VISUO-SPATIAL ABILITIES AND READING ACHIEVEMENT
IN FIRST-AND FIFTH-GRADE CHILDREN

THESIS

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By

Peggy Ann Wilcox, B. A.
Denton, Texas
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This study attempted to clarify the relationship between visuo-spatial abilities and reading achievement at the first and fifth grades. Groups of good and poor readers were selected at each grade level on the basis of student's scores on the Wide Range Achievement Test in Reading. All subjects had obtained an I.Q. score of ninety or better. The sample was composed of twenty-one females and twenty-seven males.

Four tests from the Reitan-Indiana Neuropsychological Battery were given to assess visuo-spatial ability. It was hypothesized that visuo-spatial abilities are related positively to reading achievement and that this relationship is approximately equal at the two grade levels. Statistical analyses of results gave partial support to the first hypothesis.
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The nature of reading disability has been investigated for many years by those persons concerned with the disabled reader. Most of these investigations have tried to identify a specific syndrome that would allow the early identification of the disabled reader and planning of the necessary remedial techniques which would allow for maximal reading development. While investigations of reading have discovered many different correlates of poor reading such as improper instruction, poor vision, etc., most research today centers around what has been termed "specific dyslexia" or "specific reading disability." Eisenberg (Money, 1962) in discussing specific dyslexia states that it is an idiopathic condition and describes it as "a situation in which a child is unable to learn to read with proper facility despite normal intelligence, intact senses, proper instruction, and normal motivation [p. 4]."

The research on specific reading disability has been conducted from a wide range of theoretical approaches. Since an exhaustive review of this research is beyond the scope of this paper, only those theories central to a neuropsychological investigation will be mentioned. Research
attempts to understand specific reading disability as it might relate to neurological dysfunction have included its possible relationship to aphasia, alexia, mixed-lateral dominance, a developmental lag in the maturation of the central nervous system, and the neuropsychological investigation of cerebral dysfunction.

Doehring (1968) notes that "aphasia is customarily used to denote language disorders resulting from acquired cerebral dysfunction [p. 5]." While the work of neuropsychologists encompasses both language and non-language functions, their findings have generally concurred with explanations of cerebral dysfunction as it relates to aphasias. Aphasia is a result generally of lesions to the areas of the left hemisphere; anterior lesions are related to problems in writing and speech; posterior lesions are related to problems with listening and reading (Doehring, 1968).

Alexia is a specific form of aphasia. In a recent discussion of neurological theories of reading disability (Olson, Olson, & Duncan, 1968), alexia has been described as a disorder resulting from a lesion or developmental flaw in the angular and supra-marginal gyri of the left hemisphere resulting in an inability to understand the form or shape of letters and thus an inability to read.

The problem of mixed-lateral dominance and its relation to reading disability developed from the work of
Harris (1957). When he compared 215 children with severe reading disability with 345 other school children, he found that 40 per cent of the children with reading problems exhibited mixed-lateral dominance, while only 18 per cent of the other children showed it. Harris speculated that a possible slowness in neurological maturation might therefore be present in retarded readers.

Somewhat related to this idea of Harris is the "developmental lag" theory of Satz and Sparrow which postulates a slowness of maturation of the CNS which delays the acquisition of a developmental heirarchy of skills. A recent study (Satz, Radin, & Ross, 1971) was designed to test this theory by predicting that skills which the authors say are developed "ontogenetically earlier" would be present in younger dyslexics (ages 7-8) but not in older ones (ages 11-12). After taking six measures of such supposed differentially developing skills, results contradicted some of the four hypotheses investigated and offered only limited support to others. The authors conclude that while they interpret these data as lending support to the theory, that the postulated mechanism of maturational lag of the left hemisphere "lacks direct verification at this time [p. 2020]."

The above mentioned authors developed their hypotheses for the investigation, in part, from the work of Semmes (1968). Semmes in attempting to account for the organization
of differing complex functions in the cerebral hemispheres postulates "that focal representation of elementary functions in the left hemisphere favors integration of similar units and consequently specialization for behaviors which demand fine sensorimotor control such as manual skills and speech [p. 11]." These skills, Semmes feels, are diffusely represented in the right hemisphere thus rendering it more flexible for integrating differing units allowing for specialization of spatial abilities. Semmes ties her theory to the early notion that language functions are located in the hemisphere contra-lateral to the preferred hand.

Reitan (1970) studied children ranging from five to eight years of age who fell into one of two groups: those with evidence of cerebral damage and those functioning normally. In discussing his results he notes that his data contradict some of Semme's hypotheses. Comparisons of the brain-damaged and normal children studied "indicated more significant differences in comparisons of the non-dominant hands for skilled motor functions and the left hand for somatosensory functions than occurred for the dominate or right hands on corresponding measurements [p. 25]." Reitan suggests that hand preference of brain-damaged children develops in relation to the facility of the two upper extremities. The hand contra-lateral to the damaged hemisphere will therefore become the non-preferred
hand. This would make speculation as to language representation based on preferred hand especially risky at least in these cases.

Analysis of any investigation involving the pattern of abilities of dyslexic children in which matching between them and normal readers is based upon pattern of IQ scores should not overlook the findings of Reed (1967). This study investigated first grade children (CA 6) and fifth grade children (CA 10) and the relation of differences between their WISC Verbal and Performance IQ's and reading achievement. Reed found that Full Scale IQ accounted for more of the variance in reading achievement at CA 6 than did the relative pattern of Verbal vs. Performance IQ values. A relationship was found between kind of intelligence and reading achievement in the older group (CA 10); those children whose Verbal IQ was higher than their Performance IQ showed greater skill in reading. Reed cautions that this does not mean that low reading achievement may be regarded as resulting from low verbal IQ.

The work of neuropsychologists such as Halstead and Reitan has become increasingly more involved with reading research in recent years. Reitan's development of a neuropsychological test battery for assessing locations of cerebral lesions and the damage resulting from them in adults has led to the development of similar batteries
for children ages five to eight and nine to fourteen years. These batteries are highly similar, but each contains some different tests. The batteries have been designed to utilize three methods of inference: (a) measurement of level of performance by an individual on certain psychological tests; (b) the differential score approach; (c) and a within individual comparison of performance of one side of the body against the other and checking this with normative data (Reitan & Heineman, 1968).

Results of investigation by Reitan (1960) of acquired dysphasia with his adult battery have stimulated interest in the children's batteries as means for investigating possible cerebral dysfunction of non-reading abilities as they related to reading disability. While some might consider specific reading disability a unique disorder, Doehring (1968) has noted the usefulness of a multifactored model in research of the problem. This would allow for the study of specific reading disorder as a pattern of abilities that may vary somewhat independently of each other. Doehring suggested that reading disability might be studied "not as a unique disorder, but in the context of other pattern of disability such as a specific deficiency in the comprehension of spatial relationships or a specific difficulty in numerical reasoning [p. 3]."

A comprehensive study of the abilities of 39 male retarded readers aged 10-14 years carried out by Doehring
(1968) used many of the tests from the Reitan-Indiana Neuropsychological Battery. The retarded readers were compared with 39 male normal readers and 39 female readers whose mean age and Performance IQ equated that of the retarded readers. A "blind" interpretation (no knowledge of subject's history or neurological status) of the results of the tests from the Reitan battery minus any results of tests requiring reading or spelling was carried out on the records of 39 retarded readers and 39 male normal readers. A Chi-Square test of a judge's placement of each record into one of three categories (reading disability, possible reading disability, and normal) yielded a difference between groups significant beyond the .01 level. Statistical analyses of differences between the normal and retarded readers revealed the performance of normal readers to be significantly better on 22 of the variables included from Reitan's battery (14 of these differences being significant at the .001 level). These findings support the use of the Reitan-Indiana Neuropsychological Battery as a tool for the investigation of reading retardation. Doehring suggests that comparisons of such test results of retarded readers with children with confirmed cerebral dysfunction would be valuable in providing indications of cerebral dysfunction and left hemisphere involvement in reading disability.

In approaching reading disability from a multi-factor theory, the use of a battery that measures a wide variety
of skills would be helpful. Reed (1968) carried out a study designed to determine if behaviors required for learning to read are different from those needed for the reading process itself. In discussing his use of tests from Reitan's battery, Reed noted that while little work had been done on normally functioning children with the battery, it measures skills thought necessary for reading and thus might prove useful for an investigation of reading. Groups of good and poor readers in the first grade (age 6) and fifth grade (age 10) were identified by their test scores on standardized tests of reading. They were also given the Wechsler Intelligence Scale for Children (WISC, Wechsler, 1949) as well as several other tests from the Reitan-Indiana Neuropsychological Battery. Differences between the means of good and poor readers in each age group were calculated for each measure and then transformed to standard scores. Then these scores were ranked from 1 to 20. A Spearman's rank order correlation coefficient of .76 was found between the two ranks. After an examination of the results, Reed concluded

Within the range of variables measured by these tests, it does not appear that older children who have difficulty with reading are characterized by one set of difficulties and younger children who have trouble with the process of learning to read are characterized by another set of deficits. However, deficits in the ability to perceive and express visuo-spatial relations appear to be somewhat more characteristic of children who have difficulty in the process of learning to read. [p. 139]
The question of importance of visuo-spatial abilities to reading is raised by results obtained in another study by Reed (1970). Using tests from Reitan's battery, Reed sought to illustrate how the ability patterns of retarded readers are in part determined by the expectancy measures and estimates of reading potential employed by the investigator. Three groups of fifth-grade poor readers were identified: (a) those with WISC Verbal I.Q. 90 or greater, (b) those with WISC Performance I.Q. 90 or better, (c) those whose WISC Full Scale I.Q. was 90 or better. Each child in each group was paired with a good reader on basis of VIQ, PIQ, PSIQ respectively. Then selected tests from Reitan's battery were administered to each group. The results were reported as the number of good and poor readers falling below the twenty-fifth percentile on each test when good and poor readers were matched as to the three measures of intelligence. Ability deficit patterns were found to vary greatly according to which intelligence measure was used for matching. Only two tests measured differences between good and poor readers consistently: these are the Progressive Figures Test and the Color Form Test. Reed concludes:

Both tests appear to require some ability to analyze spatial relations among geometrical shapes as well as the ability to hold an instruction or shift set. Possibly these skills are related to achievement in reading, but it cannot be assumed that good and poor readers would still be differentiated on these tasks had another estimate of learning been employed [p. 35].
The study by Reed (1968) while showing a significant relationship between abilities of young and older readers seems to indicate that visuo-spatial relations may be more closely related to reading at the beginning level than at a more advanced level. A later study (Reed, 1970) showed tests which require ability to analyze spatial relations and also to shift set (Color Form and Progressive Figures) to be the only two tests, in a group of tests measuring non-reading skills, which produce consistent differences between good and poor older readers. Thus the relationship of visuo-spatial abilities to reading at these different age levels is in question. If proper remedial, diagnostic, and prevention techniques are to be developed, it is necessary that we understand the abilities that are related to reading at all levels.

The present study was conducted to help clarify the relationship between visuo-spatial abilities and level of reading achievement. In agreement with Reed, it is believed that older children experiencing trouble in reading and younger children who are having trouble learning to read are characterized by similar patterns of deficits and, further, that visuo-spatial abilities are closely related to reading at both levels. It was hypothesized that (a) visuo-spatial abilities will be found to have a significant, positive relationship to reading.
achievement in older and younger children and (b) there will be no significant difference in the size of this relationship at either age level.

Method

Subjects and Group Composition

Subjects in this study were drawn from Grade I and Grade V classrooms of two middle-income elementary schools in a north central Texas city. Teachers from these grades were asked to draw up a list of good and poor readers from their classes. These students were then administered the Wide Range Achievement Test (WRAT) in Reading (Jastak & Jastak, 1965). Because it has been shown that characteristics of retarded readers will vary according to the expectancy measure used (Reed, 1970), it was decided to define good and poor reading achievement on the basis of the untreated WRAT score.

Those children scoring at the 34th percentile or lower on the WRAT reading subtest were designated as poor readers, and those children scoring at the 66th percentile or higher were designated as good readers. An abbreviated form of the WISC (Satz, Van die Riet, & Mogel, 1967; Yudin, 1967) was administered to these children; all those children obtaining a WISC Full Scale I.Q. of 90 or above were retained as subjects. Forty-eight subjects (26 at Grade I
and 22 at Grade V) were divided into four groups: Group I (N=10) composed of Grade I poor readers; Group II (N=12) composed of Grade I good readers; Group III (N=14) composed of Grade V poor readers; and Group IV (N=12) composed of Grade V good readers. The mean chronological age (CA) of subjects in Grade I at the time testing began was 6 years 8 months; at Grade V, the average CA was 11 years 0 months. The sample was composed of 27 males and 21 females. Testing was completed in approximately a six weeks interval during April and May.

Tests Administered

In order to obtain measures of visuo-spatial skills in these subjects, four tests from the Reitan-Indiana Neuropsychological Test Battery (Reitan, 1970) were administered:

1. Color Form Test: The stimulus material is composed of geometrical figures of different colors and shapes. The subject must trace through the pattern of figures by moving from the first shape to another which has the same shape but a different color and next to a form having the same color but a different shape, etc. The test score is the total time to complete the task. The test seems to measure the ability to analyze spatial relationships and also the ability to shift set.

2. Progressive Figures Test: The stimulus is an 8 1/2" x 11" sheet of paper printed with eight stimulus
figures; each figure is composed of a large outer geometric figure with a smaller geometric figure of different shape inside. The subject must draw a line from the initial figure to another figure whose large outside shape was the same as the small geometric shape of the initial figure, etc. The score is the total time needed for completion of task.

3. The Target Test: A stimulus figure 18" x 18" in size is attached to the wall in front of the subject. The figure is composed of nine large black dots arranged in rows of three forming a square. The subject has an 8 1/2" x 11" answer sheet consisting of twenty small replicas of the stimulus figure. After watching the examiner complete each pattern and waiting for a three-second interval, the subject must draw the presented pattern on his answer sheet. There are twenty items. In addition to reproduction of a visually perceived spatial pattern the task requires a delayed response. The test score is the number of correctly reproduced items.

4. Matching V's: The subject is required to match stimulus figures according to the size of angle represented. A card on which printed V's of increasing width from left to right is presented to the subject along with a set of small blocks on which V's of angles matching those on the card are printed. The subject is then instructed to match the small blocks with the V's on this card. The score is
the number of errors made and time taken to complete the task.

Results
At each grade level, the difference between the means of the good and poor readers on each measure was tested for significance by a \( t \) test. At grade one, while Group II (good readers) outperformed Group I (poor readers) on all the visuo-spatial tasks, only the Progressive

TABLE 1
Means, Standard Deviations and \( t \) Values for Grade I

<table>
<thead>
<tr>
<th>Test</th>
<th>Groups</th>
<th></th>
<th></th>
<th>( t )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group I (N=10)</td>
<td>Group II</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
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<td>-----------------------</td>
<td>-------</td>
<td>-------</td>
<td>---------------</td>
<td>-------</td>
</tr>
<tr>
<td>Progressive Figures</td>
<td>166.90</td>
<td>140.83</td>
<td>48.58</td>
<td>15.34</td>
</tr>
<tr>
<td>Color Form</td>
<td>39.00</td>
<td>16.18</td>
<td>17.5</td>
<td>8.02</td>
</tr>
<tr>
<td>Matching V's</td>
<td>45.4</td>
<td>11.63</td>
<td>38.08</td>
<td>9.92</td>
</tr>
<tr>
<td>Target</td>
<td>11.6</td>
<td>2.76</td>
<td>14.5</td>
<td>4.08</td>
</tr>
<tr>
<td>WISC</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Verbal I.Q.</td>
<td>119.8</td>
<td>10.98</td>
<td>142.42</td>
<td>12.09</td>
</tr>
<tr>
<td>Performance I.Q.</td>
<td>105.9</td>
<td>14.41</td>
<td>125.08</td>
<td>14.02</td>
</tr>
<tr>
<td>Full Scale I.Q.</td>
<td>115.1</td>
<td>10.51</td>
<td>137.58</td>
<td>11.52</td>
</tr>
</tbody>
</table>

*\( p \leq .01 \)
**\( p \leq .001 \)

Figures and Color Form yielded a significant difference.
Results of the comparisons of first grade groups are presented in Table 1.
At Grade V good readers (Group IV) also performed better on the visuo-spatial tasks than poor readers (Group III). Only the Color Form Test produced a significant difference between these groups at Grade V. Results of the comparisons of the Grade V groups are presented in Table 2.

**TABLE 2**

Means, Standard Deviations and $t$ Values for Grade V

<table>
<thead>
<tr>
<th>Test</th>
<th>Group III (N=14)</th>
<th>Group IV (N=12)</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive Figures</td>
<td>Mean: 49.64</td>
<td>Mean: 32.33</td>
<td>1.64</td>
</tr>
<tr>
<td></td>
<td>SD: 32.55</td>
<td>SD: 14.12</td>
<td></td>
</tr>
<tr>
<td>Color Form</td>
<td>Mean: 15.29</td>
<td>Mean: 10.00</td>
<td>2.30*</td>
</tr>
<tr>
<td></td>
<td>SD: 7.15</td>
<td>SD: 2.98</td>
<td></td>
</tr>
<tr>
<td>Matching V's</td>
<td>Mean: 34.00</td>
<td>Mean: 25.33</td>
<td>1.70</td>
</tr>
<tr>
<td></td>
<td>SD: 14.05</td>
<td>SD: 10.69</td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td>Mean: 16.62</td>
<td>Mean: 16.83</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>SD: 2.18</td>
<td>SD: 3.04</td>
<td></td>
</tr>
<tr>
<td>WISC</td>
<td>Verbal I.Q. Mean: 110.29</td>
<td>Mean: 133.92</td>
<td>-5.10**</td>
</tr>
<tr>
<td></td>
<td>SD: 9.0</td>
<td>SD: 13.57</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Performance I.Q. Mean: 109.36</td>
<td>Mean: 120.92</td>
<td>-2.16*</td>
</tr>
<tr>
<td></td>
<td>SD: 11.19</td>
<td>SD: 14.93</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Full Scale I.Q.  Mean: 110.79</td>
<td>Mean: 130.00</td>
<td>-4.55**</td>
</tr>
<tr>
<td></td>
<td>SD: 6.92</td>
<td>SD: 13.26</td>
<td></td>
</tr>
</tbody>
</table>

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

**Discussion**

The hypothesized positive relationship between reading achievement in older and younger children and visuo-spatial abilities, as measured by the tests used in this study, was given partial confirmation by the statistical analyses. While both the Color Form Test and the Progressive Figures
Tests yielded significant differences between Grade I good and poor readers, only the Color Form Test Yielded a significant difference at Grade V. Reed (1970) has noted that these tests require an ability to shift set and to remember instructions as well as the ability to analyze spatial relations. The fact that both Matching V's and the Target Test failed to produce a significant difference between groups at either level, may suggest that these are tasks requiring fewer abilities. The fact that Color Form and Progressive Figures yielded significant differences between groups whereas Matching V's and Target did not, might be explained by Reed's (1968) idea that reading impairment results from a group of deficits rather than a specific deficit. Thus, performance on tests (Color Form and Progressive Figures) requiring a number of abilities would more likely be affected in children with reading problems than would performance on tests (such as Matching V's and Target Test) more limited in abilities tapped.

The second hypothesis regarding the size of the relationship between visuo-spatial abilities and reading achievement at Grade I and Grade V was not supported. The findings of this study seem to support Reed's conclusion (1968) that while older and younger readers seem to share a similar pattern of deficits, deficit in visuo-spatial abilities is more often seen in children having trouble learning to read. The fact that one of the visuo-spatial tests (Color Form)
yielded a significant difference at both grade levels may be due, in part, to the complex type of analysis of the relationship between color and geometric shapes that this task represents. This more complex task may, in fact, more nearly approximate the reading process than any of the other measures. Since a significant difference was found at both grade levels on the Color Form, it seems doubtful that the pattern of deficits associated with reading impairment is greatly different at these levels.

Comparisons of WISC Verbal, Performance, and Full Scale I.Q.'s of the first grade groups showed a significant difference favoring the good readers on Verbal and Performance I.Q.'s. While good readers did obtain a higher group mean on the Full Scale I.Q. variable, the difference was not significant. Both first grade groups obtained higher Verbal than Performance means. This finding is in agreement with a previous report that level of intelligence rather than Verbal-Performance I.Q. ratio is related to reading achievement in younger children (Reed, 1967).

Good readers obtained significantly higher scores on all WISC variables than poor readers in the fifth grade. Both groups scored higher on the Verbal than on the Performance Scale. With the difference between the groups on the Full Scale and Verbal variables being significant at the .001 level, it is necessary to recognize that the difference in reading skill of these groups might be due
to the I.Q. advantage of the good readers. Differences obtained between the groups on the visuo-spatial tasks might be more descriptive of a difference of I.Q. level rather than a difference in reading achievement level.

Other characteristics of the sample may be useful in interpreting the failure to find significant differences between good and poor readers on the visuo-spatial tasks. In a previous study (Reed, 1970) in which differences were found on both the Color Form and Progressive Figures Tests between fifth grade good and poor readers, all fifth graders in three schools were administered these tests as part of a normative study. Afterward, records of good and poor reader's performance on these tests were compared and the results reported; any fifth grade student was a potential subject. In the present study the pool of potential subjects was partially limited by the judgement exercised by teachers in drawing up the lists of good and poor subjects.

It is also important to note that Reed (1968, 1970) used the Gates Diagnostic Survey Test and the Iowa Silent Reading Test as his measures of reading achievement. The present study used the reading subtest of the Wide Range Achievement Test. This test is largely an oral measure of word recognition and may measure different abilities than the tests used by Reed.

The groups of poor readers in the present study were almost equally composed of males and females. The incidence
of reading disability in males has been reported as at least twice that in females (Money, 1962, p. 31). Because of a failure to find this reported male-female ratio in the present sample as well as the manner in which the groups in the present study were formed, it is possible that this sample included cases of low reading achievement that may have been due to environmental or emotional factors as well as possible neurological dysfunction. This tends to be substantiated by the finding that there were no significant differences between the first- and fifth-grade groups on the Target Test and Matching V's.
References


