantly differ on their tendency to make errors in judgment of right and left.

10. In the remedial and nonremedial samples under nine years of age, significantly more b-d reversal errors in word reading were made in words which produced meaningful words when b or d was exchanged than in those which have no meaningful counterpart when such errors were made.

11. In the remedial and nonremedial samples under nine years of age, words that produce meaningful words when b and d are reversed did not generate a significantly greater number of errors than did words without meaningful counterparts when such errors were made in writing-spelling.

12. The word reading of nonremedial readers was found to differ significantly (.01 level) from writing-spelling in the proportion of b-d reversals made in words with meaningful counterparts when b and d were substituted.

13. In reading a list of both real and nonsense words, both remedial and nonremedial readers tended (at either the .05 or .01 level) to make more reversal errors in words which produced meaningful words after a key letter reversal.

14. Among nonremedial readers, nonsense words produced significantly more b-d reversals than would be expected by chance in both word reading and written spelling.

15. Among remedial readers, nonsense words did not produce significantly more b-d reversals than would be expected by chance in either word reading or written spelling.
16. In sentence reading of both remedials and non-remedials, key words preceded by prior meaning clues produced a significantly smaller proportion of b-d reversals than did words with no prior meaning determinants.

17. The number of b-d reversals in word reading was significantly related (.01 level) to the number of such errors in writing-spelling.

18. In both reading and writing-spelling, a highly significant difference was found to exist between types of error shifts made in initial and final positions. At the beginning of a word, a d was more likely (at nearly a three to one ratio) to be reversed than a b. The converse was true in the final position.

19. In word reading, significantly more b-d reversals occurred at the ends than at the beginnings of words. In spelling, positional location of b and d does not significantly influence the number of reversal errors.

Findings: Phase II

Standardized test data from the school records of the twenty-three individuals who were judged extreme reversers were used to make several comparisons. These findings resulted:

1. Group intelligence scores (reported for about half the extreme group) did not yield significant differences in the language and nonlanguage factors.
2. The median score made by the group on a first-grade readiness test was below average although nearly half of the group for whom scores were available were within average limits or above.

3. Achievement test data available for about half the extreme group revealed a significant difference between reading achievement and the actual grade placement at the time of testing.

Other personal factors and school records were collected. The data were used to describe the extreme reversers as follows:

1. A remedial reading sample contained significantly more subjects with extreme b-d reversal problems than did a sample of nonremedial subjects.

2. Subjects with b-d reversal problems tended to receive low grades in all academic areas.

3. Fourteen percent of the extreme reversers repeated grades, while an additional four percent had been promoted on request of parents against the judgment of school personnel.

4. No significant sex bias was observed in the group which profoundly confused b and d.

5. Fourteen percent of the extreme b-d reversers were left handed.
The extreme \( b-d \) reversers were compared with those who were above average in \( b-d \) responses for their age level. The following findings resulted:

1. The group of extreme reversers made significantly more errors in identifying letters other than \( b \) and \( d \) than did the above average group, yet twenty-two percent of the extreme group made no letter identification errors other than \( b \) and \( d \).

2. The extreme group was able to read significantly fewer words on the word reading test than the above average group, although one-third of the extreme group pronounced all words.

3. Without the examiner's assistance, the extreme group spelled significantly fewer words than did the above average group, although nearly one-third of the extreme group required no examiner assistance.

4. The extreme reversers did not significantly differ from the above average group in the production of real and nonsense words when \( b \) and \( d \) were reversed.

5. The extreme reversers significantly differed from the above average group in the location of reversals within words (either initial or final position) when reading words but not when spelling them.

6. The group with reversal problems significantly differed from the above average group in the type of shift
(b to d versus d to b) made at initial and terminal positions in writing-spelling but not in word reading.

7. The reversal of b and d was not significantly associated in the same population as b-p reversals.

The following were the indications of the incidence of extreme reversers in two populations:

1. Extreme reversers in the seven- to ten-year-old age range comprised nearly six percent of the nonremedial sample.

2. In the remedial sample, approximately twenty-two percent of the sample were found to be extreme reversers.

Conclusions: Phase I

Based on the findings of this study, the following conclusions can be drawn. (The universality of these conclusions are restricted by the limitations of the study detailed in Chapter I.)

1. The reversal of b and d in letter naming word reading and writing can be expected to be more common in a population of remedial readers from age eight through ten than in a population of nonremedial readers of the same age.

2. The exaggerated incidence of b-d reversals is associated with at least some types of reading disability.

3. In a remedial population, maturation does not significantly reduce reversal errors whereas age is a significant negative correlate of reversals in the non-remedial population.
4. The rather advanced skills in knowledge of left and right required on the Standardized Road-Map Test of Direction Sense generally developed later than directional mastery of b and d and its low relationship to b-d reversals fails to support a causal relationship between advanced knowledge of right and left and b-d reversals.

5. In the reading of short words, the confusion of b and d is more common and persists longer than letter sequence confusion.

6. The ability of children to more reliably respond to the letters b and d than to a question requiring them to relate how they differentiate between the two letters suggests that overcoming b-d reversals for most children is the product of an inductive process rather than a deductive one.

7. In reading, words with meaningful counterparts when b and d are reversed produce significantly more key letter reversals than do words without meaningful counterparts when reversal errors are made.

8. In spelling, possession of a meaningful counterpart when key letter reversals are made does not significantly influence b-d reversal errors.

9. Unfamiliar words tend to produce significantly more b-d reversals than familiar words among nonremedial subjects but not among remedial readers.

10. In sentence reading (at the 3.1 level), b-d reversals tend to be meaningful substitutions for the printed words.
11. The degree to which a student has difficulty with b–d reversal errors in reading tends to be similar to the degree of b–d reversal tendency he exhibits in writing.

12. Since the propensity for using a b at the beginning of a word and a d at the end of a word tend to match the actual bias in the usage of these letters in commonly used words, it may be reasoned that inductive factors gained from experience with written language influence b–d reversals.

13. Since more reading reversal errors are made at the terminal than at the initial position and since earlier researchers had determined that initial letters are more important in word identification than terminal letters, it may be theorized that inattention may be a factor in b–d reversals.

Conclusions: Phase II

1. A population of remedial readers is more likely to contain a higher proportion of subjects with extreme difficulty in reversing b and d than will a nonremedial population.

2. Persons who are judged extreme in their age group in b–d reversal tendency may be suspected of being retarded in reading skills.

3. The general level of academic achievement attained by a group with extreme b–d reversal problems can be expected to be below average.
4. There appears to be no link between sex and b-d reversal difficulty.

5. Left-handedness is probably not a causal factor in b-d reversals of extreme subjects.

6. In general, the extreme b-d reversers are less independent in word attack and spelling skills than a group which is above average in b-d responses.

7. The proportion of extreme reversers in the remedial population may be greater than previous estimates in the literature have indicated.

8. In subjects seven to ten years of age, b-d reversals and b-p reversals may proceed from different causes.

Educational Implications

The findings and conclusions of this study when examined in the light of the results of previous research lead to some implications which may serve as a guide for educational decisions and planning. Educators may expect increased maturity and experience with written language to reduce the b-d reversal tendencies of most children, but remedial readers do not show a significant reduction in b-d reversals with increased age. For this reason, some specific therapy may be indicated if these reversals greatly interfere with accuracy in reading and writing. Educators may also need to revise their notions as to the importance of b-d reversal errors among remedial readers since the incidence of
individuals in this group who exhibited severe confusion of the key letters is more than double the figure that had previously been projected by reading authorities.

In describing reading errors, reading specialists and diagnosticians should differentiate between types of reversal errors. Some basic differences, for example, between the incidence and persistence of kinetic and b-d reversals suggests that these two types of reversals should not be lumped together as though they comprise a single error type. In addition, the fact that b-d and b-p confusions are not associated in the same groups of individuals should indicate to educators that even various types of static reversals may proceed from different causes and may thus require different types of therapy if the confusion is extreme and persistent.

Several factors also need to be considered in devising strategies to assist students with severe reversal confusions in overcoming the problem. If overcoming b and d confusion is ordinarily basically an inductive process (as was concluded from findings of Hypotheses Six and Thirteen), this factor should be taken into account in developing strategies for assisting subjects with extreme reversal problems. Remedial teachers should not assume that subjects who have extreme reversal problems merely need a way to distinguish between the two letters. The teacher must be aware that the use of a deductive approach may be quite different from the
usual way by which the problem is overcome and that the subject may need much assistance in implementing the new cue into the process of reading and writing. Since inattention appears to be a factor in the production of b-d reversals, remedial techniques should be designed to assist students to attend to these letters.

In probing further the causes of b-d reversals, investigators should consider several factors. The highly significant relationships between b-d reversals in reading and writing should suggest to researchers that a major source of the difficulty must be factors which are common to both activities. One such factor seems to be the inflated incidence of b-d reversals in words that differ in the location of b and d from the preponderance of high incidence words. Another feature which significantly influences both reading and writing reversals is the pupil's familiarity with the word which contains the confusing letters.

Conversely, researchers must also take into account some factors which exert a differential effect on the two activities. First, the possibility for meaningfulness seems to have a strong influence on reading reversals but not on those made while writing. Second, the location of the key letter at the end of a word is a more potent factor in the production of b-d reversals in reading than in spelling.
The results of this study should assist educators to understand better the nature of several types of reversal errors and to develop strategies for reducing b-d reversals. In addition, increased knowledge of the developmental nature of the reduction in b-d reversals should be of help in identifying individuals who have severe reversal problems.

Suggestions for Further Research

1. If the "b-d Discrimination Test" is to be used in further research, additional norming data especially at the nine-year-old level may be required.

2. Further investigation into the developmental nature of a sense of right and left is needed.

3. To determine if knowledge of left and right is at all related to b-d reversals, tests that gauge performance on a continuum of skills in directional sense should be correlated with measures of b-d reversals.

4. To add to the developmental picture of the way that b-d reversals are diminished by age, a longitudinal study should be undertaken.

5. Since the highly significant findings of this study which noted fewer kinetic reversals than b-d reversals are in conflict with some earlier findings, further research should investigate what differing variables may produce these paradoxical results in order to better understand the basic nature of both types of reversals.
6. Further research is needed to determine if meaningfulness of words actually produced is a significant factor in b-d reversals of reading and spelling and if remedials and nonremedials significantly differ on the possible impact of this factor.

7. Further investigations should explore reasons why some factors which significantly affect b-d reversals of nonremedials do not significantly influence the reversals of remedial subjects.

8. A lower level and more reliable sentence reading test may be constructed to test the impact of sentence context of b-d reversals at less mature reading levels.

9. A more thorough investigation should be made of psychological, physiological, and educational factors which characterize subjects identified as having b-d reversal problems.

10. A more thorough investigation may be made into the interrelationships of various types of static reversals.

11. A controlled experiment should be conducted to test the effectiveness of suggested methods for reducing b-d reversals in extreme cases of b-d confusion.

12. Further research should determine if a significantly higher degree of reversals occurs in initial and final positions when test words preserve the frequency of b and d expected at those positions based on their occurrence in commonly used words.
13. Other samples of nonremedial and remedial readers should be tested to determine if the proportion of extreme reversers in the population is consistent with the findings of this study.
APPENDIX A

The "b-d Discrimination Test"
EXAMINER'S MANUAL

b-d DISCRIMINATION TEST

By

Marjorie Kerwin, B.S., M.A.
1974
OUTLINE OF EXAMINER'S MANUAL

I. Description of test
   A. Introduction
   B. Test materials
   C. Purpose of subtests and criteria for item selection
      1. Letter Naming Test
      2. Word Reading Test
      3. Sentence Reading Test
      4. Writing-Spelling Test
      5. Nonsense Spelling Test
      6. Sense-Nonsense Test
   D. Means of establishing validity
   E. Means of establishing reliability

II. Directions for administering test
   A. General procedures
   B. Check list of materials
   C. Scoring procedures for subtests
      1. Letter Naming Test
      2. Word Reading Test
      3. Sentence Reading Test
      4. Writing-Spelling Test
      5. Nonsense Spelling Test
      6. Sense-Nonsense Test
   D. Instructions for subtests
      1. Letter Naming Test
      2. Word Reading Test
      3. Sentence Reading Test
      4. Writing-Spelling Test
      5. Nonsense Spelling Test
      6. Sense-Nonsense Test

III. Test cards and spelling lists with samples of writing paper.

IV. Appendix
DESCRIPTION OF TEST

Introduction

The "b-d Discrimination Test" is designed for individual administration for students aged 7.0 - 10.11. The test consists of six parts which are used to evaluate a child's ability to discriminate between b and d while he is involved in various types of expressive language activities--specifically reading and writing. The six subtests are the "Letter Naming Test," the "Word Reading Test," the "Writing-Spelling Test," the "Sentence Reading Test," the "Sense-Nonsense Test," and the Nonsense Spelling Test."

Not all of the tests are to be used with all children. The child should be examined only with those tests which are appropriate for his functional level. Subjects who can recognize the letters of the alphabet with no more than five errors* should be able to complete the first three tests. The remainder of the tests are appropriate for subjects who can read third grade level material.

---

*b and d must be recognized correctly or by the name of a letter which is its reversed or rotated counterpart. Such errors are not counted as errors in this criterion measure.
Test Materials

In giving the "b-d Discrimination Test" the examiner will need the "Examiner's Manual," the Test Cards with the Cover Card, the Examiner's Scoring Sheets, two sheets of writing paper, several pencils, a recorder, and a stop watch.

Examiner's Manual.--The "Examiner's Manual" is an essential item in the administration of the test because it contains instructions to the subject and directions for scoring.

Test Cards.--Test Cards are to be used by the pupils in taking the subtests with the exception of the spelling tests. They contain the test items to which the child must respond. The "Letter Naming Test" and the "Word Reading Test" are typed in primary type for use with students under 8.0 years of age. All tests for use with older subjects are typed in regular pica type and each test is to be mounted on a separate card. A Cover Card is provided and is to be used by students for covering letter groups and words and sentences after responses have been made. The purpose of the card is to prevent the subject from referring to a symbol on which a judgment has already been made to guide him in a later response.

Examiner's Scoring Sheets.--Subtests should be duplicated and arranged so that the errors of each subject can be marked and analyzed.
Recorder.---A tape recorder is to be used on oral tests so that the examiner's on sight error marking can be checked later for accuracy. Because the recording is to be done openly, an introduction to the instrument is provided in the instructions for administering the test.

Stop watch.---A stop watch will be used on several tests with the assumption that this will encourage automatic responses. It, too, will be introduced to the child in the general procedures used to acquaint the child with the mode of testing.

Purpose of Subtests and Criteria for Item Selection

Letter Naming Test.---The purpose of the "Letter Naming Test" is to measure the child's ability to quickly and correctly identify b and d within the context of naming letters in general.

Each of the twenty items consists of four letters one of which is a b or d. The selection of b or d for each item was made by random choice with the requirement that the random set of twenty must contain a ratio of 10:10 of 11:9 before the set was acceptable. The other three letters were selected at random and were placed around the key letter which had previously been positioned in the set of letters by use of a table of random numbers. In pica type, twenty, letter groupings were arranged in a column
with single spacing between letters in the items and
double spacing between the items.

**Word Reading Test**.--The purpose of the "Word Reading
Test" is four fold, (1) to evaluate the subject's ability
to discriminate \( b \) from \( d \) in words. (2) to test the
incidence of \( b-d \) reversals in reading words without
context support, (3) to gauge the difficulty factor
involved in initial and terminal positions of key letters
and (4) to measure the degree to which words with meaning-
ful counterparts when \( b \) or \( d \) is reversed may influence
\( b-d \) reversals.

The first aim that directed item selection was the
need for simplicity so that the words would be within the
word recognition range of low level readers. Therefore,
word length was restricted to four letters or fewer.
Words were selected only if they were phonetically regular\(^*\)
(preferably with a short vowel since most phonics series
begin with these vowel patterns) and/or were included on
Stone's revision of the Dale List of 769 easy words.\(^+\)

\(^*\)Phonetically regular.--descriptive of words which
contain consonants or consonant digraphs which represent
their most common phonetic value. Vowels also represent
the sound most characteristic of the consonant or vowel
pattern in which they are located.

\(^+\)Clarence R. Stone, "Measuring Difficulty of Primary
Reading Material: A Constructive Criticism of Spache's
Measure," *The Elementary School Journal*, LXII (October,
1956), 36-41.
A balance was sought between words which would produce meaningful words even though b and d were reversed and those which had no meaningful counterpart. In order that the results on this test could be compared and combined with data from the "Writing-Spelling Test" an acceptable balance was sought between these two tests on the following criteria: (1) number of words on the "Easy Word List" mentioned above, (2) number of counterparts of the "Easy Word List," (3) total number of b's and d's and (4) number of b's and d's in initial and final positions. A chart is included in the Appendix to show how this balance was achieved.

**Writing-Spelling Test.**—One purpose of the "Writing-Spelling Test" is to measure the incidence of b-d reversals that children make in writing and/or spelling common words. Another aim is to gauge the difficulty of the key letters b and d, and to determine if the initial position is more likely to produce different types of errors (i.e. b for d) than the terminal position (i.e. d for b). Finally, the test may be used to determine the relationship between b-d reversals and the production of meaningful words (as opposed to nonsense words) when the errors are made.

Word selection criteria were identical to those used for the "Word Reading Test." Short sentences using easy vocabulary were constructed to be read as the spelling
words are given. The purpose was to provide subjects with a context for each key word. Words were randomly ordered for test presentation using a table of random numbers.

Sentence Reading Test.--The purpose of the "Sentence Reading Test" is to measure b-d reversals as they relate to two aspects of reading in context, (1) errors made after prior meaning determinants have been given and (2) errors made after no meaning or syntactic cue has been provided to assist in b-d interpretation.

In order to allow for the testing of students at the lowest possible level, sentences were constructed of only phonetically regular words or words which are contained in the "Easy Word List." Words that differ from those on the list only by common plural endings or common verb endings such as s, ed, or ing were also considered acceptable. When the sentences were tested as a group with the Spache Readability Formula, the readability level was found to be 3.1.

Sentences were constructed in pairs containing either the same key word or the counterpart of the key word with b or d reversed. One sentence was so constructed that even if the b or d were reversed, the sentence produced would be meaningful. The second sentence of the pair was written in such a way that meaning revealed prior to the key word would give a clue to assist in the correct
reading of the key word without a b-d reversal.

The criteria for selecting the key words were that they must (1) contain a b or a d, (2) be phonetically regular or be on the "Easy Word List," (3) have a meaningful counterpart of the same part of speech when b or d is reversed and (4) be amenable to the types of sentence pairs described above.

The ten sentence pairs receiving the highest acceptability rating by the panel of judges were numbered independently and randomly ordered using a table of random numbers. Random order was amended only when such placement resulted in sentence pairs being placed in consecutive order.

Sense-Nonsense Test.—One of the aims of the "Sense-Nonsense Test" is to provide a way of testing children on b-d reversal tendencies in unfamiliar situations. The second objective is to gauge the degree to which lexical sense may influence the tendency to reverse b and d.

Four groups of ten words were selected to fulfill the specific criteria. All words were to contain a b or a d, have only one syllable and be not more than five letters in length. Two groups were to contain real English words that were not on the "Easy Word List" but that were felt to be within the listening vocabulary of most third grade aged children. One group of these real words was composed of
words which would not produce a meaningful sound if $b$ or $d$ were reversed. The second half of the real words was limited to words which would produce a word on the "Easy Word List" if $b$ or $d$ were reversed. The twenty nonsense words were limited to phonetically regular English spelling patterns. One group of "Words" was constructed so that a reversal of $b$ or $d$ would not produce a meaningful English word, and the other half of the nonsense words were limited to one syllabled constructions that would produce a word on the "Easy Word List" if the $b$ or $d$ were reversed. The Appendix contains a list of the words in a form which makes analysis of the balance easier. The forty words were numbered and ordered by use of a table of random numbers.

Nonsense Spelling Test.—A purpose of the "Nonsense Spelling Test" is to measure the occurrence of $b$-$d$ reversals in children in a situation in which their correct responses will produce an unfamiliar visual Gestalt. A further aim of the test is to provide data to indicate the possible influence of familiar forms in producing writing errors involving $b$-$d$ reversals.

Twenty nonsense words were developed to conform to phonetically regular English spelling patterns. The length of the words was limited to one syllabled constructions
which did not exceed five letters in length. One half of
the words did not produce familiar English word when the
b of d was reversed while the second half were fabricated
so that a reversal of the b or d would produce a word
included on the "Easy Word List." In the Appendix the
words are arranged in a manner to facilitate the study
of the factors which were balanced on this test.

Means of Establishing Validity

A panel of judges was selected from a group of
experienced reading clinicians, reading supervisors and
and college professors who were instructors in reading
methods. Each panel member was furnished an initial
form of the "Examiner's Manual" which contained (1) a
statement of the purposes of each subtest, (2) an
explanation of the procedures used to select test items,
(3) instructions for the scoring of each subtest, and
(4) directions for administering each subtest. The
judges also were given copies of proposed subtests
together with data indicating the balance that was
written into some of the subtests.

The judges were asked to suggest any changes which
they felt appropriate either in the "Examiner's Manual"
or in the test items. They were asked to focus
particularly on the appropriateness of the test items
for the stated purposes and the suitability of the proce-
dures for administering and scoring the items. On some
subtests they were requested to participate in the selection of designated numbers of items from a broader sample of items. Suggestions for revision were marked on the copies of the "Examiner's Manual" and the list of test items. If three judges agreed on a revision, the revision was regarded as mandatory. If fewer than three judges suggested a revision, the change was considered optional.

Reliability

A split-half reliability coefficient was established for each of the subtests of the "b-d Discrimination Test." On subtests which contained a balance on items in two or more categories, halves of the subtests were made so that an equal or nearly equal number of items representing each category appeared on each subtest half. To establish reliability subjects were drawn from populations of non-remedial and remedial readers. Thirty subjects at each of the four age levels (seven-, eight-, nine-, and ten-year-olds) were tested. The remedial readers were from the same age levels and numbered from seventeen to twenty in each age classification.

Subtests were tested only with those subtests which were appropriate for their developmental level as indicated on the first page of this manual. Therefore, the sample size for each subtest varied but in no case was the sample
size less than eighty. The coefficient of reliability was computed by using the Pearson produce-moment correlation and the Spearman-Brown formula. The following table is a report of test reliability.

**TABLE I**

**RELIABILITY OF TESTS**

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample Size</th>
<th>Number of Items</th>
<th>Coefficient of Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Letter Naming Test&quot;</td>
<td>195</td>
<td>20</td>
<td>.91</td>
</tr>
<tr>
<td>&quot;Word Reading Test&quot;</td>
<td>194</td>
<td>20</td>
<td>.85</td>
</tr>
<tr>
<td>&quot;Writing-Spelling Test&quot;</td>
<td>194</td>
<td>20</td>
<td>.92</td>
</tr>
<tr>
<td>&quot;Sentence Reading Test&quot;</td>
<td>80</td>
<td>20</td>
<td>.43</td>
</tr>
<tr>
<td>&quot;Sense-Nonsense Test&quot;</td>
<td>120</td>
<td>40</td>
<td>.90</td>
</tr>
<tr>
<td>&quot;Nonsense Spelling Test&quot;</td>
<td>122</td>
<td>20</td>
<td>.87</td>
</tr>
<tr>
<td>Total b-d Score*</td>
<td>120</td>
<td>60</td>
<td>.85</td>
</tr>
</tbody>
</table>

*This score represents the combined performance of the first three subtests and was used to determine b-d reversal problems.

The reliability of the "Sentence Reading Test" is considered unsatisfactory for use in isolation except for the purpose of investigating the nature of random b-d reversal errors in context reading.
DIRECTIONS OF ADMINISTERING TEST

General Procedures

Several general procedures should be observed in administering the test. The examiner and child should be situated in a location separate from the child's classmates with as few external distractions as possible. No alphabet should be permitted within view of the pupil during the test. The examiner should at no time during the test comment on the subject's accuracy in discriminating between b and d or in any way indicate that the purpose of the test is to determine how well he can respond to the key letters. If the subject makes a comment concerning b's and d's, the examiner should make a reply which draws as little attention to the key letters as possible.

Check List of Materials

In administering the test the examiner will need the following materials:

_____ "Examiner's Manual"  _____ Stop watch
_____ Test Cards and Cover Card  _____ Pencils
_____ Examiner's Scoring Sheets  _____ Recorder
Scoring Procedure for Subtests

**Letter Naming Test.**—Score only responses to b and d. For correct responses the key letter will be left unmarked. Circle the key letter if a reversal error is made. A reversal error consists of a substitution of b for d or d for b on the initial response or on a response shift. The item should be counted as an error if the subject verbally expresses confusion between the two letters while responding to an item. A silent hesitation, however, should not be construed as an error. Draw a line through the key letter if an irrelevant response is made. An irrelevant response is defined as a substitution of any letter besides b for d or d for b, or the inability to respond to the key letter.

**Word Reading Test.**—Score only responses to b and d. Correct responses should be left unmarked and reversals marked by entering the reversed form of the printed letter above the confused one. Responses should be considered correct if on the first response (with no subsequent error), the subject pronounces the key letter correctly, or if he is able to give the correct sound or name of b or d when he responds to initial and final letters. An item on which a response is changed will be counted as an error.
Writing-Spelling Test.—Responses to b and d only are to be scored. Correct responses are to be unmarked. Reversal errors should be circled or marked by entering correct form of the reversed letter above it. Errors with b or d formation will be counted whether they are made while spelling from memory or in response to dictated letters by the examiner. If capital letters are used for b or d and rewriting is necessary, no error will be charged if the key letter is executed properly on the second effort.

Sentence Reading Test.—Charge b-d reversal errors only on the key words in each sentence. A reversal will be counted when a word is incorrectly pronounced due to a reversal of a key letter or if the sound of a reversed key letter is produced at a word beginning with b or d even though the word may be subsequently pronounced correctly or supplied by the examiner.

Sense-Nonsense Test.—Score only the responses to b and d. Correct responses should be left unmarked and reversals marked by entering the reversed form of the printed letter above the confused one. Responses should be considered correct if on the first response (with no subsequent error), the subject pronounces the key letter correctly. An item on which any key letter reversal is made is counted as an error even if a correction is made.
Nonsense Spelling Test.—Responses to b and d only are to be scored. Correct responses are to be unmarked. Reversal errors should be circled or marked by entering the correct form of the reversed letter above it. If capital letters are used for b or d and rewriting is necessary, no error will be charged if the key letter is executed properly on the second effort.

Instructions for Subtests

Introductions to tests.—Follow directions carefully. Read aloud sentences typed with all words in upper case letters.

Say: THIS TEST WAS MADE TO TEST MANY DIFFERENT KINDS OF PEOPLE. SOME WILL BE YOUNG, AND SOME WILL BE MUCH OLDER. SOME MAY FIND THE TEST DIFFICULT, AND OTHERS MAY FEEL THAT THE TEST IS VERY EASY. DO NOT BE DISCOURAGED IF YOU FIND THAT SOME OF THE WORK IS HARD TO DO. DO THE BEST YOU CAN. IF YOU FIND THE TEST VERY EASY, REMEMBER TO WORK AS QUICKLY AND ACCURATELY AS YOU CAN TO SHOW HOW WELL YOU CAN WORK LETTERS, WORDS AND SENTENCES.

Say: I NEED TO FIND OUT WHEN CHILDREN LEARN TO DO CERTAIN KINDS OF THINGS. TO HELP ME CHECK HOW WELL YOU DO, I WILL RECORD SOME OF YOUR ANSWERS ON THIS RECORDER. BEFORE WE BEGIN THE TEST I AM GOING TO ASK YOU A FEW QUESTIONS AND RECORD YOUR ANSWERS. Turn on the recorder.
(1) WHAT IS YOUR NAME?  (2) HOW OLD ARE YOU?  (3) WHAT GRADE ARE YOU IN?  (4) WHERE DO YOU GO TO SCHOOL?  Turn off the recorder.  WHEN WE ARE READY TO BEGIN THE TEST, I WILL TURN THE RECORDER ON AGAIN.

Show the child a stop watch.  Explain:  WHILE YOU WORK SOME OF THE EXERCISES, I WILL TIME YOU WITH THIS STOP WATCH.  DO YOU KNOW HOW A STOP WATCH WORKS?  When necessary briefly explain and demonstrate the use of the stop watch.  WHEN WE BEGIN, IT IS IMPORTANT THAT YOU WORK QUICKLY, BUT IT IS ALSO IMPORTANT THAT YOU BE RIGHT.  DO NOT GO SO FAST THAT YOU MAKE MANY MISTAKES.

Instructions for Letter Naming Test.-- Say: ON THE FIRST TEST YOU WILL SHOW HOW FAST AND HOW WELL YOU CAN CALL LETTERS.  Show the subject Sample A on the Sample Card.  PLACE THIS COVER CARD ABOVE THE FIRST LINE.  Demonstrate.  WHEN I SAY "BEGIN," READ ALL THE LETTERS ON THAT LINE AS QUICKLY AS YOU CAN.  THEN COVER THAT LINE BY SLIDING THE CARD DOWN.  Show how the card is manipulated.  IMMEDIATELY CALL OUT THE NEXT LINE OF LETTERS.  GO ON FROM LINE TO LINE IN THIS WAY UNTIL YOU FINISH.  IF YOU COME TO A LETTER YOU DO NOT KNOW, SAY "SKIP IT" AND GO ON TO THE NEXT LETTER.  DO YOU UNDERSTAND WHAT YOU ARE TO DO?  Explain the procedure until the child indicates that he understands what he is to do.
Say: WHEN I SAY "BEGIN," READ THE LETTERS AS QUICKLY AS YOU CAN. BEGIN. Time the child and record the results. If the subject makes more than five letter recognition errors (excluding b-d reversals), his achievement level is probably too low for effective measure with this instrument. In addition, the child must identify b or d correctly or by the name of its reversed or inverted forms. If the child meets the minimum requirements, explain any procedural difficulties the child may have exhibited. Practice again using the same sample lines if necessary. When the child has mastered the procedure, continue.

Say: NOW WE WILL DO THIS SET OF LETTERS. Show the child the test card for the "Letter Naming Test." YOU WILL SAY THESE LETTERS IN EXACTLY THE SAME WAY AS YOU DID BEFORE. ARE YOU READY? Wait for an affirmative indication. Start the recorder. BEGIN.

Time the performance and mark errors on the scoring sheet as the subject names the letters. Assist the subject in using the Cover Card if he forgets.

Word Reading Test.--Say: ON THE NEXT TEST YOU WILL SHOW HOW WELL YOU CAN READ WORDS. Show the subject Sample B on the Sample Card. PLACE THIS COVER CARD ABOVE THE FIRST WORD. Demonstrate. WHEN I TELL YOU TO BEGIN, READ THE FIRST WORD: THEN SLIDE THE CARD OVER IT. CONTINUE
WITH THE REST OF THE WORDS IN THE SAME WAY. IF YOU COME TO A WORD YOU DO NOT KNOW, YOU MAY GIVE THE SOUND FOR THE FIRST AND LAST LETTERS OF THE WORD AND THEN MOVE QUICKLY TO THE NEXT WORD. DO NOT SKIP ANY WORDS. UNLESS I TELL YOU TO "SKIP." DO YOU HAVE ANY QUESTIONS? Answer any questions that may arise. WHEN I SAY BEGIN YOU WILL START. BEGIN.

Time the subject, but do not record the time. If the child does not follow directions correctly, explain any procedural difficulty the child may have exhibited. If necessary practice again using the sample words. Notice that the second word is unpronounceable. If the child does not know how to handle this situation, remind him of what he is to do if he comes to a word he does not know. Have him sound the first and last letters. When the child has mastered the technique, continue.

Say: NOW WE WILL DO THIS SET OF WORDS. Show the child the Test Card for the "Word Reading Test." YOU ARE TO READ THESE WORDS IN THE SAME WAY AS BEFORE. ARE YOU READY? Wait for an affirmative response. Start the recorder. BEGIN.

Time the performance and mark errors on the scoring sheet as the subject reads the words. Assist the subject in using the Cover Card if he forgets. If the child pauses
for more than ten seconds on an item, ask him to skip to the next item.

**Writing-Spelling Test.**--Say: ON THIS TEST YOU WILL SHOW HOW WELL YOU CAN WRITE WORDS. YOU WILL NOT BE ALLOWED TO ERASE OR TO USE CAPITAL LETTERS. Show the subject Sample D on the Sample Card. THIS WILL SHOW YOU HOW YOU ARE TO WRITE YOUR WORDS. PLACE THIS COVER CARD ABOVE THE PLACE WHERE THE FIRST WORD IS TO BE WRITTEN. Demonstrate by placing the Cover Card above the first word on Sample D. I WILL SAY THE WORD YOU ARE TO SPELL, AT. THEN I WILL SAY A SENTENCE WITH THE WORD IN IT. "A YOUNG MAN IS AT THE DOOR." THEN I WILL SAY THE WORD YOU ARE TO WRITE AGAIN--AT. NUMBER ONE SHOWS YOU HOW YOU ARE TO WRITE THE WORD IF YOU THINK YOU KNOW HOW TO SPELL IT. Pull the Cover Card over AT. WHEN YOU FINISH EACH WORD, COVER IT WITH THE COVER CARD.

Say: IF YOU CAN NOT SPELL THE WORD, DRAW A CIRCLE AROUND THE NUMBER. Point to number two. THEN I WILL SPELL THE WORD FOR YOU TO WRITE. SUPPOSE I SAID, "TOY--MY NEW TOY IS A BALL.--TOY." IF YOU COULD NOT SPELL THE WORD, YOU WOULD DRAW A CIRCLE AROUND THE NUMBER. WHEN YOU DO THIS, I KNOW TO TELL YOU WHICH LETTERS TO WRITE. T-O-Y. Point to the letters as you spell the word; then pull the Cover Card over toy.
Say: THEN YOU ARE READY FOR THE NEXT WORD. "CAME--

A FRIEND CAME TO SEE ME.--CAME " Point to number three.

NOTICE THAT THE FIRST TIME THE WORD WAS WRITTEN, A MISTAKE

WAS MADE. Point to each feature as you explain. AN O WAS

PUT WHERE AN A SHOULD BE. BUT NO ERASING CAN BE DONE. ONE

LINE WAS DRAWN THROUGH THE WORD IN WHICH THE MISTAKE WAS

MADE AND THE WORD WAS WRITTEN AGAIN BESIDE IT. ANOTHER

ERROR WAS MADE. THE WORD WAS WRITTEN IN CAPITAL LETTERS.

ANOTHER LINE WAS DRAWN THOROUGH THE WORD AND THE WORD WAS

WRITTEN CORRECTLY ON THE RIGHT. DO YOU UNDERSTAND HOW YOU

ARE TO WRITE YOUR ANSWER? Answer any questions the subject

may have. IF YOU FORGET, I WILL REMIND YOU OF WHAT YOU

ARE TO DO.

During the test the examiner may: (1) repeat spelling

words an unlimited number of times, (2) remind the subject
to circle numbers when a word is to be spelled aloud for

him, (3) repeat the spelling an unlimited number of times,
(4) remind the subject to slide the Cover Card over

completed words, (5) remind the subject to draw a single

line through an error, (6) ask the subject to rewrite

words in which a capital B or D is used. However, call the

B OR D only a capital letter. Do not call attention to the

fact that it is a B or a D.

Give the pupil the answer sheet. Say: HERE IS THE

SHEET ON WHICH YOU WILL WRITE YOUR ANSWERS. Then proceed
with the "Writing-Spelling Test." If the subject is unable to remember how a particular letter is formed, point to the box in the upper right corner of the test paper and instruct him to make a box like this one when he can not remember how to make a letter.

**Sentence Reading Test.**—Say: **ON THIS TEST YOU WILL SHOW HOW WELL YOU CAN READ SENTENCES.** Show the subject Sample C on the Sample Card. **IF YOU COME TO A WORD YOU DO NOT KNOW, TRY TO FIGURE IT OUT ON YOUR OWN. IF YOU CAN NOT SAY THE WORD, AFTER A FEW SECONDS, I WILL TELL YOU WHAT IT IS. WHEN YOU HAVE FINISHED EACH SENTENCE, GO IMMEDIATELY TO THE NEXT SENTENCE. DO YOU HAVE ANY QUESTIONS?** Answer any questions that may arise.

Say: **I WANT YOU TO READ THESE PRACTICE SENTENCES TO MAKE SURE YOU UNDERSTAND THE INSTRUCTIONS. WHEN I SAY "BEGIN," READ THE FIRST SENTENCE AS QUICKLY AS YOU CAN AND CONTINUE UNTIL YOU HAVE FINISHED THEM ALL. BEGIN.**

Time the subject, but do not record the time. Explain any procedural difficulties the child may have exhibited. If necessary practice again using the sample sentences. When the child has mastered the technique, proceed.

Say: **NOW, WE WILL DO THIS SET OF SENTENCES.** Show the child the test card for the "Sentence Reading Test."
YOU ARE TO READ THESE SENTENCES IN THE SAME WAY AS BEFORE.
ARE YOU READY? Wait for an affirmative response and
start the recorder. BEGIN. Time the performance and
mark errors on the scoring sheet as the subject reads the
sentences.

**Sense-Nonsense Test.**—Place the Sample Card before the
subject. Use Sample E to demonstrate. Say: NEXT YOU WILL
BE GIVEN A PAGE OF WORDS. SOME WILL BE REAL WORDS AND SOME
WILL BE NONSENSE WORDS. I WANT YOU TO READ OR TRY TO READ
EACH WORD ALOUD. IF YOU THINK THE WORD IS REAL AND MAKES
SENSE, YOU ARE TO SAY, "SENSE." IF YOU THINK THE WORD IS
NOT REAL AND IS ONLY NONSENSE, YOU ARE TO SAY, "NONSENSE." If the subject falters, demonstrate by doing the first two
words for him. Then have him repeat those two examples
and continue through the final two.

Ask: NOW DO YOU UNDERSTAND WHAT YOU ARE TO DO? Make
any further explanation that may be required. Then give
the subject the test card for the "Sense-Nonsense Test."

Say: TRY TO PRONOUNCE EVERY WORD AND DECIDE WHETHER
IT MAKES SENSE OR NONSENSE. YOU MAY BEGIN. The subject
should be encouraged to attempt a pronunciation for each
word or pseudoword.

**Nonsense Spelling.**—Place an answer sheet before the
subject. Say: ON THIS TEST YOU WILL BE ASKED TO SPELL
SOME NONSENSE WORDS. SINCE YOU HAVE NEVER SEEN THEM BEFORE, YOU WILL WRITE THE SOUNDS YOU HEAR IN THE WAYS YOU HAVE LEARNED FROM SPELLING AND READING REAL WORDS. SOME SOUNDS MAY BE SPelled IN DIFFERENT WAYS. YOUR ANSWER WILL BE CORRECT IF YOU USE ANY USUAL WAY THAT THE SOUND CAN BE SPelled. EVEN IF YOU CAN NOT SPELL A WHOLE WORD CORRECTLY, PUT DOWN ALL OF THE SOUNDS YOU CAN HEAR. ON THE TEST YOU ARE NOT ALLOWED TO ERASE OR TO USE CAPITAL LETTERS. DRAW A LINE THROUGH ANY ERROR AND WRITE THE WORD CORRECTLY TO THE RIGHT ON THE SAME LINE. DO YOU UNDERSTAND THE INSTRUCTIONS OR DO YOU WANT TO PRACTICE FIRST? If the subject indicates that he is ready, proceed with the test. If he wishes to practice say, AS A PRACTICE I WILL GIVE YOU THREE WORDS. WRITE THEM IN A LIST AT THE BOTTOM OF THE ANSWER SHEET. The child is to be allowed to write in either cursive or manuscript. If he inquires as to which way he should write, he should be encouraged to use the method he thinks will produce his best work. Words may be repeated as many times as needed.

Pronounce the practice words. As he writes, correct any procedural difficulties he may exhibit.

Practice words:    slog
                  prem
                  lipe

23
Say: NOW YOU ARE READY TO BEGIN AT NUMBER ONE AT THE TOP OF THE PAGE. YOU WILL DO THESE WORDS IN JUST THE SAME WAY THAT YOU DID THE PRACTICE WORDS. Pronounce the test words slowly and distinctly. The examiner may continue to give procedural assistance during the test. No assistance with letter formation may be given.
The "Sample Card," the "Letter Naming Test," the "Word Reading Test," the "Sentence Reading Test," the "Sense-Nonsense Test" and the ruled pages should be duplicated for use as "Examiner's Scoring Sheets." All of these, except the ruled pages to be used for the spelling tests, should also be mounted on tagboard for use with the subjects at the time of testing. A protective plastic covering will help preserve these copies.
SAMPLE CARD

A.

xbqf
ypad
nirh
mlvg
ceto
wksz
ujyv

B.

rat
grp
man

C.

You may sit in this chair.

In the fall some birds fly south.

We have a garden in our yard.

The girl has a pretty dress.

D.

1. at
2. toy
3. come

E.

any
plog
shall
skeep
SAMPLE CARD

xbqf rat
ypad grp
nirh man
mlvg
ceoto
wkksz
ujyv

1. at
2. toy
3. come CAME came
Letter Naming

w q d t
i m b u
k l i b
j c k d
a r b q
r k v b
j d e x
b a w i
d k t l
b x c l
e w e d
u x u d
a t b u
i b c g
h d o y
v d x q
f y b p
d a n i
r p f b
b x h z
Letter Naming

w q d t
i m b u
k l i b
j c k d
a r b q
r k v b
j d e x
b a w i
d k t l
b x c l
e w e d
u x u d
a t b u
i b c g
h d o y
v d x q
f y b p
da n i
r p f b
b x h z
Word Reading Test

tub
hid
rid
box
mob
does
rub
sob
cud
boy
lob
dust
barn
dip
gob
bus
bet
red
dad
dig
Word Reading Test

  tub
  hid
  rid
  box
  mob
  does
  rub
  sob
  cud
  boy
  lob
  dust
  barn
  dip
  gob
  bus
  bet
  red
  dad
  dig
Writing-Spelling Test

1. but--I want to go to the party, but I can't.--but
2. dish--The dish is full of soup.--dish
3. bun--A wiener is often eaten on a bun.--bun
4. sod--We planted grass to sod the lawn.--sod
5. nod--As he got sleepy, his head began to nod.--nod
6. hub--The hub is at the center of the wheel.--hub
7. dab--Will you dab the medicine on the sore?--dab
8. bad--The boy had an ice cream cone.--bad
9. bug--A brown bug flew near the light.--bug
10. do--You already know what to do.--do
11. dent--There is a dent in the car fender.--dent
12. rib--You have more than one rib in your chest.--rib
13. pad--He put a pad down before he stood on his head.--pad
14. dim--Candle light is very dim.--dim
15. fib--A little lie is called a fib.--fib
16. did--We did the lesson yesterday.--did
17. web--Watch the spider spin the web.--web
18. mud--Clean the mud off your shoes.--mud
19. bog--The car began to bog down in the mud.--bog
20. bob--On Halloween we bob for apples.--bob
Sentence Reading Test

1. The man with the big gun shot the buck.
2. The tramp is a bum.
3. The boat sank in the bay.
4. The little cub walked beside the mother bear.
5. The boats are going to race on this day.
6. Don't brag around here any more.
7. The girl browned herself at the lake.
8. The door bell went ding-dong.
9. Don't dump my wagon.
10. The yellow babies swam behind mother duck.
11. I like corn on the cob.
12. The lad found many uses for the rocks.
13. Your head has a big bump on it.
14. The kitten was black, white and brown.
15. My father says that I am a little dear.
16. Your coat is beginning to drag on the ground.
17. The rocks were tested at the lab.
18. Boy! Did I feel bum!
19. Do not eat the cod.
20. I hear the bong of the big bell.
### Sense-Nonsense Test

<table>
<thead>
<tr>
<th>Word</th>
<th>Word</th>
</tr>
</thead>
<tbody>
<tr>
<td>hib</td>
<td>drosk</td>
</tr>
<tr>
<td>darn</td>
<td>dill</td>
</tr>
<tr>
<td>soab</td>
<td>dill</td>
</tr>
<tr>
<td>drape</td>
<td>dill</td>
</tr>
<tr>
<td>bone</td>
<td>dill</td>
</tr>
<tr>
<td>dook</td>
<td>dill</td>
</tr>
<tr>
<td>job</td>
<td>dill</td>
</tr>
<tr>
<td>brave</td>
<td>dill</td>
</tr>
<tr>
<td>dell</td>
<td>dill</td>
</tr>
<tr>
<td>doy</td>
<td>dill</td>
</tr>
<tr>
<td>plobe</td>
<td>dill</td>
</tr>
<tr>
<td>bog</td>
<td>dill</td>
</tr>
<tr>
<td>bass</td>
<td>dill</td>
</tr>
<tr>
<td>brink</td>
<td>dill</td>
</tr>
<tr>
<td>bress</td>
<td>dill</td>
</tr>
<tr>
<td>dax</td>
<td>dill</td>
</tr>
<tr>
<td>drown</td>
<td>dill</td>
</tr>
<tr>
<td>yarb</td>
<td>dill</td>
</tr>
<tr>
<td>fed</td>
<td>dill</td>
</tr>
<tr>
<td>dip</td>
<td>dill</td>
</tr>
</tbody>
</table>
Nonsense Spelling Test

bront
dath
sibe
spab
dring
wid
dut
tade
bife
glab
dack
bance
brop
fibe
drack
dup
dit
trud
tib
worb
APPENDIX

The appendix to this manual contains test words for the "Word Reading Test," "Writing-Spelling Test," "Sense-Nonse Test," and "Nonsense Spelling Test" arranged and marked in a way that will facilitate analysis of the balance between word types and key letter content in each test. Charts also provide data concerning the balance of the positioning of the key letters. Other factors which were brought to the attention of the judges who ruled on the content validity of the test are presented.
## WORD READING TEST

<table>
<thead>
<tr>
<th>Real Words</th>
<th>No Counterparts</th>
<th>Real Words</th>
<th>Counterparts</th>
</tr>
</thead>
<tbody>
<tr>
<td>*box</td>
<td></td>
<td>*rid</td>
<td></td>
</tr>
<tr>
<td>*hid</td>
<td></td>
<td>*red</td>
<td></td>
</tr>
<tr>
<td>dad</td>
<td></td>
<td>mob</td>
<td></td>
</tr>
<tr>
<td>lob</td>
<td></td>
<td>bet</td>
<td></td>
</tr>
<tr>
<td>*boy</td>
<td></td>
<td>sob</td>
<td></td>
</tr>
<tr>
<td>rub</td>
<td></td>
<td>*barn</td>
<td></td>
</tr>
<tr>
<td>bus</td>
<td></td>
<td>cud</td>
<td></td>
</tr>
<tr>
<td>dip</td>
<td></td>
<td>*dig</td>
<td></td>
</tr>
<tr>
<td>tub</td>
<td></td>
<td>dust</td>
<td></td>
</tr>
<tr>
<td>#*does</td>
<td></td>
<td>*gob</td>
<td></td>
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## WRITING-SPELLING TEST

<table>
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<th>Counterparts</th>
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</thead>
<tbody>
<tr>
<td>*had</td>
<td></td>
<td>rib</td>
<td></td>
</tr>
<tr>
<td>dim</td>
<td></td>
<td>*bug</td>
<td></td>
</tr>
<tr>
<td>fib</td>
<td></td>
<td>bun</td>
<td></td>
</tr>
<tr>
<td>hub</td>
<td></td>
<td>*dab</td>
<td></td>
</tr>
<tr>
<td>*but</td>
<td></td>
<td>nod</td>
<td></td>
</tr>
<tr>
<td>*dish</td>
<td></td>
<td>dent</td>
<td></td>
</tr>
<tr>
<td>#*do</td>
<td></td>
<td>*bog</td>
<td></td>
</tr>
<tr>
<td>bob</td>
<td></td>
<td>*did</td>
<td></td>
</tr>
<tr>
<td>mud</td>
<td></td>
<td>web</td>
<td></td>
</tr>
<tr>
<td>pad</td>
<td></td>
<td>cod</td>
<td></td>
</tr>
</tbody>
</table>

*On the "Easy Word List.*

*Counterpart on the "Easy Word List"

#Not phonetically regular
### TEST BALANCE

<table>
<thead>
<tr>
<th></th>
<th>Word Reading Test</th>
<th>Writing-Spelling Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>Final</td>
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<tr>
<td>No Counterpart</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Counterpart</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Other items which were considered:

Words which may be unusual to the listening vocabulary of some elementary school children:

- lob
- sod

Words with counterparts which may be unusual to some elementary school children:

- red
- sob

Words whose counterparts sound like real words, but which do not spell real words:

- bet
### Balance on Nonsense Spelling Test Words

<table>
<thead>
<tr>
<th>No Counterpart</th>
<th>Counterpart on Easy List</th>
</tr>
</thead>
<tbody>
<tr>
<td>trud</td>
<td>dut</td>
</tr>
<tr>
<td>tib</td>
<td>dring</td>
</tr>
<tr>
<td>wid</td>
<td>sibe</td>
</tr>
<tr>
<td>dup</td>
<td>dath</td>
</tr>
<tr>
<td>bife</td>
<td>worb</td>
</tr>
<tr>
<td>fibe</td>
<td>brop</td>
</tr>
<tr>
<td>spab</td>
<td>bance</td>
</tr>
<tr>
<td>tade</td>
<td>glab</td>
</tr>
<tr>
<td>drack</td>
<td>* dit</td>
</tr>
<tr>
<td>bront</td>
<td>dack</td>
</tr>
</tbody>
</table>

Number of

<table>
<thead>
<tr>
<th>b = 5</th>
<th>b = 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>d = 5</td>
<td>d = 5</td>
</tr>
</tbody>
</table>

* Dit is a term used in some dialects to mean to obstruct. It is believed, however, to be perceived as a nonsense word by the elementary children under test in this study.
### BALANCE ON SENSE-NONSENSE TEST WORDS

<table>
<thead>
<tr>
<th>Real Words</th>
<th>Real Words Counterpart on Easy List</th>
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</thead>
<tbody>
<tr>
<td>No Counterparts</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>bass</td>
<td>dill</td>
</tr>
<tr>
<td>job</td>
<td>dug</td>
</tr>
<tr>
<td>fed</td>
<td>dell</td>
</tr>
<tr>
<td>bat</td>
<td>bog</td>
</tr>
<tr>
<td>drape</td>
<td>darn</td>
</tr>
<tr>
<td>desk</td>
<td>drown</td>
</tr>
<tr>
<td>dive</td>
<td>brink</td>
</tr>
<tr>
<td>brave</td>
<td>bone</td>
</tr>
<tr>
<td>brisk</td>
<td>robe</td>
</tr>
<tr>
<td>dipl</td>
<td>gob</td>
</tr>
<tr>
<td></td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>b=5 \ d=5</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonsense Words</td>
<td></td>
</tr>
<tr>
<td>No Counterpart</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>lub</td>
<td>hib</td>
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<tr>
<td>gub</td>
<td>ribe</td>
</tr>
<tr>
<td>dax</td>
<td>dake</td>
</tr>
<tr>
<td>diss</td>
<td>doy</td>
</tr>
<tr>
<td>lide</td>
<td>dox</td>
</tr>
<tr>
<td>soab</td>
<td>dus</td>
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<tr>
<td>void</td>
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</tr>
<tr>
<td>bripe</td>
<td>brive</td>
</tr>
<tr>
<td>drosk</td>
<td>dook</td>
</tr>
<tr>
<td>plobe</td>
<td>yarb</td>
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<tr>
<td></td>
<td>Number of</td>
</tr>
<tr>
<td></td>
<td>b=5 \ d=5</td>
</tr>
</tbody>
</table>
APPENDIX B

Rationale, Instructions, and Sample of "Test of Articulation of b-d Strategy"
Test of Articulation of \textit{b-d} Strategy

\textbf{Purpose}

The objective of the "Test of Articulation of \textit{b-d} Strategy" is to determine if a subject can accurately express in words and/or by demonstration the directional difference involved with the printed \textit{b} and \textit{d}.

\textbf{Criteria for Item Construction}

The single item was composed of simple words and expressions and was written in short sentences so the question could be understood by all subjects seven years of age or older who indeed could respond to the question if it were understood.

\textbf{Scoring the Test}

Responses are to be classified into three categories—\underline{Correct}, \underline{Uncertain Correct}, and \underline{Incorrect}. The criteria for each category is as follows:

\textbf{Correct}.—The subject gives a correct directional description of the differences between the two letters. He may use words or gestures, but he may not exhibit any degree of confusion.

\textbf{Uncertain Correct}.—The subject's final response is correct, but he exhibits some confusion in arriving at the correct response. He may start his answer and then have second thoughts, have to pause and start the
explanation again or state that he sometimes gets these letters mixed up.

Incorrect.--The subject can not respond meaningfully to the question, or can not represent the directional orientation of the letters correctly. If the subject exhibits some confusion, the response is counted incorrect if his final response is incorrect.

Test of Articulation of b-d Strategy

Say: PRETEND THAT I AM JUST LEARNING THE ALPHABET. PRETEND THAT I CAN'T REMEMBER HOW TO TELL A LITTLE b FROM A LITTLE d. CAN YOU TELL ME HOW I CAN REMEMBER THE DIFFERENCE BETWEEN THEM?

If an indefinite response is made such as, "One goes one way and one goes the other," press for a more specific response by asking, BUT HOW CAN I REMEMBER WHICH LETTER GOES WHICH WAY?
APPENDIX C

Rationale, Instructions, and Sample of "Kinetic Reversal Word Reading Test"
Kinetic Reversal Word Reading Test

Purpose

The aim of this test is to measure the tendency of subjects to confuse words which contain the same letters in different order.

Criteria for Item Selection

Item selection was limited to phonetically regular words or words under five letters in length included on the "Easy Word List." Ten pairs of words which may be subject to kinetic reversal because of sameness or close similarity of letter content, but difference of letter order were selected by a panel of five judges based on the following criteria: (1) pair is known from experience to cause confusion in immature readers; (2) in the absence of experiential evidence the pair seems most likely on logical grounds to result in reversal confusion. The first criteria was weighted twice as heavily as the second. The judges were asked to select ten pairs from a sample of twenty-three pairs and to indicate which of the criteria was used as a basis for selection. The ten pairs receiving the highest weighted total from the panel were numbered separately and placed in the test list based on random selection provided that no pair was placed together on the list.
Scoring the Kinetic Reversal Word Reading Test

Correct responses should not be marked. The subject should be given credit for a correct response even if he is unable to pronounce the word provided he is able to give the characteristic sounds or names of the first and last letters in that order. An error should be charged if the response contains letters in a reversed order to the printed stimuli or for each word for which the last letter is sounded or named first. A zero should be placed before each word for which no response or an irrelevant response is made. An irrelevant response is defined as a word or sound substitution which shows no relationship to directional orientation. Irrelevant responses should not be regarded as reversal errors.

Instructions for the Kinetic Reversal Word Reading Test

Say: ON THE TEST YOU WILL SHOW HOW WELL YOU CAN READ WORDS. Show the subject Sample B. on the Sample Card. PLACE THIS COVER CARD ABOVE THE FIRST WORD. Demonstrate. WHEN I TELL YOU TO BEGIN, READ THE FIRST WORD; THEN SLIDE THE CARD OVER IT. CONTINUE WITH THE REST OF THE WORDS IN THE SAME WAY. IF YOU COME TO A WORD YOU DO NOT KNOW, YOU MAY GIVE THE SOUND FOR THE FIRST AND LAST LETTERS OF THE WORD AND THEN MOVE QUICKLY TO THE NEXT WORD. DO NOT SKIP ANY WORDS UNLESS I TELL YOU TO "SKIP." DO YOU HAVE ANY
QUESTIONS? Answer any questions that may arise. WHEN I SAY "BEGIN" YOU WILL START. BEGIN.

Time the subject, but do not record the time. If the child does not follow directions correctly, explain any procedural difficulties the child may have exhibited. If necessary practice again using the sample words. Notice that the second word is a nonsense letter sequence. If the child does not know how to handle this situation, remind him of what he is to do if he comes to a word he does not know. Have him sound the first and last letters. When the child has mastered the technique, proceed with the test.

Say: NOW WE WILL DO THIS SET OF WORDS. Show the child the Test Card. YOU ARE TO READ THESE WORDS IN THE SAME WAY AS BEFORE. ARE YOU READY? Wait for an affirmative response. Begin the recorder. BEGIN.

Time the performance and mark errors on the Scoring Sheet as the subject reads the words. Assist the subject in using the Cover Card if he forgets. If the child pauses for more than ten seconds on an item, ask him to skip to the next item.
Kinetic Word Reading Test

pan
ten
stop
tar
file
of
spot
rat
no
dam
nap
won
mad
on
life
for
saw
net
now
was
APPENDIX D

Letter to Panel of Judges for Test Validity
To the panel member:

I have asked you to assist me in establishing the content validity of three instruments designed for research into the nature and incidence of reversal errors. First, this packet contains the "b-d Discrimination Test" together with an "Examiner's Manual" which contains (1) a statement of the purpose of each subtest, (2) an explanation of the procedures used to select test items, (3) instructions for scoring each subtest, and (4) directions for administering each subtest. You will also find some sheets which indicate the balance written into some of the subtests. With a colored pencil mark any changes you feel appropriate. Particularly focus on the appropriateness of the items for the stated purposes and the suitability of the procedures for administering and scoring the items. On the "Sentence Reading Test" please check the ten sentence pairs which you feel would be most appropriate for the stated objective.

Second, the packet contains the "Kinetic Reversal Word Reading Test" with similar information as was provided for each of the subtests for the "b-d Discrimination Test." For the test make the same types of recommendations as for the "b-d Discrimination Test." Listed are twenty-three pairs of common words which may be subject to reversal. Select the ten pairs which you feel will be most susceptible to reversal errors. Place a 2 (two) before each choice if the pair is known from experience to be confused by beginning readers. Place a 1 (one) before each choice which you select because it seems likely to cause reversal errors, although you can not specifically recall instances in which children have confused the pair.

Third, the packet includes the "Test of Articulation of b-d Strategy." Make any suggestions for change which you feel are needed.
APPENDIX E

Study Answer Sheets

The Study Answer Sheets were originally designed for an investigation that differed somewhat from the one that was actually made. Therefore, part of the form was irrelevant to the present study, and some data or data summary were added for which no space was provided. Since these forms had already been printed before the changes in the study were made, these were used and adjustments were made by hand.
# Study Answer Sheets

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

<table>
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<table>
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<th>General</th>
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<td></td>
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<table>
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<tr>
<th>Population Sample</th>
<th>Over 8.0 (96)</th>
<th>Over 9.0 (108)</th>
<th>Errors WR or SR</th>
<th>Completed b-d tests with one or more errors</th>
<th>Pass AT with error on WR or WS</th>
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<tbody>
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## Letter Trial

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<th>SR</th>
<th>KR</th>
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<tbody>
<tr>
<td>y p a d</td>
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<td>WR</td>
<td>WS</td>
<td>SR</td>
<td>KR</td>
<td>WR</td>
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<td>u j y v</td>
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<td>Writing Spelling</td>
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<td>Time</td>
<td>Time</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>* w q d t</td>
<td>tub</td>
<td>but</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>i m b u</td>
<td>hid</td>
<td>* dish</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* k l i h</td>
<td>* rid</td>
<td>bun</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>j c k d</td>
<td>* box</td>
<td>sod</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* a r b q</td>
<td>* mob</td>
<td>* nod</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r k v b</td>
<td>* does</td>
<td>hub</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>* j d e x</td>
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<td>d a b</td>
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<td>b u g</td>
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<td>* r P f b</td>
<td>* dad</td>
<td>* h o b</td>
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<td>b x h z</td>
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- o. of errors
  - b-d
  - others

- o. tried
  - percentage
  - Rank

- Rank
<table>
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<th>Sentence Reading</th>
<th>Kinetic Word Reading</th>
<th>Articulation Test</th>
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<tr>
<td>Time</td>
<td>PM</td>
<td>NPM</td>
</tr>
<tr>
<td>* buck</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* bum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* bay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>bear</td>
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<td>day</td>
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<td>brag</td>
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<td>browned</td>
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<td>* dong</td>
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<tr>
<td>* dump</td>
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<tr>
<td>* duck</td>
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<td>cob</td>
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<tr>
<td>lad</td>
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<td>bump</td>
<td></td>
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<tr>
<td>brown</td>
<td></td>
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<tr>
<td>* dear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* drag</td>
<td></td>
<td></td>
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<tr>
<td>lab</td>
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<tr>
<td>bum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* cod</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* bong</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Totals | | |
Tot. Errors | | |
E/IT % | | |
Others | | |
* | | |

No. of Rev. | | |
Other Errors | | |
No. of Errors | | |
No. Correct | | |
Sentence Reading Test

1. The man with the big gun shot the buck.
2. The tramp is a bum.
3. The boat sank in the bay.
4. The little cub walked beside the mother bear.
5. The boats are going to race on this day.
6. Don't brag around here any more.
7. The girl browned herself at the lake.
8. The door bell went ding-dong.
9. Don't dump my wagon.
10. The yellow babies swam behind mother duck.
11. I like corn on the cob.
12. The lad found many uses for the rocks.
13. Your head has a big bump on it.
14. The kitten was black, white and brown.
15. My father says that I am a little dear.
16. Your coat is beginning to drag on the ground.
17. The rocks were tested at the lab.
18. Boy! Did I feel bum!
19. Do not eat the cod.
20. I hear the bong of the big bell.
<table>
<thead>
<tr>
<th>Nonsense Spelling</th>
<th>Sense Nonsense</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>* bront dath</td>
<td>* hib darn</td>
<td></td>
</tr>
<tr>
<td>* sibe spab dring</td>
<td>* scab drape</td>
<td></td>
</tr>
<tr>
<td>* wid dut tade</td>
<td>* job brave</td>
<td></td>
</tr>
<tr>
<td>* bife glab dack</td>
<td>* dell doy</td>
<td></td>
</tr>
<tr>
<td>* bace drack dup</td>
<td>* plobe bog</td>
<td></td>
</tr>
<tr>
<td>* brob fibre drack</td>
<td>* tank dax</td>
<td></td>
</tr>
<tr>
<td>* trud tib worb</td>
<td>* yarb fed</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>E/IT %</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Totals**

TOTALS

E/IT %
APPENDIX F

Parent Permission Letters
Dear

I have permission from the Dallas Independent School District to conduct a research project in reading and spelling. The purpose of the study is to enable reading specialists to design better ways to teach reading.

I would like your permission to include your child, who has been randomly selected, as a possible participant in this study. The study will involve minimal testing in special areas of reading and spelling and may involve the use of the school's records, such as achievement test data. Scores of many students will be pooled and analyzed in a general way. None of the scores from the special testing will be placed on any of the school records, nor will your child's name be mentioned in any report of the study.

May I have your permission to invite __________ to participate in this reading and spelling test?

Sincerely,

Marjorie Merwin
Reading Clinician

I give my permission for __________ to take some reading and spelling tests. I also give my permission for other school record information such as achievement test data to be used in this study.

__________________________  ______________________________
Date                     Signature of Parent or Guardian
Estimado __________________

Tengo permiso del Dallas Independent School District de llevar acabo un proyecto de estudio sobre la habilidad de los niños de leer y deletrear. El propósito del estudio es para enseñar a los maestros que enseñan a leer a encontrar métodos más eficientes para ayudar a los niños.

Quisiera su permiso para incluir a su niño, quien ha sido elegido en una selección impensada, como un participante posible en este estudio. Esto envuelve dar unos exámenes mínimos en las áreas de leer y deletrear y puede incluir el uso de registros permanentes de la escuela, como los datos de las pruebas de alcance. Los resultados de muchos estudiantes serán puestos juntos y analizados en una manera general. Los resultados de estos exámenes no serán puestos en ningún registro permanente de la escuela, ni tampoco se mencionará el nombre de su hijo o hija en ningún reporte del estudio.

Podré tener su permiso a invitar a __________________ a participar en este examen de leer y deletrear?

Sinceramente,

Marjorie Merwin

Doy mi permiso para que __________________ tome algunos exámenes sobre leer y deletrear. También doy mi permiso para que otra información de registros escolares como los datos de las pruebas de alcance se pueda usar en este estudio.

_________________   __________________
Fecha               Firma de padre o
APPENDIX G

Letter to Panel for Proposal for Identifying Children with Severe Difficulty in Discriminating Between b and d
Dear

You have been selected because of your knowledge of the field of reading to serve on a selection panel. The purpose of this group is to rule on a criterion level for identifying children with b-d reversal problems. The results of your collective judgment will be used to investigate further the nature of this problem which is known to constitute a persistent difficulty in some children.

The norming sample of nonremedial students was given the Letter Naming Test, the Word Reading Test and the Writing-Spelling Test. These tests provided subjects with twenty, twenty-one, and twenty-three opportunities respectively to reverse the letters b and d. The subjects were not told that they were being judged on their reaction to the key letters. They were told only that they were being tested on their skills in working with the alphabet, reading and writing. The accompanying paper analyzes some of the results of this testing and suggests a level believed appropriate for identifying children with b-d reversal problems.

Please examine the enclosed proposal. If you feel that the criteria are reasonable, indicate by checking the proper blank below. If you feel that the criteria should be changed, check the alternate blank and specify what changes would seem appropriate. Then briefly state your reason for recommending the change.

Thank you for your cooperation.

Sincerely,

Marjorie Merwin

________________________
__I feel that the criteria are appropriate.

________________________
__I feel that the criteria should be changed. (Briefly explain on the back of this paper.)

________________________
Signature
APPENDIX H

Proposal for Identifying Children with Severe Difficulty in Discriminating Between b and d
A problem with reversing b and d should be considered severe if the child's performance in letter identification, reading words, and in writing indicates that he significantly deviates from the norms of his age group. In order to establish criteria for selecting children who have severe difficulty in distinguishing between these two letters, children were tested on three subtests of the b-d Discrimination Test (the Letter Naming Test, the Word Heading Test, and the Writing-Spelling Test). Normative data were obtained from one hundred twenty randomly selected individuals who were not involved in special education or remedial reading programs and whose parents granted permission for testing. Thirty subjects were tested from each of four age groups (seven, eight, nine and ten year olds). The resulting data has been used to establish criterion scores of each age group that would identify those who have great difficulty distinguishing between b and d.

Ability of an individual child to distinguish between b and d was not necessarily similar on all three tests, but for most subjects the performance in the varying categories tended to be similar. It is proposed that the term severe cases should be applied only to those subjects who show a
generalized difficulty in discrimination or whose poor performance in one or two categories deviates extremely from that of his general age group. Evaluation of the three score total seems to be the simplest way of locating severe cases of the type just described. In the event that an individual could not perform any one of the given tests, his classification would be made on the basis of the extreme nature of his scores on the tests to which he could respond.

The mean and standard deviation of the combined scores from the Letter Naming Test, the Word Reading Test and the Writing-Spelling Test were computed. This information was used to determine the error totals at each age level that would discriminate between the extreme and less extreme cases. Both the .05 and the .01 levels of significance were used. To explain further, those who make a total number of b-d reversals that equal or exceed the scores indicated at the .05 level would rank in the top five per cent of reversers in their age group by standards characteristic of a normal distribution. Those whose error scores are at or greater than the .01 level score would fall within the highest one per cent of their respective age classifications based on normal curve expectations.

The following table shows the result of these computations. It also indicates the number of individuals
in the nonremedial sample (the norming group) and the remedial group who would be identified as extreme cases based on the two criteria.

NORMATIVE DATA FOR TOTAL ERROR SCORES OF THE FIRST THREE SUBTESTS OF THE b-d DISCRIMINATION TEST

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Score Removed from Mean at .05 Level</th>
<th>Score Removed from Mean at .01 Level</th>
<th>Number in Norming Group In Each Category</th>
<th>Number in Remedial Group In Each Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>9.31</td>
<td>8.09</td>
<td>23</td>
<td>29</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>5.20</td>
<td>6.43</td>
<td>16</td>
<td>21</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>4.70</td>
<td>9.82</td>
<td>21</td>
<td>28</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>2.27</td>
<td>4.50</td>
<td>10</td>
<td>13</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Total</td>
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<td>8</td>
<td>6</td>
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The .05 category is inclusive of the .01 category.

An additional seven year old would be added due to extreme scores on the two tests she could complete.

As can be seen from the above chart, the means for the advancing age groups are successively smaller. This generalization is true of the nine year old category even though there were two extreme scores in the norming group. However, an unusually high standard deviation resulted from
the presence of these high scores. Consequently, the score required of a nine year old for significant deviation from the mean is higher than would be required of an eight year old. A suggestion that a different criterion be used to identify nine year old students with reversal difficulty than is used for other age groups is based on the following graphs.

**FREQUENCY DISTRIBUTIONS FOR THE TOTAL ERROR SCORES OF THE FIRST THREE SUBTESTS OF THE b-d DISCRIMINATION TEST BY AGE GROUPS**

**Seven Year Olds**

**Eight Year Olds**
Nine Year Olds

By inspecting these graphs it can be seen that the spread of scores in the seven year old group was greater than that of succeeding age groups. As age level increased a generalized trend toward lower error scores can also be observed. In the nine year old sample the massing tendency toward lower scores for the bulk of the sample appeared at an intermediate position between the achievement
of eight and ten year olds. This observation was confirmed by the median scores at each age level. The median number of errors for the seven year old group was 7.9; eight year olds, 2.99; nine year olds, 1.69 and ten year olds, 1.3. However, in contrast to this basic developmental progression was the appearance of two extreme individuals in the nine year old sample. It seems fair to conclude that these extreme scores unduly inflated both the mean and standard deviation of the nine year old group and, therefore, presented an inaccurate developmental picture for this age group. Since frequency distributions and medians indicate a continuous developmental tendency toward a reduction in b-d reversal errors, it follows that the number of errors that would define an extreme case in the nine year old category should not be greater than that which defines an extreme case of reversal among eight year olds. An adjustment is consequently proposed for the nine year old group.

It is recommended that subjects whose error scores on the first three subtests of the b-d Discrimination Test would theoretically place them in the highest one per cent of their age group be described as severe cases except in the case of the nine year old group. In the nine year old bracket the highest five per cent is recommended.
This arrangement will doubtlessly result in a conservative selection at the nine year old level since the level of errors required for identification as an extreme case is as great as that expected of the eight year old group. For the purposes of this study, however, conservative selection is to be preferred. The basic purpose of Phase II is to describe extreme cases, and it would be unwise to make an artificial definition based on logic rather than empirical data, if the arrangement might spuriously identify cases which do not belong among the extreme reversers. The reasonableness of this adjustment can be seen in that the number of extreme nine year olds selected is fewer than the number selected in either the eight or nine year old categories. Thus, the number of individuals selected by the relaxed criteria does not appear to be artificially inflated. Still another argument to support the adjustment is that the criterion score seems reasonably removed from the bulk of the test scores in the nine year old group. This judgment is based on an evaluation of the graph of the frequency distribution of the nine year old sample. The dotted line which is the dividing line between the normal and extreme cases is separated from the bulk of the scored by a distance representing at least fourteen more errors than were committed by most of the individuals falling within the normal range.
In summary, it is proposed that for age groups seven, eight and ten, subjects obtaining a score which differs from his age group mean to a highly significant degree (.01 level) be identified as having a b-d reversal problem. For the nine year old category it is suggested that only a significant deviation (.05 level) from the mean be required for designation to the extreme group.
APPENDIX I

Percentage Distribution Charts for Each Test at Each of the Four Tested Age Levels
Fig. 10--"Letter Naming Test" seven-year-old sample

Fig. 11--"Letter Naming Test" eight-year-old sample
Fig. 12--"Letter Naming Test" nine-year-old sample

Fig. 13--"Letter Naming Test" ten-year-old sample
Fig. 14 - "Word Reading Test" seven-year-old sample

Fig. 15 - "Word Reading Test" eight-year-old sample
Fig. 16--"Word Reading Test" nine-year-old sample

Fig. 17--"Word Reading Test" ten-year-old sample
Fig. 18--"Writing-Spelling Test" seven-year-old sample

Fig. 19--"Writing-Spelling Test" eight-year-old sample
Fig. 20--"Writing-Spelling Test" nine-year-old sample

Fig. 21--"Writing-Spelling Test" ten-year-old sample
Fig. 22--"Kinetic Reversal Word Reading Test" seven-year-old sample.

Fig. 23--"Kinetic Reversal Word Reading Test" eight-year-old sample.
Fig. 24--"Kinetic Reversal Word Reading Test" nine-year-old sample.

Fig. 25--"Kinetic Reversal Word Reading Test" ten-year-old sample.
Fig. 26--"Sentence Reading Test" seven-year-old sample

Fig. 27--"Sentence Reading Test" eight-year-old sample
Fig. 28--"Sentence Reading Test" nine-year-old sample

Fig. 29--"Sentence Reading Test" ten-year-old sample
Fig. 30--"Sense-Nonsense Test" seven-year-old sample

Fig. 31--"Sense-Nonsense Test" eight-year-old sample
Fig. 32--"Sense-Nonsense Test" nine-year-old sample

Fig. 33--"Sense-Nonsense Test" ten-year-old sample
Fig. 34--"Nonsense Spelling Test" seven-year-old sample

Fig. 35--"Nonsense Spelling Test" eight-year-old sample
Fig. 36--"Nonsense Spelling Test" nine-year-old sample

Fig. 37--"Nonsense Spelling Test" ten-year-old sample
Fig. 38--A Standardized Road-Map Test of Direction Sense seven-year-old sample.

Fig. 39--A Standardized Road-Map Test of Direction Sense eight-year-old sample.
Fig. 40--A Standardized Road-Map Test of Direction Sense nine-year-old sample.

Fig. 41--A Standardized Road-Map Test of Direction Sense ten-year-old sample.
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**Unpublished Materials**

