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ORIGINAL ARTICLE

Is Visual Memory Predictive of Below-Average Academic Achievement in Second through Fourth Graders?

MARJEAN TAYLOR KULP, OD, MS, FAAO, KRISTYNE E. EDWARDS, OD, MS, FAAO, and G. LYNN MITCHELL, BS, MAS

The Ohio State University College of Optometry, Columbus, Ohio

ABSTRACT: *Purpose.* Controversy exists regarding the relation between visual memory and academic achievement. *Methods.* A masked investigation of the relation between visual memory and academics was performed in 155 second- through fourth-grade children (mean age = 8.83 years). Visual memory ability was assessed with the Test of Visual Perceptual Skills visual memory subtest. The school administered the Otis-Lennon School Ability Test and Stanford Achievement Test. Age and verbal ability were controlled in all regression analyses. *Results.* Visual memory score was significantly predictive of below-average word decoding ($p = 0.027$), total math score ($p = 0.031$), and Stanford complete battery score ($p = 0.018$). Visual memory score showed a positive trend in predicting reading comprehension ($p = 0.093$). *Conclusions.* Poor visual memory ability (as measured by the Test of Visual Perceptual Skills) is significantly related to below-average reading decoding, math, and overall academic achievement (as measured by the Stanford Achievement Test) in second- through fourth-grade children, while controlling for age and verbal ability. (Optom Vis Sci 2002;79:431–434)

Key Words: visual memory, children, reading, math, academic achievement

Visual memory is a visual perceptual skill that involves the ability to recall a visual image. It is generally agreed that there is a positive relation between academic performance and visual memory,[1–7] although other points of view exist.[8] For example, Lyle[1] investigated the relationship between visual memory ability and reading performance in children aged 6.5 to 12.5 years ($N = 108$) of average IQ. He found a significant difference in visual memory ability, as measured by the Memory-for-Designs test, between reading retarded and adequate readers. Furthermore, Friedman[2] compared nonmotor visual memory ability in IQ-matched, reading disabled ($N = 38$, ≥ 2 years below expected reading level as tested on the Wide Range Achievement Test reading test) and normal readers ($N = 38$) in the fourth, fifth, and sixth grades. He found that the reading disabled readers performed significantly worse on the visual memory test than the normal readers ($F_{1,72} = 8.17$, $p < 0.01$). Similarly, Solan et al.[6, 7] have reported a significant positive relationship between visual memory, as measured by the tachistoscopic exposure test, and reading and math ability. Moreover, Rusalem[9] has shown that visual memory can be improved. On the other hand, Golden and Steiner[8] investigated auditory and visual function (using several subtests of the revised Illinois Test of Psycholinguistic Abilities and the Monroe Visualization Test) in 10 pairs of good and poor second-grade readers matched according to age and IQ and concluded that the primary deficit in the poor readers was auditory rather than visual.

Although previous studies have explored the relationship between academics and visual memory, a number of limitations exist in the current literature, and differences of opinion remain.[10] For example, some prior studies have one or more of the following limitations: (1) use of a visual memory test that does not provide normative data, (2) failure to include controls for intelligence, or (3) use of a visual memory test that involves drawing the response (which may lead to the study results being confounded by motor coordination and/or visual motor integration skills). Finally, previous studies have generally focused on determining whether a correlation exists between visual memory and academic performance (e.g., reading), rather than exploring whether visual memory is predictive of below-average performance in academics. It would be valuable to be able to identify the children with potential academic difficulty. The purpose of this study was to determine whether a relation exists between performance on the Test of Visual Perceptual Skills (TVPS) visual memory subtest and below-average performance in reading (decoding and comprehension), math, and overall academics.

METHODS

Subjects

All of the children in the second-, third-, and fourth-grade classes from a primarily white, middle-class, suburban elementary school near Columbus, Ohio, were invited to participate in this study. Participation was voluntary and consented. Sixteen children did not participate due to lack of parental consent or absence during the study. Thirty-five children were not eligible to participate because their standardized academic achievement scores were not available. Thus, 155 children ranging in age from 7 years, 0 months to 11 years, 1 month (mean age = 8.83 years) participated in this study (N = 44 second graders, N = 53 third graders, and N = 58 fourth graders).

Procedures

The elementary school independently administered the Stanford Achievement Test Series (9th Edition, The Psychological Corporation, Harcourt Brace, 1995) and the Otis-Lennon School Ability Test (7th Edition, The Psychological Corporation, Harcourt Brace, 1996) the previous spring to all enrolled first, second, and third graders. The resultant scores were used as measures of academic achievement and ability, respectively. Because the academic year ended shortly after the administration of the standardized testing and because the visual memory test was administered at the beginning of the subsequent school year, academic changes were not expected to occur during this time frame.

A vision screening was also performed to rule out vision problems (e.g., uncorrected refractive error) as confounders. A Modified Clinical Technique vision screening and its associated referral criteria were used to screen the vision of each child because of their high efficacy.[11] This screening included an evaluation of visual acuity, refractive error, ocular alignment, and ocular health. The number and distribution of failures found in this study was similar to that found in previous studies.[11]

Visual memory was assessed with the TVPS visual memory subtest. It is a commonly used, norm-referenced, motor-free test.[12] The revised version of the TVPS (1996) was not obtained in time for this study; however, 11 of the 16 stimuli are the same on the visual memory subtest. Although McFall et al.[13] reported that the results of individual subtests should be used with caution because the test-retest reliability of some subtests was low when used with learning disabled children, the present study included older children from regular classrooms. No known learning disabled–diagnosed students were included in this population. The TVPS has demonstrated reliability and validity, and its individual subtest scores are commonly used.[14]

The visual memory subtest consists of one demonstration and 16 test items. Testing was performed according to manufacturer's directions. Specifically, (1) the child is told, "Look at this form and remember it so that you can find it on another page," (2) the figure is shown for 5 s, (3) the figure is removed (by turning the page), (4) the child is shown an answer plate that contains the test stimulus and four distracters, and (5) the child is asked to find the form (test stimulus) (Fig. 1). Testing is continued until the child answers four of five consecutive items incorrectly. Possible scores on the test range from 0 to 16. The testing was performed in the morning, in a separate classroom with standard fluorescent overhead lighting.

Statistical Analyses

SPSS Base 10 was used for all statistical analyses. A two-independent sample t-test was performed to determine whether there was a significant difference in performance on the visual memory test between children who passed versus those who failed the vision screening.

Because this was an investigation of whether visual memory was predictive of below-average academic achievement, logistic analysis was performed. The dependent variable was academic achievement (below average vs. average/above average). Achievement was based on Stanford Achievement Test stanine scores, with scores of one to three coded as below average. Independent variables included Test of Visual Perceptual Skill visual memory standard score, Otis-Lennon School Ability Test verbal ability stanine score, and age. Age and verbal ability were included as controls. An alpha level of $p < 0.05$ was used for all analyses. Adjusted odds ratios (aOR) are reported for visual memory.

RESULTS

All the children in the sample (N = 155) were able to complete the visual memory test. The distribution for the visual memory scores was sufficiently normal. Descriptives were determined for the TVPS visual memory subtest scores (Table 1). One child who was 11 years, 1 month of age was included with the 10-year-old children in the age-related descriptives. A two-independent sample t-test revealed no significant difference in performance on the visual memory test between children who passed vs. failed on the vision screening ($t = 0.195$, $p = 0.846$). Therefore, all children were included in the logistic analyses.

Logistic analyses were performed to determine the predictive ability of visual memory for academic achievement. Age and verbal ability (as measured by the Otis-Lennon School Ability Test) were

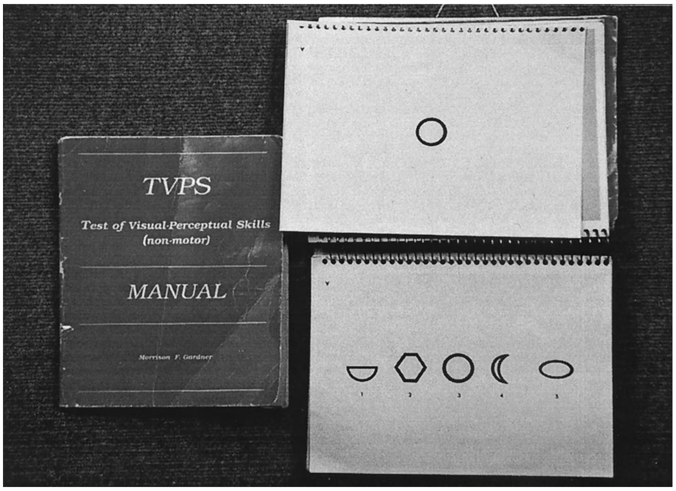

FIGURE 1.
Test of Visual Perceptual Skills visual memory subtest.

TABLE 1.
Mean (± SD) and median Test of Visual Perceptual Skills visual memory scores.

Population	N	Mean	SD	Median	Published Median
Grade					
Second	42	8.00	3.57	9.00	—
Third	55	8.24	2.65	8.00	—
Fourth	58	9.19	3.32	10.00	—
Age (yrs)					
7	38	8.76	2.85	10.00	7.70
8	42	7.52	3.51	8.00	8.95
9	56	8.88	3.16	9.00	9.95
10	19	9.26	2.90	10.00	10.70
Total	155	8.53	3.19	9.00	—

included in all models. Visual memory was predictive of below-average reading decoding (aOR = 0.816) at the level of $p = 0.027$ and reading comprehension (aOR = 0.891) at the level of $p = 0.093$ (Table 2). Therefore, each unit increase in visual memory standard score decreased the odds of having below-average performance on reading decoding by 18.4% ($1.0 - 0.816 = 0.184$). Visual memory also showed significant predictive value for below-average total math (aOR = 0.846; $p = 0.031$) and complete battery score (aOR = 0.789; $p = 0.018$) (Table 2). The analysis indicates that for every additional one-point increase in standard score on the visual memory test, there was a 15.4% decrease in the odds of having below-average performance in total math and a 21.1% decrease in the odds of having below-average performance overall on the Stanford Achievement Test.

DISCUSSION

Previous literature has shown a relation between academic performance and visual memory.[1–7] However, differences of opinion remain.[8] The current literature focuses on exploring whether a correlation exists between visual memory ability and academic performance (e.g., reading or math), although it would be clinically valuable to predict which children might have academic difficulty. Some previous studies also have one or more of the following limitations: (1) use of a test that lacks normative values and is not commercially available or (2) the presence of potentially confounding factors (e.g., visual motor integration skill, motor coordination ability, and/or intelligence). A masked investigation was performed to investigate whether visual memory ability (as measured by the TVPS) is predictive of below-average reading (decoding and comprehension), math, and overall academic achievement.

Increasing visual memory scores were associated with lower odds of poor performance on the Stanford in reading decoding, total math, and overall academic achievement. In other words, poor visual memory score was found to be significantly predictive of below-average performance on Stanford decoding (word study skills), total math, and complete battery score. Therefore, this study showed a significant protective effect for visual memory skill (aOR = 0.816 for decoding, aOR = 0.846 for total math, and aOR = 0.789 for complete battery), while controlling for age and verbal ability.

The significant relation found between word study skills (decoding ability) and visual memory could be attributable to the use of visual memory to recall letters, phonemes, and irregular words. Although correlation does not prove causation, Halliwell and Solan[15] previously reported greater improvements in reading ability in children designated as having potential reading problems who received perceptual instruction in addition to regular reading instruction (N = 35) compared with a group of children who received regular reading instruction and special reading assistance (N = 35) and compared with a control group (N = 35). The perceptual therapy included tachistoscopic procedures to improve visual memory. On the other hand, this study did not support previous work that reported a significant correlation between reading comprehension and visual memory, although there seems to be

TABLE 2.
Ability of visual memory to predict achievement while controlling for age and verbal ability.

Area of Achievement	Grade (N)	Adjusted Odds Ratio	p Value	95% Confidence Interval for Odds Ratio	
				Lower Bound	Upper Bound
Word study skills (decoding)	2 and 3 (94)	0.816	0.027	0.681	0.977
Reading comprehension	2–4 (151)	0.891	0.093	0.778	1.020
Total math	2–4 (152)	0.846	0.031	0.728	0.985
Complete battery	2–4 (143)	0.789	0.018	0.648	0.961

a trend in this direction.[3, 16, 17] It is possible that a significant relation may have been found if older children had been included in the study because older children may be more likely to use visual memory to organize and remember mental images of the story.

Visual memory score was also significantly predictive of below-average Stanford total math scores. This supports the findings of Solan,[7] who showed a significant relation between math ability and visual memory. This relation could be partly attributed to the use of visual memory to recall numbers in younger children. Visual memory also could be used to enhance computational and problem-solving skills. For example, if a child with good visual memory skill was asked to add the digits 2 and 3, the child could visualize two apples and three oranges and then count the resultant pieces of fruit. This approach could be particularly helpful for problems that must be solved mentally. In addition, a child could use visual memory skills to remember simple mathematical tables that could, in turn, be used to solve more complicated problems. For example, to mentally add 44 to 44, the child could use visual memory to recall that 4 plus 4 equals 8. Thus, the larger problem could be solved by breaking it down into two simpler problems that could, in turn, be answered by using visual memory of simple math facts.

In conclusion, this study shows that poor visual memory skill is significantly predictive of below-average performance in reading decoding, total math, and overall academic achievement, while controlling for age and verbal ability. This study suggests that an eye care professional should be part of the multidisciplinary team of a child with academic difficulties to identify and address any untreated vision problems. Further research is needed to explore the effects of visual memory therapy on academic achievement.

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Marjean Taylor Kulp
The Ohio State University
College of Optometry
320 West 10th Avenue
P.O. Box 182342
Columbus, Ohio 43218-2342
e-mail: kulp.6@osu.edu