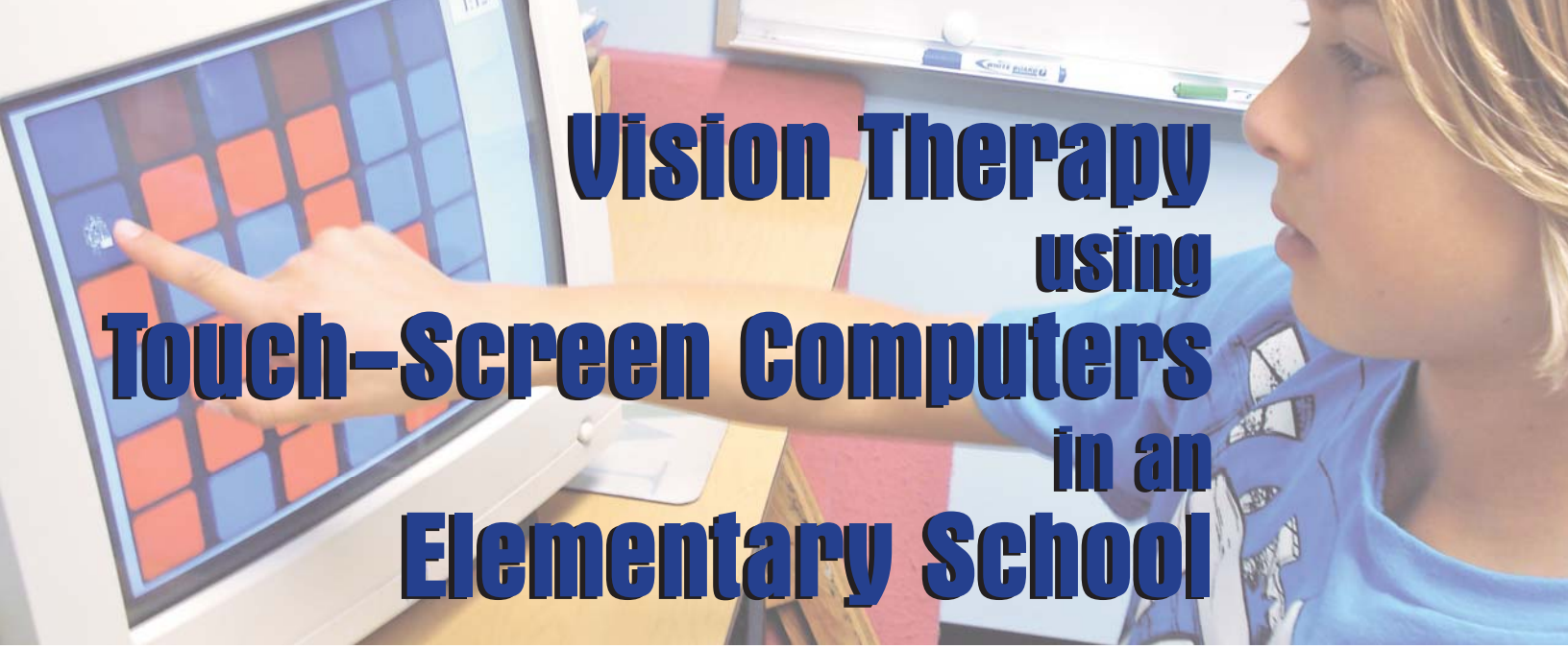

Vision Therapy using Touch-Screen Computers in an Elementary School

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Abstract

Visual tracking abilities have been shown to be an important component in reading fluency and information processing. Oculomotor performance can be modified and improved with therapy. In a previous study, the Teacher Symptom Observation Survey (TSOS), successfully identified students who had visual problems and were at risk for learning and reading disabilities. The present study utilized the TSOS instrument in an elementary school setting followed by the Developmental Eye Movement (DEM) and Visagraph II tests to identify those students in first through fourth grade who may benefit from vision therapy. The goal of this pilot study was to assess the effect of a computerized vision therapy (VT) program on ocular-motor functioning on elementary school students. These students had been identified with visual dysfunctions. Computerized vision therapy was initiated at school twice a week for 20 weeks. Following the therapy the students were retested with the DEM and Visagraph II. There was a significant improvement in tracking for all grades. Reading scores for second through fourth grades were also improved.

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Key Words

Developmental Eye Movement Test, fixations, reading comprehension, reading rate, regressions, Visagraph II, vision therapy

INTRODUCTION

Visual dysfunctions can interfere with the learning process in children. Visual tracking abilities have been shown to be an important component in efficient reading fluency and information processing.[1,2] Visual tracking performance can be modified and improved with various types of therapy. Early treatment will preclude later problems with reading and cognition.[3,4] 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. Good readers demonstrate significant differences in eye movements compared to poor readers. This is specifically for the duration of the fixation, length of the saccades and the number of regressions.[5,6]

Garzia and colleagues[7] established a test of saccadic tracking using a Developmental Eye Movement test (DEM)[a] that compares time and accuracy of reading digits vertically as well as horizontally. This clinical psychometric test assesses the accuracy and speed of eye movement.[7,8] Oculomotor efficiency as measured by the DEM test has been associated with reading performance and comprehension.[8]

In addition to the DEM, a more direct approach to assess reading abilities can be obtained using the Visagraph II Eye Movement Recording System (Visagraph).[a] The Visagraph directly measures eye movements while the subject is reading. The test also assesses the level of comprehension of the reader. The results of the Visagraph testing are compared to a general database that has been standardized over a large population with grade level taken into consideration.[9]

While the DEM and Visagraph are important tools for assessing eye movements and reading, they are time consuming and labor intensive to administer over a large population. In a previous study, the Teacher Symptom Observation Survey (TSOS), an assessment tool, successfully identified students who had visual problems and were at risk for learning and reading disabilities.[10] In that study, the TSOS utilized by the teachers was found to be easy and rapid, producing compliance and cooperation from those administering it. The TSOS was derived from the long-form College of Optometrists Vision Development–Quality of Life Checklist (COVD-QOL). This instrument has been shown to reliably assess post vision therapy (VT) changes.[11] However, its lengthy number of questions was a negative factor. Therefore, the TSOS survey was kept to 12 statements that were assessed by the teacher as present or absent in each particular student and seemed to reliably reflect the teachers' observations after six months into the school year.[10] Those elementary school students who had three or more checked deficits on the assessment tool comprised the experimental group, while those with less than three were the controls. Testing the two groups of students with the DEM and the Visual-Motor Integration tests showed that the TSOS

significantly discriminated the experimental group with lower scores on both visual tests. This indicated that the instrument may have an important potential for teachers to identify children at risk for learning related vision problems.

The present study utilized the TSOS instrument in an elementary school setting followed by the DEM and Visagraph tests to identify those students who may benefit from VT. At least several studies have provided evidence that VT can have a beneficial effect on eye movements and reading. Solan et al[4] found that both eye movement therapy and comprehension therapy were effective in improving reading skills. Using computerized VT in a school setting, Goss et al[12] demonstrated that the reading level of fourth grade students significantly improved. Research has shown that eye movement therapy results in oculomotor readiness and improved reading comprehension in children.[3,4]

In a study by Brodney et al[13] VT was performed in an elementary school setting for children with reading difficulties. They were successful in significantly improving vertical and horizontal eye movements and accommodative facility. Therapies consisted of activities frequently employed in the clinician's offices. These therapies included head rotation, letter tracking books, Brock string, rhythmic writing and tachistiscopic imaging. In a more recent pilot study[10] a subset of students who had visual dysfunctions, evidenced by low DEM scores, were given computerized VT at school. The results of this small set of subjects showed significant improvement in visual functioning.

The goal of this pilot study was to assess the effect of a computerized VT program on ocular-motor functioning on elementary school students.

Methods

Subjects and Procedures

Children were from a public elementary school in Lubbock, Texas. The children represented grades 1 through 6. Ethnic representation at the school was 65% Caucasian, 32% Hispanic, 2% African American, and 1% Asian. In October of 2007 all the teachers of Grades 1 through 4 were asked to fill out a TSOS survey for each child in their class. A survey was obtained for each of 643 children and 127 (19.6%) were identified as having three or more of the problems listed on the survey.

These children were examined for exclusion criteria that would negate their enrollment in the study. Of the 127 students identified, 26% were excluded for various reasons, including: near monocular and binocular visual acuity less than 20/20, negative response on Randot E Stereo, diagnosis of dyslexia and psychological disability. Of the 94 students eligible for the study, 47 were randomly chosen for VT. The subjects were issued parental consent forms for inclusion in the VT study and 41 consent forms were received. The first grade group consisted of nine males and four females. The second through fourth grades were comprised of 20 males and eight females.

In November of 2007 second and fourth grade students were tested with the DEM and the Visagraph. First grade students were tested only with the DEM. After each student was assessed according to the initial protocol VT commenced in late January 2008 for 10 weeks, finishing in April 2008. After the completion of VT each student was retested with the DEM and Visagraph.

The TSOS was previously validated at a Los Angeles, California school on students from second to fifth grade.[10] TSOS is composed of 12 statements that the teacher answers with a check indicating a characteristic of that student versus leaving it blank (Table 1). A student with three or more checks is considered in need of further testing and possible remediation.

DEM was performed as a clinical assessment of the accuracy and speed of eye movement function.[8] The DEM is standardized for children from 6 to 13 using a pretest, a vertical subtest and a horizontal subtest. Each subtest is scored according to the time required by the subject 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 yield the calculated ratio. The use of the ratio indicates if below expected performance on the horizontal subtest is a product of oculomotor deficiency, a deficiency in rapid automatic naming, or deficiencies in both factors. Oculomotor efficiency, as measured by the DEM test, had been associated with reading performance and comprehension.[7,8]

The Visagraph is considered a more direct approach to assess reading symptoms. It automatically records eye movements. The parameters measured include eye movements during actual reading and the comprehension level that are then compared to established population standards.

Table 1. TSOS Ranked Order of Statements for Positive Responses from High to Low Frequency

6. Below average reading ability
4. Uses finger as a marker when reading
10. Poor handwriting
12. Has difficulty completing assignments in time allotted
11. Has a short attention span
2. Avoids reading and near work
1. Frequently skips or repeats lines when reading
8. Writes uphill or downhill and/or with poor spacing
3. Omits small words when reading
9. Misaligns digits in columns of numbers
7. Has difficulty copying from the chalkboard
5. Holds reading material too close

**Numbers indicate the position of the statement in the TSOS.*

In the present study, only students from second to fourth grade were tested with the Visagraph. First grade students were only tested with the DEM.

Vision Therapy

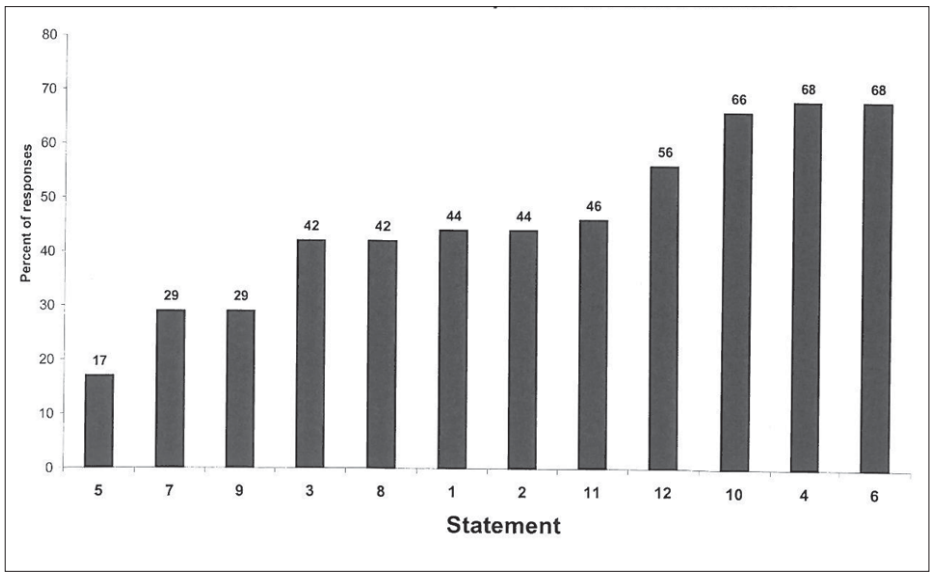
Students were taken out of class twice per week for the 10 weeks of VT. To deliver the therapy a touch screen and computer were set-up where each student spent 20 minutes completing the exercise. Following the completion of the VT each student in Grades 2 through 4 was retested with the DEM and Visagraph. The first grade students, because of wide-spread reading difficulties, were only tested with the DEM.

The Visual Motor Touch-Screen set up utilized a Mac OS, PowerPC and Touch screen display (Elo touchsystems). The touch-screen methodology used was based on the LaBarge Electro-Therapist tool.[14] Once the CD is opened the choice of the therapy program is available. (Appendix) The instructor explains the use of the system to the child with a demonstration of how the movements are to be performed. During the entire therapy, the instructor is present for assistance and takes notes on unusual behavior or deviations from the procedures.

Statistical Analyses.

Descriptive statistics are expressed as mean with $\pm$ standard error for continuous variables and percentages for categorical variables. The overall sample of subjects was assessed for change in visual and

Figure 1.
Teacher Symptom Observation Survey
Percent of Positive Responses to Each Statement Number



reading variables using paired t-tests comparing their pre and post therapy scores. Gender differences in outcome variables were assessed to compare pre and post therapy scores using repeated measures ANOVA. All assumptions underlying t-tests and ANOVAs were checked and met. A discriminant analysis was conducted to assess the predictability of the DEM and reading scores towards classification of a subject to a problem. Since the first graders were not assessed with the Visagraph, a discriminant analysis was conducted specifically in this group with only the four DEM scores as outcomes (vertical, horizontal, error and ratio). The remaining subjects (2nd to 4th grade) were combined and a discriminant analysis was conducted based on 8 outcomes (4 DEM scores and 4 Visagraph scores). Subjects in the 2nd to 4th grade were similar in their responses to the outcomes so that combining them was deemed appropriate. Statistical analyses were performed with Statistica and SAS/STAT.

Results

TSOS survey

The TSOS survey completed by the teachers identified 127 students out of 643 that had 3 or more problems listed on the questionnaire. Of the 41 subjects 29 (71%) were male. Table 1 contains the 12 items in the order of the frequency checked by the teacher. Figure 1 demonstrates the percentage of students who were assessed as having a problem with each particular question on the survey that is reflected in Table 1. There was a mean of 5.5 problems reported on the TSOS survey for the 41 students with no significant difference for gender. Four of the items; below average reading ability (68%), uses finger as a marker when reading (68%), poor handwriting (66%) and has difficulty completing assignments in time allotted (56%) were over 50%.

Discriminant analysis was conducted on the survey in order to predict the possible existence of a particular problem based on the visual and reading scores. A similar analysis was completed for second through fourth grade students based on both visual and reading scores. For first grade students, questions 1, 2, 4, 5, 7, 9, 10, and 11, on the TSOS do well in correctly identifying the existence of a problem in at least 75% of the cases. For second through fourth grade students, questions 1, 4, 5, 6, 7, and 9 are predictive of the presence of a problem in at least 75% of the cases.

DEM

The 13 first grade students were only tested with the DEM and thus, their results are reported separately (Figure 2). There were no significant gender differences in any of the DEM scores for the first grade students, 69% of whom were males. Overall the t-tests for the first grade students showed a significant difference in the pre- and post-therapy scores for horizontal ($t=-3.51$, $df=12$, $p<.001$), errors ($t=2.17$, $df=12$, $p<.05$) and ratio ($t=-2.70$, $df=12$, $p<.02$). However, no significant difference was found between the pre- and post-therapy vertical scores of the DEM for the first grade subjects ($t=-.36$, $df=12$, $p<.72$).

The t-tests for the DEM (Figure 3) for the second through fourth grade students demonstrated a significant difference between the pre- and post- therapy scores for horizontal ($t= -3.68$, $df=27$, $p<.001$), vertical ($t=-7.54$, $df=27$, $p<.05$), and ratio ($t=-2.85$, $df=27$, $p<.01$). However, the error difference pre- and post-therapy showed only a trend towards significance ($t=1.87$, $df=27$, $p=.07$).

Visagraph

No gender differences were found with the change in Visagraph II scores, 71% of whom were males.

The pre- and post-therapy scores for the Visagraph were significantly different for all four parameters of the test for the 28 second through fourth grade students (20 boys and eight girls). Figure 4 demonstrates graphically that reading rate as assessed by the Visagraph was significantly increased following the VT ($t= -5.39$, $df =26$, $p<.001$) as was comprehension ($t=-2.52$, $df=26$, $p<.02$). The mean reading rate of the students prior to therapy was 110 words per minute which is equivalent to just below the second grade level per the Visagraph norms.[9] Following the therapy the reading rate increased to approximately 140 words per minute which is equivalent to slightly above third grade level.

Additionally, as depicted in Figure 5, reading regressions decreased significantly ($t=2.81$, $df=26$, $p<.01$) while grade level effectively increased after therapy with the touch-screen computerized therapy ($t=-4.36$, $df=26$, $p<.001$). The students on average score 33 regressions per 100 words on the Visagraph pretest, equivalent to a 3.6 grade level. On the post test they scored 25 regressions per 100 words or the equivalent of 6th grade level, a substantial increase in their reading efficiency.

Discussion

A sample of 41 students in first through fourth grades who demonstrated visual dysfunctions in eye tracking and reading were administered computerized VT at school. The therapy produced an improvement in their DEM scores for all grades and improved reading scores for second through fourth. Since there was no control group, the positive changes following therapy must be viewed with caution.

Twenty percent of students were scored by their teachers as having three or more problems with the TSOS. This is comparable to a previous study that found essentially the same.[10] Also, more than two-thirds (71%) of this sample found to have problems were males. A fairly large body of research has begun to reveal that there is a significant gender difference in reading disabilities. One study concluded that the diagnosis of reading disability was a male to female ratio of 2:1.[15] Rutter et al, reviewed four separate epidemiological studies on the extent of sex difference in reading disabilities and concluded that boys are more often disabled compared to girls.[16]

It appears that poor readers are not often assessed for visual skills and thus, a visual dysfunction may be a factor in lagging cognitive functioning. Mechanisms are now available where students could be assessed and treated early for visual factors impacting reading and avoid long term reading disabilities. In recent research, students in grades one through eight were assessed by a vision therapist at school for adequate visual skills based on clinical and behavioral observations.[17] An investigator located elsewhere examined the same students remotely using an internet-based computer orthoptics program over three assessment sessions. While the remote investigator identified 61% of the students in need of referrals, the school therapist was able to document others through behavioral observations. This illustrates that on site therapists and teachers have a better understanding of the students' capabilities and limitations. It may be quicker and more cost effective to utilize those in attendance to assess visual dysfunctions and reading difficulties. In our study, the elementary school teachers were able to quickly report what they had observed over part of the school term in an efficient manner using the 12-question survey (TSOS). From the discriminant analyses, it is clear that at least five of the questions were clearly predictive of vision and reading problems for the majority of those tested. In fact the problems that were most predictive of visual difficulties had to do with below average reading ability, skipping and repeating lines, finger marking, difficulty copying from the board, and misalignment of digits in columns. Each class teacher was able to make observations about these behaviors in those students who were correctly identified as having significant problems with oculomotor functioning and reading as diagnosed by the DEM and Visagraph.

Figure 2.

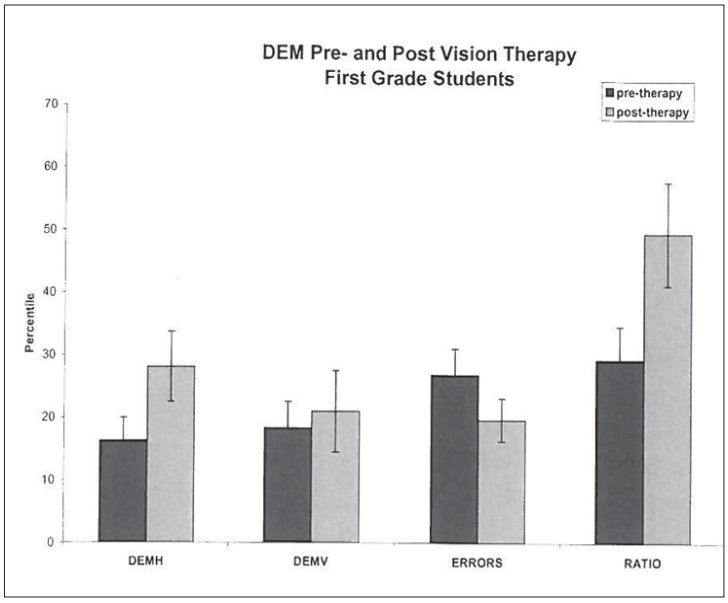
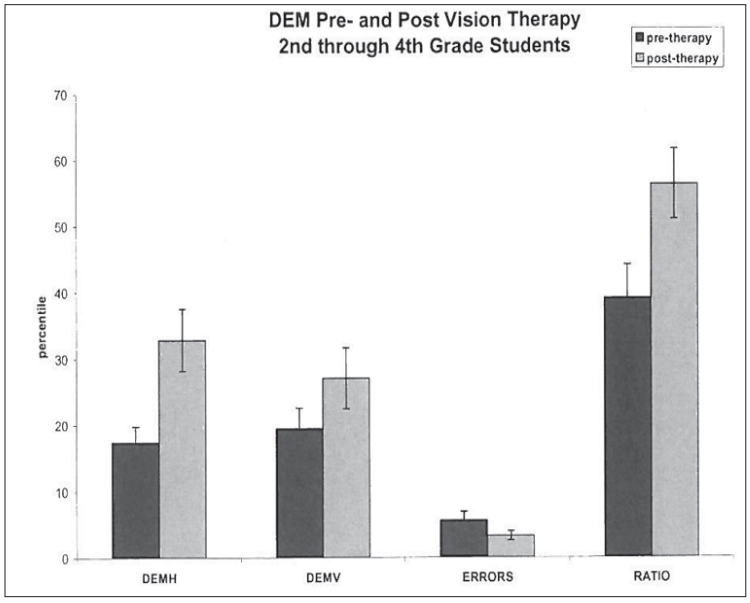


Figure 3.



For the first grade students, given that the vertical percentile of the DEM did not significantly improve post therapy, it is assumed that automaticity of number naming might still be a problem for these students.[8] However, the DEM ratio percentile post therapy increased to greater than 50%, along with a reduction in errors, perhaps indicating that oculomotor control effectively improved in these children.

For the second through fourth graders, all aspects of the DEM improved following the in-school therapy, with the ratio increasing to well above the 50th percentile. Given that the horizontal and vertical percentile scores increased, it appears that both oculomotor control and automaticity behaviors improved following therapy.

While test-retest data should be taken into consideration, Powers et al[5] demonstrated that an immediate retest produced no change in vertical scores and only minimal change in horizontal scores producing a slightly better ratio. In the present study the DEM retest was performed approximately six months after the original testing presumably having little or no effect. Furthermore, the fact that the retest was given within the same school year as the original test, it seems likely that the improvement seen after therapy was not

Figure 4.

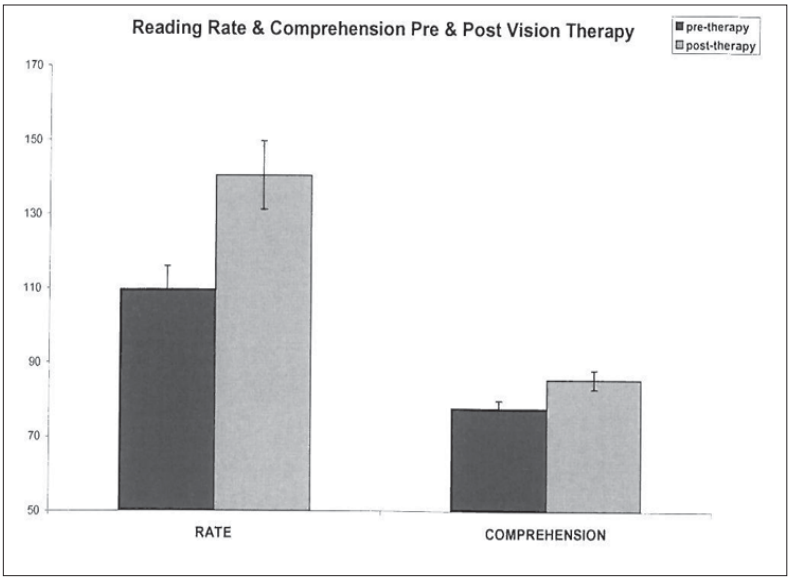
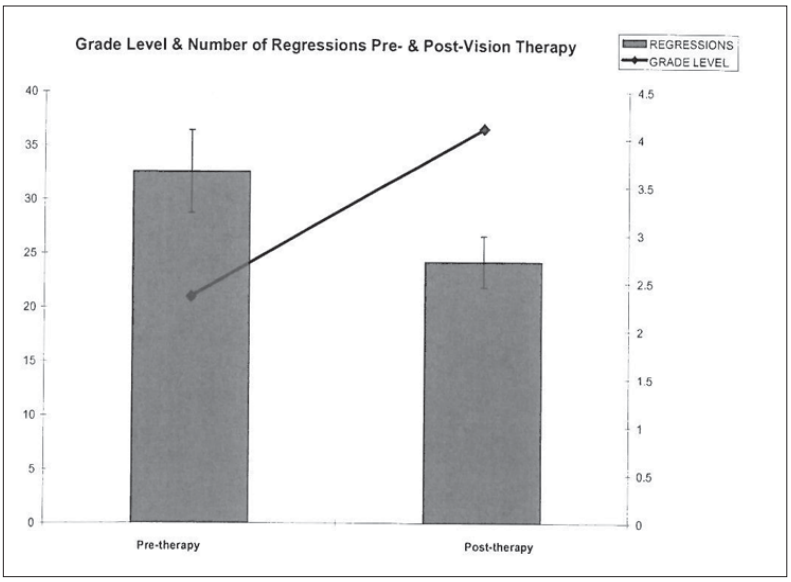


Figure 5.



maturation alone. However, future studies should require a larger subject population and an age and gender matched control group that also demonstrates oculomotor dysfunction.

While traditional VT requiring the use of a professional therapist is still considered the "gold standard" it has been found recently that various types of computerized programs are effective. As summarized by Cooper[18] VT via computer has resulted in standardization of protocols, response feedback both positive and negative and elimination of therapist's bias. Furthermore, it appears that computerization increases patient's motivation and offers data that can evaluate ones progress. While most of these computer programs have been used in the office or home, the present study offered the VT via computer in an elementary school where a significant number of children appear to be at risk.

The specific type of VT used for the present study was accomplished with a touch-screen computerized system that can be used in a school setting. It does require the presence of an instructor who can assist with at least two students at the same time. In fact this particular program can be utilized as therapy as well as testing the student's skills at each session. An important part of therapy is the feedback given during and at the end of the session so that a student can judge his/her own progress and ability. While it is necessary to further test the improvements made with the use of this computer therapy, it does appear that significant changes were made following only 10 weeks of usage. In a previous pilot study[10] using this touch-screen computer VT, the students improved significantly when retested with the DEM. In that study it was found that at least nine weeks of therapy was necessary to make improvements that were clinically meaningful.

In an earlier study, students who were in a reading remedial program were given 22 weekly sessions of in-school therapy by optometrists using activities consisting of oculomotor, accommodation and binocularity techniques.[13] In comparison to a non-therapy control group, the experimental subjects significantly improved in their vertical and horizontal DEM scores as well as accommodative facility scores. In that earlier research the student's reading abilities were not tested as they were in the present study using the Visagraph. While the first grade students only had the DEM as evidence of therapy-induced improvements, the second through fourth grade students had both the DEM and Visagraph scores as indicators of change.

In the second through fourth grade subjects, symptoms of reading problems had been noted in the TSOS survey. Perhaps this can be interpreted subjectively by the teachers as having reading disabilities. Research shows that poor readers make more fixations and regressions than good readers[19] and those were the findings in the present study where the reading regressions went from 33 to 25 per 100, a statistically significant decrease.

The grade level of the students as scored by the Visagraph on the post test following VT did show a significant increase compared to the pretest. However, Borsting et al,[20] demonstrated that while many of the variables in the Visagraph testing are repeatable, the values for the grade equivalent levels are vulnerable to normal variability and must be viewed with caution. Also, while the Visagraph is useful in identifying oculomotor-based problems, it may not assess those reading problems that are language-based.

With the significantly improved scores on both the DEM and Visagraph upon retest, it appears that the computerized touch-screen therapy had successfully increased the efficiency of eye movements in these children. Further studies are needed, particularly with control subjects to validate the use of this type of VT. Bonilla- Warford et al [21] performed a review of VT for improvement of reading skills and found

evidence that oculomotor VT does improve reading skills especially when used in conjunction with conventional reading therapy.

Whatever the method, it is imperative to identify the student's with reading difficulty early so that oculomotor therapy can be applied to the visual system. Grisham[22] et al, has shown that even in a high school sample of students, poor readers were often at risk for poor saccadic tracking skills and may well be amenable to improvement through VT. Providing such services in a school setting could reach a large number of children and possibly prevent reading disabilities and improve cognitive functioning of those in need. The results of the present study, although modest, is promising in that improvement in oculomotor status and reading abilities was obtained with in-school therapy for children at an early age.

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References

1. Kulp MT, Schmidt PP. Visual predictors of reading performance in kindergarten and first grade children. Optom Vis Sci 1996;73:255-62.
2. Kulp MT, Schmidt PP. Effect of oculomotor and other visual skills on reading performance: a literature review. Optom Vis Sci 1996;73:283-92.
3. Rounds BB, Manley CW, Norris RH. The effect of oculomotor training on reading efficiency. J Am Optom Assoc 1991;62:92-99.
4. Solan HA, Larson S, Shelley-Tremblay J, Ficarra A, et al. Role of visual attention in cognitive control of oculomotor readiness in students with reading disabilities. J Learn Dis 2001;34:107-18.
5. Powers M, Grisham D, Riles, P. Saccadic tracking skills of poor readers in high school. Optometry 2008;79:228-34.
6. Raynor K, Eye movements in reading and information processing: 20 years of research. Psychol Bull 1998; 124:372-422.
7. Garzia RP, Richman JE, Nicholson SB. A new visual-verbal saccade test: the Developmental Eye Movement Test (DEM). J Am Optom Assoc 1990;61:124-35.
8. Richman JE, Garzia RP. Developmental eye movement (DEM) test examiner's booklet. Mishawka, IN: Bernell, 1987:3-4.
9. Taylor SE. Visagraph eye movement recording system. Huntington Station, New York: Taylor Associates, 1997.
10. Brodney AC, Kehoe P. Identifying visual dysfunctions in elementary school children using a teacher's assessment. J Behav Optom 2006; 17:13-19.
11. Maples WC, Bither M. Efficacy of vision therapy as assessed by the COVD- Quality of life checklist. Optometry 2002; 73:492-98.
12. Goss DA, Downing DB, Lowther MA, Horner DG, et al. The effect of HTS vision therapy conducted in a school setting on reading skills in third and fourth grade students. Optom Vis Dev 2007;38:27-32.
13. Brodney AC, Pozil R, Mallinson K, Kehoe P. Vision therapy in a school setting. J Behav Optom 2001;12:99-103.
14. Myers SN, Winter JJ, Klaff M. Program manual for the LaBarge ElectroTherapist. La Barge Electronics, Tulsa OK, 1970.
15. Pablano A, Borja S, Elias Y, Garcia-Pedroza F, et al. Characteristics of specific reading disability in children from a neuropsychological clinic in Mexico City. Salud Publica Mex 2002;44:323-27.
16. Rutter M, Caspi A, Fergusson D, Harwood,LJ. Sex differences in developmental reading disability: new findings from 4 epidemiological studies. J Am Med Assoc 2004;29:2007-12.
17. Powers M, Grisham D, Wurm JK, Wurm WC. Improving visual skills: Remote assessment via internet. Optometry 2009; 80:61-69.
18. Cooper, J. Computerized vision therapy for the home and office treatment or accommodative & vergence disorders & amblyopia. J Behav Optom 2007;18:88-93.
19. Cuiffreda M, Ciuffreda K, Santos D. Visagraph baseline analysis and procedural guidelines. J Behav Optom 2003;14:60-64.
20. Borsting E, Rouse M, Shin S, Dold E, et al. Repeatability of the Visagraph II in the analysis of children's eye movements during reading. Optom Vis Dev 2007; 38:67-73.
21. Bonilla-Warford N, Allison C. A review of the efficacy of oculomotor vision therapy in improving reading skills. J Optom Vis Dev 2004; 35:108-15.
22. Grisham D, Powers M, Riles, P. Visual skills of poor readers in high school. Optometry 2007;78:542-49.

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Appendix

- A 5X5 grid of blue and red squares was presented to the student with one eye patched. The student was instructed to start with the second finger of the right hand touching the right ear with elbow bent. They then point the same finger at the center of each square going from left to right or top to bottom. After each square is touched, the finger returns to the ear and then points to the next square. The software offers the opportunity to assess the placement of the finger for each square, leaving a fingerprint as evidence. In addition, accuracy scores were given at the end of each screen is completed to allow the instructor to offer feedback for improvement on the next assignment.
- The second exercise in the sequence consisted of a 6X6 grid carried out binocularly left to right and top to bottom.
- The third exercise switched from squares to arrows that pointed right and left. The student was instructed to touch the left arrows with the left hand and the right arrows with the right hand in order as seen.
- The fourth exercise the student was instructed to alternate hands and touch all arrows first left to right and then top to bottom.
- The last exercise consisted of the student touching the arrows and calling out the direction of the arrow, right or left.