Visual Sequential Memory in Reading Disability

John T. Guthrie, Ph.D. and Herman K. Goldberg, M.D.

Relationships between visual sequential memory and reading in 81 normal and 43 disabled readers were investigated. The children had normal intelligence and a mean reading grade of 2.5. The mean chronological age of the normals was 8.5 years, and the mean of the disabled was 10.3. Partial correlations between three tests of visual sequential memory and three tests of reading were computed. Significant, positive associations were identified between visual sequential memory and paragraph comprehension, oral reading and word recognition. The intercorrelations of the visual memory tests were moderate indicating that these tests do not measure identical abilities. The results suggest that reading disability may derive from the lack of coordination among three different visual memory functions which are required for reading.

A logical analysis of the reading process suggests that visual sequential memory is necessary for the successful comprehension of sentences which are presented in written form. First, visual sequential memory is vital to word recognition. For example, recognition of the word "dog" depends on the memory of all of the letters in the correct sequence. If either the total number of letters or their sequence was distorted, the word "dog" might be recalled as "do," or "og," or "good." Second, the comprehension of phrases is dependent on visual sequential memory. When a phrase such as "light green butterflies" appears in writing, the reader must recall the correct order of the words to prevent confusion with other possible arrangements of the words such as "green butterflies light" which may convey an entirely different meaning. Thus, it is apparent that visual sequential memory refers to the retention of the order of a series of visually presented stimuli, and it is probable that this ability is relevant to reading.

Visual sequential memory must be distinguished from other types of visual perception and visual memory. For example, the Bender-Gestalt Test is primarily a measure of visual perception of form. In this test, the examinee is required to reproduce complex forms which are available for his inspection, and the individual's performance is judged on the basis of the accuracy of the reproductions. No assessment of memory for form or sequence is included in this test.

Visual sequential memory is also distinct from visual discrimination. An example of a test of visual discrimination is the Position in Space subtest of the Frostig Developmental
Test of Visual Perception. This measure consists of the presentation of a stimulus such as $\mathbf{h}$ and the simultaneous presentation of several alternative choices including $\mathbf{h}$, $\mathbf{i}$, $\mathbf{q}$. The examinee's task is to select the alternative which is identical to the original stimulus. The difference between visual discrimination and visual sequential memory is that the former consists of the visual comparison of several stimuli. On the other hand, the latter requires the retention of a sequence of visually perceived stimuli.

The purpose of the present investigation was to relate visual sequential memory to reading in normal and disabled readers. Unfortunately, previous research on visual sequential memory has been either irrelevant to reading or methodologically unsound as a basis for conclusions regarding reading. Silverstein (1962) found the Benton Test to possess fair reliability ranging from .62 to .81 depending on the response mode. However, no correlations with reading were provided. Two studies (Whipple and Kodman, 1969; Rizzo, 1939) have reported disabled readers to be inferior to normal readers in visual sequential memory tasks. However, both studies included tachistoscopic presentation of stimuli with exposure times of .1 second. Since the perceptual speed of disabled readers is known to be slower than that of normal readers (McGrady and Olson, 1970), it is likely that the stimuli could not be accurately perceived by disabled readers in the short time periods used in the above studies. Consequently, the alleged inferiority of disabled readers in visual memory is undoubtedly attributable to a deficiency of perception. Thus the relationship between visual sequential memory and reading has not been rigorously examined in previous investigations, and the hypothesis of the present study was that a positive correlation between visual sequential memory and reading would be identified.

METHOD

Subjects. The subjects in the study were drawn from the Baltimore Public Schools, the laboratory school of Towson State College, and a summer remedial reading program conducted at the Kennedy Institute of Baltimore, Maryland. There were two groups formed, normal readers and disabled readers. There were 81 normal readers who had an average age of 8.55 years. The IQ scores of the normal group, as measured by the WISC, had a mean of 98.27, with a standard deviation of 16.07. The reading ability of this group as assessed by the Gray Oral Test was a grade level of 2.55, with a standard deviation of 1.93.

The disabled readers were defined as children who had IQ scores higher than 80 and reading ages two or more years behind chronological age. It should be noted that the normal and disabled groups are virtually identical in both IQ and reading achievement. It is possible that visual memory has differential effects on reading at different levels of reading ability. Since the intent of the study was to compare the role of visual memory in reading for normal and disabled readers, the two groups of readers were formed to have similar reading levels. See Table I for a summary of these data.

Tests. The tests of visual memory administered to all of the subjects included the Benton Visual Retention Test and the Visual Sequential Memory Subtest of the Illinois Test of Psycholinguistic Abilities. These two measures are similar, although not identical. They both include: the presentation of a series of geometric forms to the subject, the removal of the forms and the requirement that the subject remember the forms. The response mode of the two tests is different. In the Benton, the subject is required to recognize the correct series of forms when they are presented with several incorrect alternatives. However, in the ITPA subtest of visual sequential memory, the subject is required to construct the sequence from individual forms which are available to him. Other tests which were administered to the normal group were the Knox Cube Test and the Visual Closure subtest of the Illinois Test of Psycholinguistic Abilities. The tests were administered to all of the subjects individually and the examiners did not know whether the readers were normal or disabled prior to the administration of the tests.

The reading tests administered to the subjects included the Gray Oral Test which was given to all children, the Metropolitan Reading
Achievement which was administered to the disabled readers, and the Wide Range Achievement Test (WRAT) which was administered to 48 of the children in the normal group. The mean chronological age of the children who received the WRAT was 8.0 years, the mean WISC IQ was 91.42 and the mean WRAT grade equivalent was 2.17.

RESULTS

The data were analysed by correlating the reading test scores with the visual memory test scores separately for the normal and disabled readers. The results for the normal readers are summarized in Table II. As the figures in the table indicate, performance on the Gray Oral Test correlated .47 with the ITPA subtest of visual sequential memory, .31 with the Benton Visual Retention Test and .34 with the Knox Cube Test. All of the correlations were significantly greater than zero at the .01 level. These correlations reflect the fact that students who perform well on the Gray Oral also perform well on the three measures of visual memory; and students who perform poorly on reading also perform poorly on visual memory. Further discussion on the interpretation of these correlations will be presented at a later point in the results section.

The relationship between visual memory and reading for disabled readers is displayed in Table III. First, the correlation between the Gray Oral and the ITPA subtest of visual sequential memory was .15 which was not significantly different from zero. On the other hand, the Benton Visual Retention Test correlated .32 with the Gray Oral Test and .36 with the Metropolitan reading comprehension subtest. Both of the latter coefficients were significant at the .05 level of significance. In sum, for the disabled group, the Benton correlated with oral reading and comprehension although the ITPA visual sequential memory test did not exhibit a significant relationship with reading.

Partial correlation coefficients were computed for all of the measures of reading and visual memory. The rationale and importance of this statistical procedure are outlined below. It can be observed in both Tables I and II that the measures of visual memory were positively correlated with the chronological ages of the subjects. For example, among normal readers, the correlation of the Benton Test and chronological age was .48 which is significant at \( p < .01 \). It is also apparent that the chronological age of the subjects was positively correlated with their performance on the reading measures. For instance, the correlation of chronological age and the Gray Oral was .70 for normal readers. Thus both visual memory and reading was positively correlated with age. Under these conditions, it is possible that the correlation between visual memory and reading was an artifact of their mutual correlation with age. If such were the case, the two capabilities of visual memory and reading might not bear a functional relationship to one another. That is, it is possible that visual memory and reading are not truly associated but only appear to be associated due to the fact that they both improve with age.

The purpose of computing the partial correlation coefficients was to determine whether visual memory and reading were functionally related apart from their joint correlation with chronological age. Statistically speaking, the effects of chronological age were partialed out of the scores on the reading measures, and the
adjusted reading scores were correlated with the measures of visual memory. Separate partial correlation coefficients were computed for each visual memory test and each reading test on which data were available. In each case, the variable of chronological age was removed from the zero-order correlation coefficients between visual memory and reading. The partial correlation is a pure measure of the association between reading and visual memory, uncontaminated by age.

The results of the partial correlation analyses are presented in Table IV. The significant partial correlations for normal readers include: Benton and Gray Oral .28; ITPA visual sequential memory and Gray Oral .35; Benton and Wide Range Achievement Test .47; and Knox Cube and Wide Range Achievement Test .23. For the disabled readers, the sole significant relationship was the partial correlation of .47 between the Benton Visual Retention Test and the Metropolitan Reading Comprehension subtest. It is noteworthy that the partial correlation procedure identified fewer significant relationships between the tests of visual memory and reading than the zero-order correlation procedure. For example, the zero-order correlation between the Knox Cube and the Gray Oral was .34 for normal readers which was significant. However, the partial correlation for the Knox Cube and the Gray Oral when chronological age was removed was .11 which does not differ significantly from zero. In other words, the apparent relation between the Knox Cube and the Gray Oral for normal readers is illusory. The insignificant partial correlation indicates that these two measures are not directly associated. Their association derives from their mutual correlation with chronological age. The association does not derive from their functional interdependence.

The intercorrelation among the different measures of visual memory and perception in this study are presented in Table V. The strength of the associations is remarkably consistent. The range of correlations is from .38 to .49. All of these correlations are significantly greater than zero. Although the measures are highly interrelated, they are not necessarily related to reading with equal strength or consistency as indicated by the partial correlations between these measures and the reading tests.

**DISCUSSION**

Visual sequential memory is one of the many visual functions required for reading. Other necessary capabilities include visual perception,

**TABLE III. Correlation of visual memory and reading for disabled readers (N = 43).**

<table>
<thead>
<tr>
<th></th>
<th>CA</th>
<th>ITPAM</th>
<th>BVR</th>
<th>G.O.</th>
<th>MRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronological Age</td>
<td>.26*</td>
<td>.43**</td>
<td>.58**</td>
<td>-.14</td>
<td></td>
</tr>
<tr>
<td>ITPA Visual Sequential Memory (ITPAM)</td>
<td>.38*</td>
<td>.16</td>
<td>.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benton Visual Retention Test (BVR)</td>
<td>.32*</td>
<td>.38*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gray Oral (G.O.)</td>
<td>.54*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metropolitan Reading Comprehension (MRC)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < .05
** p < .01

**TABLE IV. Partial correlation between visual memory and reading.**

<table>
<thead>
<tr>
<th>TESTS</th>
<th>Normal Readers</th>
<th>Disabled Readers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benton – Gray Oral</td>
<td>.28**</td>
<td>.43</td>
</tr>
<tr>
<td>ITPAM – Gray Oral</td>
<td>.35**</td>
<td>.43</td>
</tr>
<tr>
<td>Knox – Gray Oral</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>Benton – Metropolitan Reading Comprehension</td>
<td>N. A.</td>
<td>.43</td>
</tr>
<tr>
<td>ITPAM – Metropolitan Reading Comprehension</td>
<td>N. A.</td>
<td>.43</td>
</tr>
<tr>
<td>Benton – Wide Range Achievement Test</td>
<td>.18</td>
<td>.23</td>
</tr>
<tr>
<td>Knox Cube – Wide Range Achievement Test</td>
<td>.23</td>
<td>.23</td>
</tr>
</tbody>
</table>

* p < .05
** p < .01
N. A. = not available

**TABLE V. Correlations among several measures of visual memory and perception (N = 81).**

<table>
<thead>
<tr>
<th></th>
<th>ITPAM</th>
<th>BVR</th>
<th>G.O.</th>
<th>ITPAVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITPA Visual Sequential Memory (ITPAM) Retention</td>
<td>.42*</td>
<td>.46*</td>
<td>.49*</td>
<td></td>
</tr>
</tbody>
</table>

* p < .01

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visual discrimination and visual fusion. It stands to reason that visual sequential memory depends on the three other abilities. If an individual is unable to perceive a given visual stimulus, that is if he is unable to determine whether the stimulus is present or absent in the visual field, he will not be able to remember the stimulus. Likewise, if a person cannot distinguish whether two different stimuli are actually the same or different, he will not be able to retain in memory either one of the two stimuli. Confusion among these various visual functions should be avoided since the functions may affect reading in distinct ways. Furthermore, these functions may be influenced by completely different variables (Benton, 1962). The measures employed in this study provide indicators of visual sequential memory and include: the Benton Visual Retention Test, the ITPA subtest of visual sequential memory and the Knox Cube test.

The primary outcome of the study was that the tests of visual sequential memory were significantly correlated with several measures of reading. Some of these correlations were found to be positive and significant even after the effects of chronological age were removed from the correlations. However, since a few of the significant zero-order correlations between visual memory and reading were reduced to insignificance when the effects of age were removed, the use of partial correlations rather than the traditional zero-order correlations would appear to be warranted in studies of this type.

It is particularly noteworthy that the Benton Visual Retention Test showed more partial correlations with reading than all of the other tests combined. For some reason, the Benton appears to be more central to reading than the ITPA subtest of visual sequential memory. The Benton differs from the other tests in several important respects. All of the tests require visual memory. That is, the tests require the examinees to remember the order of a series of stimuli presented to them. However, the Benton Test also requires the subject to remember both the form and the attitude (rotation) as well as the sequence of the stimuli.

The Benton Test places a simultaneous demand of memory for form, attitude and sequence of stimuli on the examinee. Since the Benton Test correlates highly with reading, it is probable that reading also requires the simultaneous demand of memory for form, attitude and sequence. For example, the skill of word recognition requires the retention of the specific letters contained in the word (memory for form) the attitude of the letters (rotations such as d and p) and the sequence of the letters (bad versus dab).

The high partial correlation of the Benton with reading and the moderate partial correlation of the ITPA subtest of visual sequential memory and the Knox Cube with reading indicate that central to reading is the simultaneous operation of several memory functions. If the coordination among these functions is disrupted, or if the functions fail to act in concert, reading is likely to be impaired. It appears that memory for form, attitude, or sequence may be intact if they are tested separately, but if they are tested simultaneously, one or more of the abilities may be inoperative. Thus, reading disability may result from the lack of coordination, interaction, and simultaneity of the several visual memory abilities required for reading. Further research into this source of reading disability appears to be promising.

A final point of importance is that the Benton Test had a positive correlation with several different types of reading measures. The Benton was related to paragraph comprehension, oral reading, and work recognition as assessed by the Metropolitan reading comprehension subtest, the Gray Oral and the WRAT. Consequently, the simultaneous memory for form, attitude, and sequence is critical at several levels of analysis in reading. Future investigations should be addressed to the issue of whether visual memory can be improved and whether training on visual memory facilitates reading skills. – J.F.K. Institute for the Habilitation of the Mentally & Physically Handicapped, 707 North Broadway, Baltimore, Md. 21205

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REFERENCES

BASED ON TITLE 18A, Chapter 46 of the New Jersey Statutes, Inter-Agency has produced a brief folder, titled "Rights of the Handicapped Child to a Public School Education in New Jersey." The folder is aimed at the families of some 25,000 handicapped youngsters currently in special programs in the public schools, and an estimated 50,000 additional youngsters who aren't getting the services they need.

"Many parents of handicapped children are unaware of the mandatory requirements for local public schools to provide a suitable education for virtually all children from age 5 to 20," said Richard Ziegler of Trenton, chairman of the Inter-Agency Committee for the Handicapped, official liaison body for nine statewide voluntary agencies concerned with people who have mental or physical disabilities.

The folder was produced with the cooperation of the New Jersey Department of Education's Branch of Special Education. Dr. Daniel Ringelheim, deputy commissioner of education and head of the Branch of Special Education and Pupil Personnel Services, stated, "This outline should certainly help the parent who has a question about the educational program of his handicapped child. It offers specific steps to help assure that the parent understands the school's evaluation and placement for the child."

Inter-Agency produced an initial 25,000 folders and has set a target of distributing at least 50,000 during this school year. The folder explains that the law covers children who are (1) mentally retarded, (2) visually handicapped, (3) auditorily handicapped, (4) communication handicapped, (5) neurologically or perceptually impaired, (6) orthopedically handicapped, (7) chronically ill, (8) emotionally disturbed, (9) socially maladjusted or (10) multiply handicapped.

The folder lists questions frequently on the minds of parents and brief answers. Some of the areas covered are: who is included under the law, must the school system provide a local facility, how to get services, who decides on placement, what procedure to follow if the parent disagrees with classification or placement and how a community can better meet the needs.

Inter-Agency's member agencies frequently are a source of information to parents. The folder lists the statewide office address of the 9 agencies, many of which have regional or county chapters. The member agencies are the Easter Seal Society for Crippled Children and Adults of N.J., N.J. Association for Children with Learning Disabilities, N.J. Association for Mental Health, N.J. Association for Retarded Children, N.J. Council of Organizations and Schools for Emotionally Disturbed Children, N.J. League for the Hearing Handicapped, N.J. Welfare Council, Spina Bifida Association of Northern New Jersey, and United Cerebral Palsy Associations of N.J.

Single copies of the folder are free for a stamped self-addressed envelope. Quantity prices are $3 per hundred and interested groups such as PTA's, women's clubs and service clubs are invited to distribute them as a public service. Order from Inter-Agency Committee for the Handicapped, 312 West State St., Trenton, N.J. 08618.