IDENTIFYING VISUAL DYSFUNCTIONS IN ELEMENTARY SCHOOL CHILDREN USING A TEACHER'S ASSESSMENT

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Abstract

Visual dysfunctions can interfere with the learning process in children. The purpose of this study was to determine whether teachers' observations of particular behaviors of their students were related to potential visual problems. We developed a twelve item symptom survey which was completed by teachers of 204 children from second to fifth grade. Thirty-three children whose surveys indicated a criterion level of at least three symptoms comprised the experimental group. They were compared to a matched control group whose surveys showed no symptoms. Both groups were then administered the Developmental Eye Movement (DEM) and Visual Motor Integration (VMI) Tests. The mean scores of the DEM and the VMI for each group were converted to percentiles. The results showed that the survey significantly discriminated between the two groups; the experimental group scored lower on each of the two tests than the control group. This indicates that the screening instrument has significant potential for teachers in the early elementary school grades to identify children at risk for learning related vision problems. These children would then warrant referral for a complete optometric evaluation for further diagnostic and management services.

Key Words

Developmental Eye Movement Test (DEM), elementary school vision testing, learning, reading, Teacher Symptom Observation Survey (TSOS), Test of Visual-Motor Integration (VMI), vision symptoms surveys

INTRODUCTION

Our overall goal was to adapt and adopt portions of existing surveys to develop a questionnaire that could be easily used by teachers to identify children who exhibited symptoms of visual dysfunctions. In order to determine the efficacy of the survey, we compared the results of our questionnaire with performance on two established tests of the visual system. Performance on these tests has been shown to be related to academic achievement. This was done by using experimental and control groups of elementary school children.

PREVIOUSLY DEVELOPED SURVEYS

Children with academic difficulties are often referred to optometrists. The Optometric Extension Program produced a pamphlet entitled "Vision in the Classroom" to assist both teachers and parents in identifying visual problems that could interfere with learning and classroom performance.[1] Borsting et al. developed a more specific tool in the form of a parent and child questionnaire to assess convergence insufficiency (CI) in children (Convergence Insufficiency and Reading Symptom Survey-CIRS).[2] The instrument proved to be valuable in differentiating children with CI from those with normal binocular vision. More recently, Scheiman et al.[3] used the same CIRS Symptom survey to demonstrate significant statistical and clinical improvement in reducing symptoms following vision therapy (VT). Thus, the CIRS Symptom survey was a valuable tool in both assessing abnormalities and monitoring the improvement in visual functioning in children following therapy.

Another instrument that has been used to assess both visual dysfunctions and their improvement with optometric VT is the College of Optometrists in Vision Development-Quality of Life Checklist (COVD -QOL). Maples and Bither[4] used this parent and child questionnaire both before and after VT on children between 7 and 18 years of age. They found that the COVD-QOL tool reliably assessed positive changes in subjects' quality of life following the VT. However, the researchers noted that the survey's lengthy number of questions was a negative factor as related by the optometrists involved in the study.

TESTS OF THE VISUAL SYSTEM

The Developmental Eye Movement Test

Visual tracking abilities have been shown to be an important component in efficient reading fluency and progress in learning.[5] Visual tracking performance can be modified and improved with various types of therapy, and early treatment will preclude later problems with information processing.[6, 7]

An important component of the normal visual tracking system is a specific pattern of eye movements that include the alternation of saccades with fixational pauses. One method to measure and assess these eye movements is the Developmental Eye Movement (DEM) test. It is a clinical assessment of the accuracy and speed of eye movement function.[8] The DEM is standardized for children from age 6 to 13. It uses a pretest, a vertical subtest and a horizontal subtest. Each subtest is scored according to the time required by the patient to complete and the number of errors made. The times are adjusted by factoring in the number of errors. The quotient of the horizontal time divided by the vertical time is the ratio. The use of this number indicates whether below expected performance on the horizontal subtest is a product of an oculomotor deficiency, a deficiency in rapid automatic naming, or deficiencies of both factors. Either of these deficiencies can impede reading performance. Oculomotor efficiency, as measured by the DEM test, has been associated with reading performance and comprehension.[9] Further, Coulter, et al.[10] have shown that attention may influence accuracy in those who do poorly in the DEM test.

The Developmental Test of Visual-Motor Integration

In addition to oculomotor functioning, visual-motor integrative abilities are necessary to perform effectively in an academic setting. Visual-motor integration is the act of utilizing visual information to perform motor tasks. School activities that require visual-motor integration include drawing, copying, and word math problems, usually tasks requiring the hands.[11] A standard measurement of visual-motor integration is the Developmental Test of Visual-Motor Integration (VMI).[12] It consists of an increasingly difficult sequence of geometric forms to be copied with paper and pencil. A standardized scoring protocol is used and scores are compared to age-related performance. Kulp[13] found that performance on the VMI was significantly linked to the teachers' evaluation of students' reading, writing and math achievement ratings, which in turn correlated highly with the students' performance on standardized testing. VMI deficiencies in children have been shown to reliably improve with optometric VT, significantly reducing typical symptoms.[11]

In summary, our goal was to develop a survey that could be used by teachers of early elementary school students to identify students with potential visual system developmental delays. We felt this was important in light of a recent study by Jones, et al. indicating that many school teachers are unaware of the possible effects of visual problems on academic progress[14] and that early identification of these children can be quite important.[15]

METHODS

Procedures and subjects

The present study was conducted at the Open Magnet Charter School (the School) during the academic year 2003 through 2004. The School was established in 1977 as a nontraditional educational program, with a strong emphasis on individualized instruction within multi-aged learning clusters, team teaching and experiential learning. It was the first Magnet Charter school in the Los Angeles Unified School District and is located in the Westchester area of Los Angeles. It has a self-selected, multicultural group of 364 students consisting of grades kindergarten through fifth.

We developed the Teacher Symptom Observation Survey (TSOS) on a consensus basis by integrating various items from the CIRS Symptom Questionnaire (parent version),[2] the COVD-QOL,[4] the Vision in the Classroom pamphlet published by the Optometric Extension Program[1] as well as clinically relevant observations. The TSOS is presented in the Appendix.

In May, 2003, with the consent of the principal and the governing board of the School, all the teachers were instructed on the need for identification of visual dysfunctions that can affect learning, particularly reading ability. Within the presentation, the teachers were introduced to the TSOS and its administration. They were requested to complete the TSOS for each child in their class on the basis of their observations during the entire academic year. Teachers in grade one through four completed the TSOS; we believed that kindergartners were developmentally immature for this study[16] and fifth graders would be graduated the following year. A total of 204 completed surveys were obtained.

Experimental Group

Those students who had three or more checked boxes in the TSOS were selected for the experimental group. Some 40 students (29 males and 11 females) met this criterion. Parental permission was requested for each candidate to continue with the visual testing part of the study. Some 33 parental consents were obtained (23 males and 10 females) and these constituted our experimental subjects. Assessments with fewer than three items checked were not retained.

Control Group

The School's principal randomly selected an equal number of age and grade matched students (17 males and 16 females) whose TSOS scores were zero. Parental permission was obtained to continue with the visual part of the testing for 15 males and 16 females.

Throughout the further testing of the study, the two optometrists who administered the tests were blind to the identification and classifications of the subjects in the experimental and control groups. This was also the case for a third optometrist who graded the results of each test.

Administration of the Visual System Tests

Early in September, 2003, the 31 control subjects and 33 experimental subjects were given the DEM and the VMI. Before these tests were administered, a near-point visual acuity screening was performed. The inclusion criterion for all subjects was at least 20/40 binocularly. No subjects were found deficient in this area. Each test was administered and graded according to that test's instructions.[8,12] Classrooms were randomly assigned to each examiner. The times to complete each section of the DEM and the error rate were converted into percentile scores. The VMI scores were also converted into percentiles.

Statistical Analysis

Multivariate analysis of variance was used to detect differences between the Control vs. Experimental groups and gender for the survey results and the visual testing factors. Repeated measures analyses were carried out for the DEM-Horizontal, DEM-Vertical, DEM-Ratio and VMI. Correlational analyses were carried out on the data between the individual questions on the survey and the visual tests.

RESULTS

Comparison of the mean percentile rankings of the Control and Experimental Groups on the tests of the visual system

The analysis of variance (ANOVA) of the control and experimental subjects was statistically significant, $F(62, 186) = 12.1$, $p < .0009$ for the main factor of group (Control vs. Experimental). As seen in Table 1, the Control Group had mean percentile scores of 59.0, 60.2, 54.4 and 56.6 for the DEM-Vertical, DEM-Horizontal, DEM-ratio and VMI respectively. This is compared to 39.4, 36.4, 40.3 and 43.9 respectively for the Experimental Group. Thus, the TSOS successfully differentiated those subjects in the present study who scored below the 50th percentile in all measures of the DEM and VMI.

Comparison of the mean percentile rankings of the Control and Experimental Groups on the tests of the visual system by gender

The DEM-horizontal and vertical and VMI findings revealed highly significant gender effects within both the Control and Experimental Groups, indicating that females in both groups had significantly higher mean scores in all tests compared to the males in that group (see Table 2). The ANOVA revealed a main effect for the group variable, $F(60,120) = 8.57$, $p < .004$, as well as a main effect for gender, $F(60,120) = 5.66$, $p < .02$. A separate analysis of the DEM ratio revealed a significant group difference, $F = 5.13$, $p < .03$, but no gender difference.

Comparison of the mean percentile rankings of the Control and Experimental Groups on the tests of the visual system by grade

In general, there was no significant difference in the mean percentile scores for the DEM and VMI tests within each grade; this is in light of the fact that the scores are standardized by age. However, the group factor remained highly significant, $F(56, 168) = 13.5$, $p < .0005$, and in almost every instance the Control Group had mean percentile scores greater than the Experimental Group (see Table 3).

Table 1

Group	DEM- Vertical	DEM- Horizontal	DEM -Ratio	VMI	n
Control	59.0 (33.4)	60.2 (31.5)	54.4 (27.2)	56.6 (23.6)	31
Experimental	39.4 (29.2)	36.4 (25.8)	40.3 (28.1)	43.9 (22.4)	33

Table 1. represents the mean percentile scores for the DEM – Vertical, Horizontal and Ratio, as well as the VMI of the experimental subjects, for the Control Group (those who scored fewer than 3 symptoms on the Vision Assessment) and the Experimental Group (those who scored 3 or more symptoms on the Teacher's Vision Assessment). (#) indicates the SD for each mean percentile.

Table 2

Group	DEM- Vertical	DEM- Horizontal	DEM -Ratio	VMI	n
Control Group - Females	66.4 (33)	65.9 (32)	52.2 (27)	62.9 (21)	16
Control -Males	51.2 (33)	54.2 (31)	54.8 (28)	50 (25)	15
Experimental - Females	52.2 (32)	40.8 (25)	29 (30)	52.9 (21)	10
Experimental - Males	33.9 (27)	34.6 (25)	45.3 (19)	39.8 (22)	23

Table 2. represents the mean percentile scores for the DEM – Vertical, Horizontal and Ratio, as well as VMI for the same experimental and control subjects as seen in Table 1 further divided by gender for each of the groups. (#) indicates the SD for each mean percentile.

Table 3

Group	Grade	DEM- Vertical	DEM- Horizontal	DEM -Ratio	VMI	n
Control	2nd	59.3	67.3	68.3	63.5	8
	3rd	53.2	51.3	45.2	44.6	10
	4th	57.0	58.0	52.9	59.0	9
	5th	77.8	73.5	45.5	67.8	4
Experimental	2nd	37.8	34.0	38.3	35.7	9
	3rd	50.1	40.2	36.5	45.0	9
	4th	33.0	35.7	45.8	59.9	8
	5th	32.8	34.8	42.7	33.1	6

Table 3. represents the mean percentile scores for the DEM- Vertical, DEM- Horizontal, DEM- Ratio and VMI tests for both control and experimental groups for each grade level (2 through 5).

Mean time for DEM vertical and horizontal tests for group and grade.

The mean number of seconds for the DEM horizontal and DEM vertical tests were analyzed for the main factors of group and grade (Table 4). As opposed to the mean percentile scores, the mean number of seconds was significantly different by grade, $F = 6.6$, $p < .0007$, but not affected by the group factor. In each succeeding grade, the mean times became significantly faster in their responses. Because there was also an interaction between grade and test,

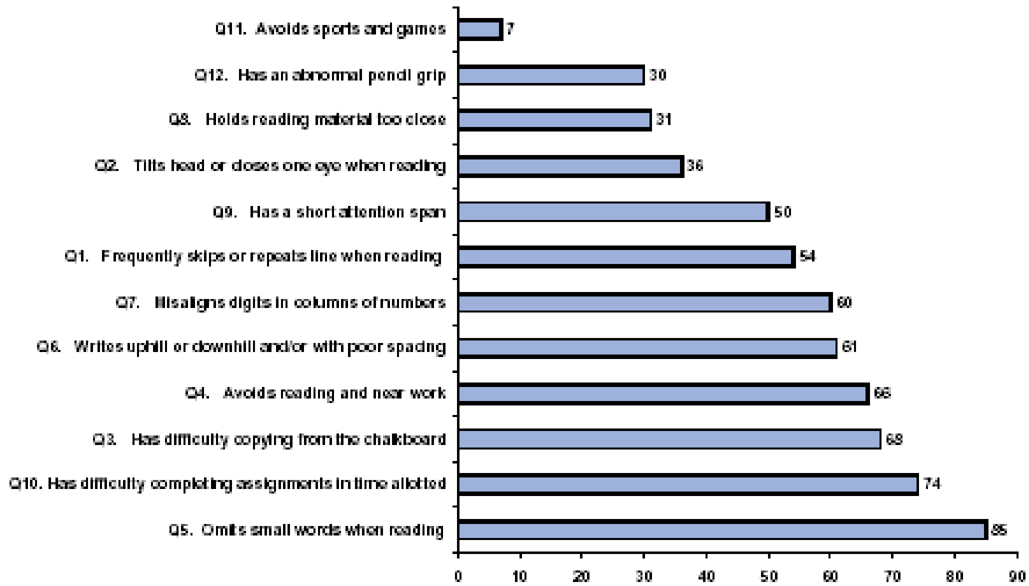
Table 4

Group	Grade	DEM-Horizontal (sec)	DEM-Vertical (sec)	n
Control	2nd	88 (27)	55 (17)	8
	3rd	57 (11)	45 (7)	10
	4th	46 (9)	39 (8)	9
	5th	40 (8)	33 (7)	4
Experimental	2nd	82 (7)	56 (11)	9
	3rd	65 (17)	48 (12)	9
	4th	63 (27)	49 (12)	8
	5th	52 (9)	43 (7)	6

Table 4. represents the mean number of seconds measured for the DEM- Vertical and DEM- Horizontal for group and grade level. (#) indicates the SD for each group.

F = 5.3, p<.003, a simple analysis was done on each of the tests separately. The mean number of seconds for the DEM horizontal was significant for grade, but not for group; however, the mean seconds for the DEM vertical was significant for both grade and group, F (55,55) = 4.3, p<.04. It appears that at every grade the Experimental Group, on average, took longer on the vertical DEM than the Control Group. The difference was most pronounced in grades 4 and 5.

Figure 1.
Teacher Symptom Observation Survey
Percent of Experimental Subjects with Positive Responses



Comparison of the mean number of errors on the DEM horizontal test by group and by grade.

Analysis of the mean number of errors on the DEM horizontal resulted in a significance for the main effects of group, F (55, 55) = 8.7, p<.005, grade, F (55, 55) = 8.6, p<.0001, and an interaction between them, F (55, 55) = 3.5, p<.02. Generally speaking, the errors decreased with each advanced grade and in each grade the Experimental Group had higher mean errors compared to the Control Group (Table 5). The mean error average for the control subjects in the fourth grade was slightly less than the fifth grade average, perhaps reaching an asymptote of expected errors.

Qualitative aspects of the TSOS questions and their relationships to the tests of the visual system in the Experimental Group

The results of the surveys of the Experimental Group were analyzed further. Figure 1 represents the percentage of positive responses for each of the 12 behaviors for this group of 33 subjects.

Questions 5 and 10 had the most positive responses, followed by questions 3, 4 and 6. In performing correlational analyses on the questions versus the visual tests, it appears that question 10, *difficulty completing assignments in the time allotted* correlated significantly, but inversely with the DEM- horizontal mean percentile scores; r = - .377, p<.03. Furthermore, question 6, *writing uphill or downhill with poor spacing* was significantly and inversely correlated to the mean percentile scores on the VMI, r = - .47, p<.006. Questions 2, *tilts head or closes one eye when reading* and 7, *misaligns digits in columns of numbers* significantly and positively correlated with the mean number of errors made on the DEM test, r = .35, p<.05 and r = .38, p<.03 respectively.

The analysis of the TSOS scores by grade showed no significant difference for the main factor grade. The respective total scores (items checked on the assessment) for each grade, 2 through 5 were 6.7, 5.7, 5.4 and 7.2, respectively. The percentage of subjects for grades 2 and 3 combined, compared to grades 4 and 5 combined, answering positively to the questions is seen in Figure 2. In general, the responses of the pooled groups did not differ significantly, although it appears that the younger students were positive for shorter attention span and tilting the head to one side versus the older students, who had abnormal pencil grips and held reading material too close.

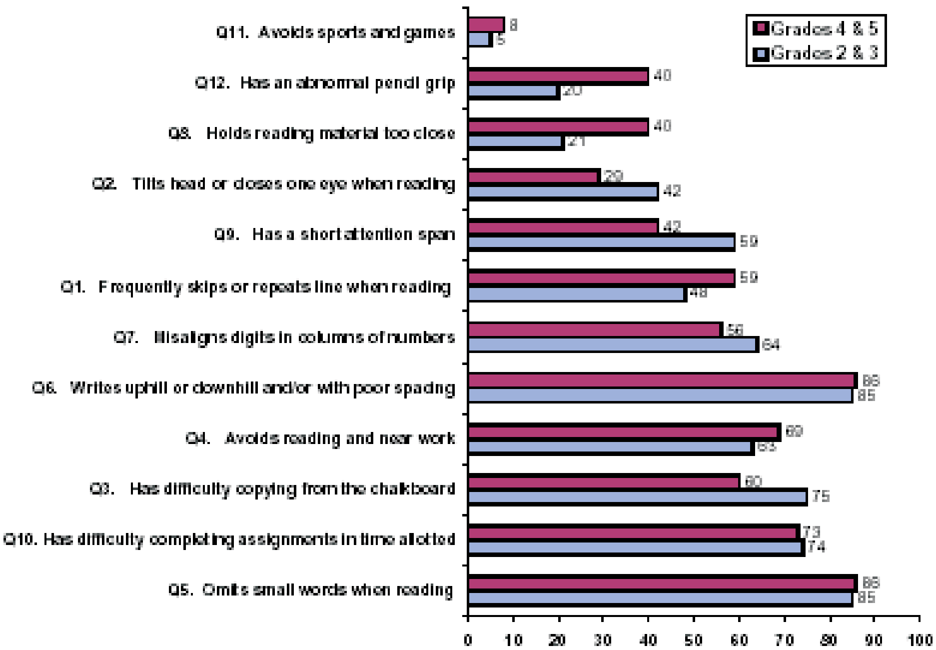
In examining the total number of positive answers on the present survey, it was found that there was no significant gender difference. The boys had an average of 6.1 and the girls had an average score of 6.3 items checked positive. However, when analyzing specific questions and their correlations with the visual testing scores, there was a significant gender difference. Boys showed a significant inverse correlation between the VMI scores and positive assessment of questions 3 *Has difficulty copying from the chalkboard* (-.36, p<.05), 6 (-.7, p<.001), and 7 *Misaligns digits in columns of numbers*(-.35, p<.05). These questions are related to writing and thus visual- motor integration. Also, for boys, the DEM horizontal percentage scores inversely correlated with questions 4 *Avoids reading and near work* (-.34, p<.08), 8 *Holds reading material too close* (-.34, p<.08) and 10 *Has difficulty completing assignments in time al-*

Table 5.

Group	Grade	Errors	n
Control	2nd	4.5 (4.4)	8
	3rd	3.5 (5.0)	10
	4th	1.1 (2.2)	9
	5th	1.5 (1.2)	4
Experimental	2nd	16.3 (6.9)	9
	3rd	6.9 (8.3)	9
	4th	2.5 (6.2)	8
	5th	1.8 (2.4)	6

Table 5. represents the mean number of errors on the DEM- Horizontal test. (#) Indicates SD.

Figure 2.
Teacher Symptom Observation Survey
Percent of Experimental Subjects with Positive Responses



lotted. (-35, p<.09). These questions are closely related to reading and information processing. Girls showed a significant inverse correlation for the DEM horizontal with question 2 (-.67, p<.03) and for the DEM vertical with question 2 *Tilts head or closes one eye when reading* (-.60, p<.05) and 3 *Has difficulty copying from the chalkboard* (-.56, p<.08). Those girls assessed positively for *head tilting or closing one eye when reading* (question 2) had lower percentile DEM scores in general. Interestingly, no females scored yes on the question concerning the avoidance of sports and games.

DISCUSSION

The present study demonstrated that the TSOS effectively discriminated between our Experimental and Control Groups. The former's mean percentile scores on all parts of the DEM, and the VMI were below the 50th percentile, while the latter's scores on these tests were above the 50th percentile. See Table 1. The same differentiation was shown by gender as indicated in Table 2. Furthermore, the use of this assessment by the teachers was easy and rapid and produced compliance and cooperation from those administering it. One reason for the success in the accuracy of the TSOS is that the instrument was administered at the end of the school year when the teachers had ample time for their observations. This should be kept in mind for future use of the TSOS.

The TSOS identified fewer girls with scores of at least three, and therefore, fewer girls were in the Experimental Group. It is possible that the teachers, in their assessment, were relying on gender schemas that boys are more likely to have reading problems compared to girls. A fairly large body of research has now begun to reveal that there is a significant gender difference in reading disabilities. One study concluded that the diagnosis of reading disability had a male to female ratio of 2:1.[17] More recently, Rutter et al.[18] reviewed 4 separate epidemiological studies on the extent of sex difference in reading disability They concluded that it is clear that boys more often have reading disabilities compared to girls.

It was noteworthy that significant gender differences were found within the DEM and VMI. See Table 2. To our knowledge, no other published research has found gender differences in the DEM. Research that is still ongoing has indicated significant gender differences for the DEM with young adult subjects.[19] The VMI test manual states that gender differences have been reported, but the preponderance of studies found no statistically significant differences.[20] Other visual tests have shown significant sex differences; for example, the Jordan Left- Right Reversal Test reports that boys of all ages scored more errors than girls. [21] Also, children given the Rey-Osterrieth Complex figure test, another visuo-motor test, demonstrated a significant gender difference with a better performance for girls compared to boys.[22,23]

Within each gender, the Control subjects scored significantly higher than the Experimental on the DEM and VMI. This indicates that the TSOS was able to identify those with potential delays in eye movement and /or visual motor integration. The Control girls scored significantly higher in all these areas compared to Control boys. Perhaps a renorming of the DEM and VMI for gender specific scoring should be considered. Further, attention mechanisms may be producing these differences. Such gender differences were found by Crookes and Moran when examining children for selective attention and information processing using the Kamin blocking computer task.[24] Their results showed that females scored higher than males at all ages tested. Coulter, et al. proposed that attention may influence accuracy over time in those patients who do poorly on the DEM test.[10] It is possible that what the present study measured was in part due to changes in attention levels and that the boys tested in this study were less attentive than the girls. Counter to this hypothesis are the findings of a recent large sample study (National Collaborative Perinatal Project); it found that children classified as having a reading disability were twice as likely to be boys than girls, even excluding children with attentional disturbances or high activity levels.[25]

As shown in Table 2, the Control females scored higher on the tests of the visual system than their male counterparts. In fact, the females scored above average. The Experimental females achieved significantly lower scores on these tests than the female Controls. Thus, the teachers' assessment of these students seemed to be accurate in a relative manner.

The students were assessed by the teachers at the end of first grade through fourth grade, and the same students were vision tested at the beginning of the next academic year when they were in second through fifth grade. In examining the DEM and VMI scores for each grade, as expected, it was found that both Control and Experimental Groups showed no grade effect, given that these tests are standardized for age. Even when the groups were analyzed separately by grade, the Experimental Group's scores remained significantly lower than the Control Group's scores. However, the DEM scores in seconds did differ by grade. See Table 4. The number of seconds to perform the test should decrease with age and that is what was seen in the present study. In the DEM vertical test, not only did the subjects differ with age, but the Experimental Group, on average, took somewhat longer to respond than the Control Group.

Analysis of the mean number of errors on the DEM showed that the second grade made the most errors, and they decreased significantly with each grade. See Table 5. Within each grade, the Experimental subjects had a greater number of errors than the Control subjects. This type of measurement, the amount of errors in rapid naming of numbers, is a strong indication of whether the information processing is being done in an efficient manner and is a precursor to reading abilities.

Figure 1 shows that the most commonly reported behaviors on the TSOS for the Experimental Group were #5, *omitting small words when reading* and #10, *has difficulty in completing an assignment in the time allotted*. Further, a positive response to this latter behavior was inversely related to the DEM horizontal percentile score; that is, the more likely to have difficulty in completing assignments, the lower the DEM horizontal score. It was also found that #6, *writes uphill or downhill and/or with poor spacing* was inversely correlated to the VMI percentile; subjects with this behavior had lower VMI scores. The low frequency of reported #11, *avoids sports and games* suggests that this behavior is of low yield in the TSOS, and could be eliminated in future use.

The TSOS scores did not differ by grade, and for the most part, each question had somewhat similar responses across grades. Also, there was no significant difference by gender, although some of the correlations between questions and the vision system tests showed differences. In general, boys showed more of a correlation between their writing behaviors and lower visual motor integration scores, while both boys and girls who had difficulties with reading also had lower DEM scores.

These preliminary results suggest that the children in the Experimental Group had a delay in visual processing that requires further testing for differential diagnoses. Low scores on the DEM test may indicate oculomotor dysfunction or difficulty in automaticity in number calling skills.[9] Since the DEM was originally developed as a screening device, these children should be appropriately referred for a complete optometric examination to rule out a variety of possible deficiencies, such as accommodative and/or binocular dysfunctions. While symptom assessment by the elementary school teacher has merit in identifying children with possible visual difficulties, false positives could occur with the DEM. To arrive at a valid diagnosis, a clinical optometric evaluation is required.[26]

We believe that some of the subjects tested in the present experiment may have tested below their actual abilities since the optimal site for DEM testing is in a clinical setting. However, even with the possibility of some false positive results, we still found a statistical difference in the DEM and VMI tests using our survey to differentiate the groups. While the sample sizes in our two groups were statistically respectable, we encourage future research with larger samples to further validate our findings.

The present study used a teacher assessment tool that successfully identified students who have visual problems and are at risk for learning and reading disabilities, and would benefit greatly from vision therapy. In our previous study, we were able to demonstrate significant improvement in children with visual dysfunctions following a modest amount of in-school group vision therapy.[15] Therefore, in a pilot study with a subset of subjects from the present study, we have begun individualized in-school therapy using a touch screen computer methodology based on the well-known LaBarge ElectroTherapist tool.[27] Our results thus far, while modest, are significant in improving visual functioning in the at-risk children. Research has clearly shown that eye movement therapy results in oculomotor readiness and improved reading comprehension in children.[6, 7]

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APPENDIX

Teacher's Vision Assessment

Student____________________________________

Teacher ____

Grade ____

Date ____

Teacher: Please check all boxes that describe this student.

☐1. Frequently skips or repeats line when reading

☐2. Tilts head or closes one eye when reading

☐3. Has difficulty copying from the chalkboard

☐4. Avoids reading and near work

☐5. Omits small words when reading

☐6. Writes uphill or downhill and/or with poor spacing

☐7. Misaligns digits in columns of numbers

☐8. Holds reading material too close

☐9. Has a short attention span

☐10. Has difficulty completing assignments in time allotted

☐11. Avoids sports and games

☐12. Has an abnormal pencil grip

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