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Conventional vision therapy vs. Taylor Reading Plus: Comparing gains in eye movement skills as a predictor of academic achievement in an at-risk population of youth

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Abstract

A group of 55 "at-risk" students at the Oregon Youth Challenge Program were randomly assigned to two vision interventions and one control group. The interventions utilized either conventional vision therapy or the computer program, Taylor Reading Plus@. This study is a comparison of the efficacy of each intervention on reading level measured by The Test of Adult Basic Education (TABE). Pre and post intervention Developmental Eye Movement (DEM) scores, as well as Visagraph reading efficiency scores were analyzed for correlation to improvements in TABE scores in order to see how well gains in the different eye movement tests predict reading improvement.

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Conventional Vision Therapy vs. Taylor Reading Plus®: Comparing Gains in Eye Movement Skills as a Predictor of Academic Achievement in an At-Risk Population of Youth

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BIOGRAPHY:

Francisco Chacon grew up in Bloomfield, New Mexico which is in the Four Corners region amidst the Navajo Nation. He completed his B.S. in Biology at University of New Mexico in Albuquerque. Francisco is currently pursuing a Doctorate of Optometry and Masters in Education-Vision Function in Learning. After completing optometry school at Pacific University College of Optometry, Francisco plans to expand the vision therapy services offered for vision related learning disabilities and acquired brain injuries in New Mexico while also practicing primary care optometry.

Jeanine Morasch grew up on a farm in Endicott, Washington. She received her Bachelor of Science degree in Biology at Pacific Lutheran University in Tacoma, Washington. Jeanine is currently pursuing a Doctorate of Optometry and a Masters in Education-Vision Function in Learning. After completing optometry school at Pacific University College of Optometry, Jeanine plans to further her education with a year-long residency in ocular disease and low vision rehabilitation at the Tucson VAMC. She looks forward to a career practicing optometry in the Pacific Northwest.

ABSTRACT:

A group of 55 "at-risk" students at the Oregon Youth Challenge Program were randomly assigned to two vision interventions and one control group. The interventions utilized either conventional vision therapy or the computer program, Taylor Reading **Plus®.** This study is a comparison of the efficacy of each intervention on reading level measured by The Test of Adult Basic Education (TABE). Pre and post intervention Developmental Eye Movement (DEM) scores, as well as Visagraph reading efficiency scores were analyzed for correlation to improvements in TABE scores in order to see how well gains in the different eye movement tests predict reading improvement.

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Introduction:

The Oregon National Guard Youth Challenge Program is an alternative high school where cadets (students) reside for 5 months. This non-traditional school is accredited by the Northwest Association of Accredited schools and approved by the Oregon Department of Education. The program operates similarly to a military academy. It is guided by military principles, structure, and discipline. After completion of class work, students are eligible to earn a high school diploma, GED or 8 certified credits transferable to their high school.

The target population for the Oregon Youth Challenge Program is "at risk" students who have dropped out of high school, are not attending school, or are failing in school. To be eligible for enrollment, the students must be 16-18 years old, Oregon residents, drug-free, not on probation or parole, nor have a felony crime conviction.

The program mission is to "provide opportunities for personal growth, self improvement and academic achievement among Oregon high school drop outs, students no longer attending and those failing in school, through a highly structured non-traditional environment, integrating training, mentoring and diverse educational activities." [1]

Each student takes a pre TABE (Test of Adult Basic Education) at the beginning of enrollment and a post TABE at completion. Based upon the pre TABE results, the education staff determines the educational track and basic classroom placement for each student during the 22 week residential program. The primary goals of the program involve increasing every student's academic math and reading level by 1.5 grade levels and requiring a minimum of 80 community service hours from each student. Other

areas of focus include: life-coping skills, job skills, health and hygiene, responsible citizenship, leadership/followership, and physical fitness. In order to be eligible for graduation, each student must have a placement and responsible plan for work, school, military, etc. to integrate back into their community.[1]

Many of these youth have struggled in school for a variety of reasons. Often the students have not had adequate access to vision care. In 2004, Dr. Willard Bleything was surprised that upon visual screening of the youth in this program he found a 42% referral rate for vision care needs.[2] Though these youth often have many compounding factors contributing to their academic struggles, Dr. Bleything concluded that the prevalence of vision needs in this population was too high to be strictly a coincidence. This concern led to this study which hopes to aid these youth by reducing a risk factor while learning more about their needs.

For decades, there has been evidence provided by professionals in vision care, as well as psychology and education that attribute vision therapy to reductions of symptoms during reading, including asthenopia (eye-strain), headaches and fatigue, as well as gains in reading rate and comprehension.[3-6] Reductions in such symptoms can lead to greater ease and enjoyment of reading for patients, which in turn often leads to greater academic success. Optometrists are well suited to prevent and manage vision related reading difficulties in patients by the use of lenses as well as active therapy.[7] Some ophthalmologists, in attempts to undermine and discredit the profession of optometry, have argued that reading difficulties are not due to poor vision development. Rather, they claim that visual development and functioning do not contribute to reading deficits, but are due solely to reasons such as low IQ, motivation, environmentally caused distress or

poor education.[8] Therefore, they claim that optometric management of reading difficulties is unwarranted.[8-9] Some ophthalmologists are willing to admit that management of reading symptoms is not their area of expertise.[10] The most compelling evidence that vision therapy is effective comes from studies that are surveys of the satisfaction of patients and parents of child patients before and after completing vision therapy programs.[11-12] The greatest improvements perceived by patients and their parents are in areas of academic performance, self-esteem, reading comprehension, time spent on assignments.[11] Despite the debate between professions as to the amount that anomalies in visual and ocular function contribute to reading comprehension difficulties, there is no denying that the task of reading is a complex and dynamic visual task that requires accuracy in eye movements, focusing and visual perception.

A complete vision examination can give a practitioner insight as to why a patient may be having symptoms or difficulties with reading tasks. Supplemental testing has been developed as potentially diagnostic and/or qualitative measurement of saccadic speed and accuracy (i.e. the ability for patients to make the types of eye movements that skilled readers use). Poor ability to make efficient eye movements has been given the diagnostic title Ocular Motor Dysfunction (OMD). Diagnostic tests for OMD include the Developmental Eye Movement Test (DEM).[13, 14] The DEM consists of three subtests and is designed to account for difficulties in symbol recognition and recall automaticity in order to give more accurate classification of potential reading difficulties due to poor eye movements, poor recall or both.[13] The Horizontal Test is designed to measure specifically the ability of a patient to make the appropriate eye movements for reading tasks. The DEM consists of another subtest, known as the Vertical Test, that is designed

to measure difficulties in symbol recognition and recall automaticity. The DEM Ratio score, which is a ratio of an Adjusted Horizontal Test Score and the Vertical Test score, is used to classify reading difficulties due to poor eye movements, poor recall or both.[13] A fourth score is the Error Score. It is a count of the number of errors while performing the test. Errors are used in converting the Horizontal Test score into an Adjusted Horizontal Test Score. The DEM is normed for children ages 6-13.

Authors of the DEM reported test-retest reliability is 0.86 for the horizontal measures, 0.89 for vertical measures, and 0.57 for ratio scores.[14] A subsequent reliability study of the DEM, by Tassinari and DeLand, reported good intra-subject test-retest reliability in all four of the DEM scores as assessed by an intra-class correlation coefficient among patients who were presenting to optometry offices for vision therapy work-ups.[15] The most reliable scores according to this correlation coefficient were the Horizontal and Vertical scores. Test and re-test agreement on a pass-fail basis, assessed using Cohen's Kappa index, showed good agreement for the Vertical scores and excellent agreement for the Horizontal, Error and Ratio scores. This same reliability study also showed that patients who reported symptoms related to OMD scored lower in all four DEM scores compared to asymptomatic patients. The Horizontal test scores for symptomatic patients had a mean percentile rank of 15.6, while the asymptomatic group had a mean percentile rank of 50.7.[15] Performances on this test have shown weak correlations with reading ability assessments in another study.[16]

Many optometrists have used the Visagraph II ™ as a demonstrative assessment of the efficiency of eye movements when reading. The instrument records a reader's eye movements via infrared sensors as they read a short passage. Though reading difficulties

can have many underlying etiologies, the Visagraph records the actual action of eyes during silent reading. This alone does not demonstrate a precise diagnosis responsible for the difficulties, but rather, the signs that manifest secondarily during reading as a result of the underlying causes of reading struggles. As readers gain experience and become better readers, their eye movements progress in a predictable manner. These trends in eye movements while reading have been normatively analyzed so that they can be plotted for patients and practitioners in terms of grade levels. They include duration and number of fixations, span of recognition and amount of regressions; all together these actions are calculated into grade equivalent efficiency values which relate to what educators refer to as fluency of reading.[17] These values can be evaluated both pre and post therapy as an indicator of progress in reading efficiency, at least with respect to smoothness and rate of eye movements essential to reading. These grade level performances have been shown to improve significantly in children that have been through long term vision therapy relative to children who received no therapy.[18]

Colby et al. determined that the Visagraph provided correct and usable data repeatedly over 500 trials.[19] Interparagraph reliability analysis showed that reading scores from the first of 10 paragraphs were significantly better than the paragraphs read later. This suggests a need to give a warm-up trial of the Visagraph to obtain the most reliable results. This same study showed that Visagraph eye movement, with the exception of the Duration of Fixation, measurements gave no significant correlation with reading comprehension as assessed by the standardized Reading Comprehension Sub-test of the Optometry Admissions Test.[19]

The reading passages of the Visagraph progress in reading levels and comprehension must be demonstrated by a 70% correct score on a ten question quiz following the completion of each passage. Due to the added comprehension criteria, one might argue that the Visagraph is a more relevant eye movement assessment with regard to reading versus the DEM. It's also important to note that the DEM is a subjective assessment, whereas the Visagraph is an objective assessment. This may also deem the Visagraph as superior. However, the subjective tests only require paper and a stopwatch to administer, whereas the Visagraph requires computers and fragile equipment.

Conventional vision therapy consists of training aimed at improving many visual skills such as tracking, fixation, focusing, visual discrimination and binocular coordination. All of these skills are important in reading. It is our expectation that optometric management in the form of vision therapy of patients with reading difficulties will show improvements in eye movements related to reading skills as measured by the DEM and Visagraph.

Besides conventional vision therapy, optometrists and educators have also implemented computer based reading programs. The Taylor Reading Plus Program is designed by Taylor Associates, the makers of the Visagraph. The program claims to improve reading fluency and comprehension in readers of all ages with "…programs [that] develop: accuracy in visual tracking, instant word recognition, rapid word association, visual memory and adequate silent reading rates that ensure good comprehension and ease and comfort."[20] The Visagraph is supposed to serve as a pre and post program monitor of reading fluency. One study indeed showed grade level

efficiency improvements as measured by the Visagraph due to the use of the program, but makes no conclusions as to whether or not there were gains in comprehension.[21]

Lack showed that performance on the DEM and the Visagraph Numbers Test (designed for those who have difficulty with 1st grade prose) correlate to performance on the English Language Arts section of the Test of New York State Standards when they were scored by time.[16] This suggests that improving reading related eye movements could have potential benefits for academic success and make large impact in the lives of our special population.

There is a consensus amongst the optometric community that reading disabilities should be appropriately managed with a multidisciplinary approach.[22-23] Computer based reading therapy seems to be gaining popularity among optometrists. Use of the Visagraph is already taught in optometric curriculums as a reliable tool of the trade to detect reading related vision dysfunction. Since the Reading Plus program uses the Visagraph to monitor progress, it is possible that more optometrists will begin to recommend the reading program as therapy.

In this study we pose two questions. The first question is which type of therapy would be the most effective in improving TABE reading scores in an at-risk population of youth. The second is whether or not improvements in either DEM scores or Visagraph reading efficiency scores correlate to improvements in TABE reading scores. We will use the reading level scores of the TABE, as it is relevant to our particular patient population. It is designed to measure achievement of basic skills commonly found in adult basic education curricula and taught in instructional programs.

Methods

At the beginning of the study, an initial vision screening was performed on 134 students of the Oregon Youth Challenge Program. Informed Consent was obtained from parents and coordinated with the School for each subject. The inclusion criteria for this study required that all subjects who participated "failed" the initial vision screening and had pre-test academic scores at least 2 grades below the expected. Failure on the initial screening was determined by inadequate performance on the Beery VMI and/or a modified version of the New York State Optometric Association (NYSOA) Screening Battery. Of the 134 students that were screened, 27 "failed" the NYSOA tests and 38 "failed" the Beery VMI. With 11 students failing both tests, 55 students were determined as needing a comprehensive optometric examination.

Four of these 55 students dropped out and 51 students were examined by volunteer optometrists and optometric technicians using the following test battery: Optometric Analytical Examination, Accommodative/Vergence Facility, Stereopsis, Dyslexia Screening, DEM, Visagraph, Life Style Questionnaire, and the Van Orden Star. Five students' needs exceeded the services of this setting and were referred accordingly. One student participated in pre-testing but failed to return for post-testing. Lens prescriptions were written as needed and the School and the Children's Foundation followed up with parents.

The trial divided the remaining 45 students into three groups. Group A (16 subjects) received conventional vision intervention, Group B (15 subjects) received Taylor Reading Plus intervention, and Group C (14 subjects) served as the control group.

Once the project was completed, Group C subjects had access to the Reading Plus program.

Group A was split into two groups of 8 students to facilitate therapy administration. Vision training was done in a dedicated therapy room set up within the School where subjects rotated from station to station on 5-minute intervals. Group B used the Taylor Reading Plus program in a computer lab. Group A and Group B received intervention for 45 minutes 4 days per week for 10 weeks. During this time, the students from the Group C were in study hall. Students in the control group participated in the Start Making a Reader Today (SMART) Program and read books one-on-one with elementary school kids.

At the end of the 10 weeks of therapy, subjects were re-examined and data for the post-therapy Visagraph and DEM were obtained. In order to avoid bias leaking into post-testing data or "clinical memory" of findings taken at the beginning of the study, a "fresh" crew of examiners was recruited for post-testing. Post-test examiners were masked to the intervention group to which individuals were assigned. Pre and Post TABE scores were obtained from the Youth ChalleNGe High School.

Results:

All three experimental groups showed an increase in TABE reading level with the Reading Plus group showing the greatest mean increase of 1.400 grade levels. The Conventional VT and control groups showed mean increases of 1.269 and 1.186 reading grade levels respectively. These results give poor statistical variance in reading level between groups as determined with Fisher's PLSD with the greatest variance being

between the Reading Plus and control group (p-value 0.80). Pre and Post-therapy TABE scores for each individual are shown in Figures 1-3.

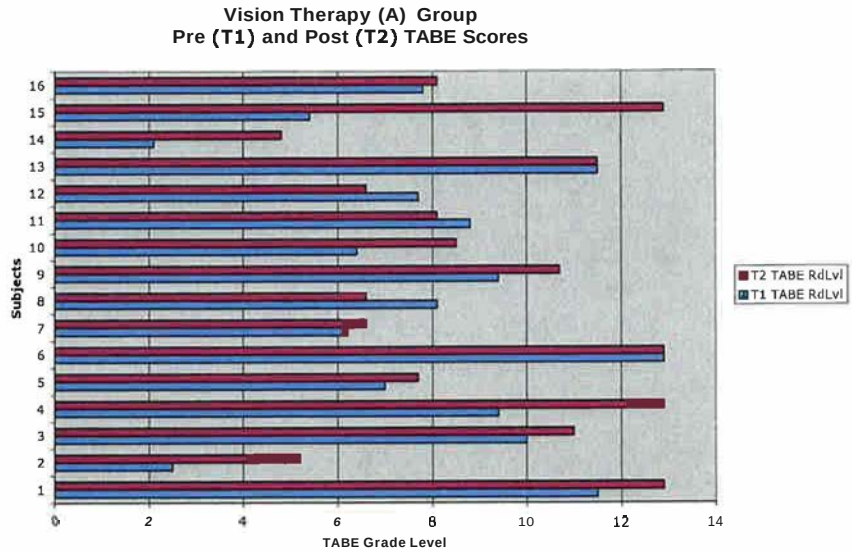

Figure 1 Group A TABE reading level scores before and after vision therapy

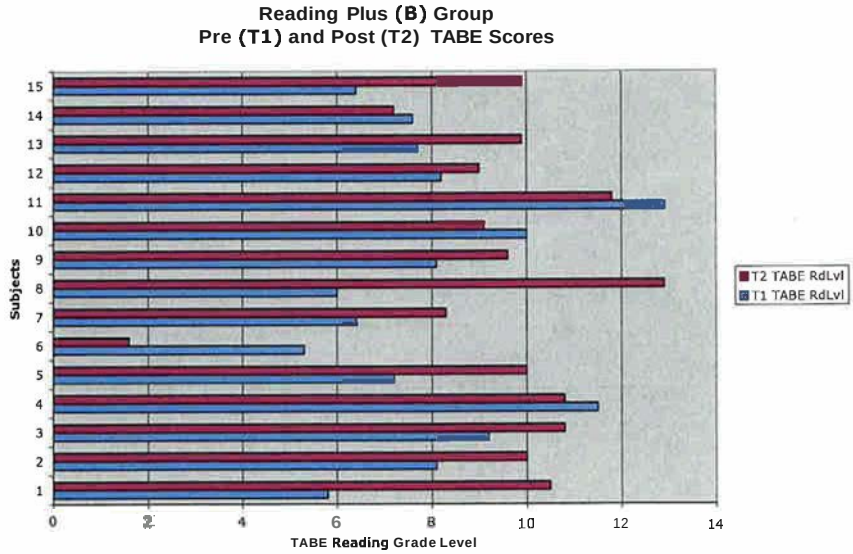

Figure 2 Group B TABE reading level scores before and after Reading Plus

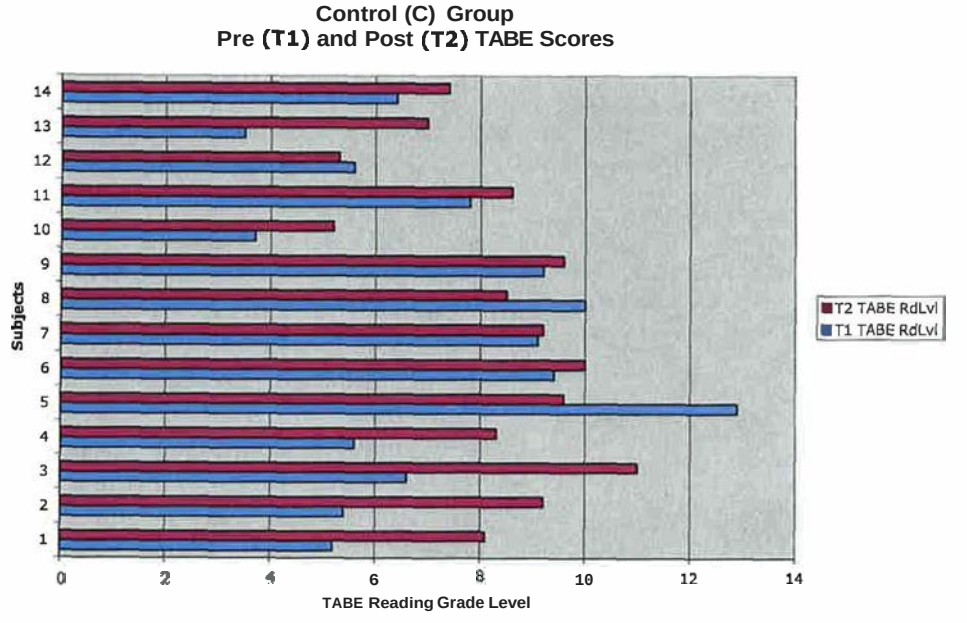

Figure 3 Group C Control TABE reading level scores

Paired t-tests showed no significant differences between pre and post TABE scores when comparing the treatment and control groups. Table 1 shows that although the Reading Plus group had the highest mean difference of TABE reading grade level between pre and post-therapy testing, comparison to the control group shows very low statistical difference.

Table **1** TABE reading grade level improvement t-test analysis

	Mean Pre and Post TABE Difference	Pre and Post TABE Standard Deviation	Paired t Test Comparison to Control	Mean of Experimental Group TABE Difference minus Control Group TABE Difference
Vision Therapy Group A	1.269	2.177	t=0.3922 p=0.7013	-0.293 (95% CI: -1.906-1.320)
Reading Plus Group B	1.400	2.595	t=0.0718 p=0.9438	0.064 (95% CI: -1.869-1.998)
Control Group C	1.186	2.143	---------	----------

Pre and post-therapy differences in our two eye movement scores do not show good correlations to pre and post-therapy differences for individual test subjects in our standardized reading level assessments. The correlation coefficient between improvements in the TABE Reading Grade Level and Visagraph Reading Level Efficiency is 0.1382, and the correlation coefficients between improvements in the TABE Reading Grade Level and the DEM Horizontal Raw Score and Horizontal Standard Scores are 0.1489 and -0.3373. Figures 4-6 display scatter plots of individual improvements of DEM and Visagraph scores compared to improvements in TABE scores. The Visagraph improvements show a weak positive correlation relative to the TABE improvements, while the DEM improvements show a weak negative correlation relative to TABE improvements.

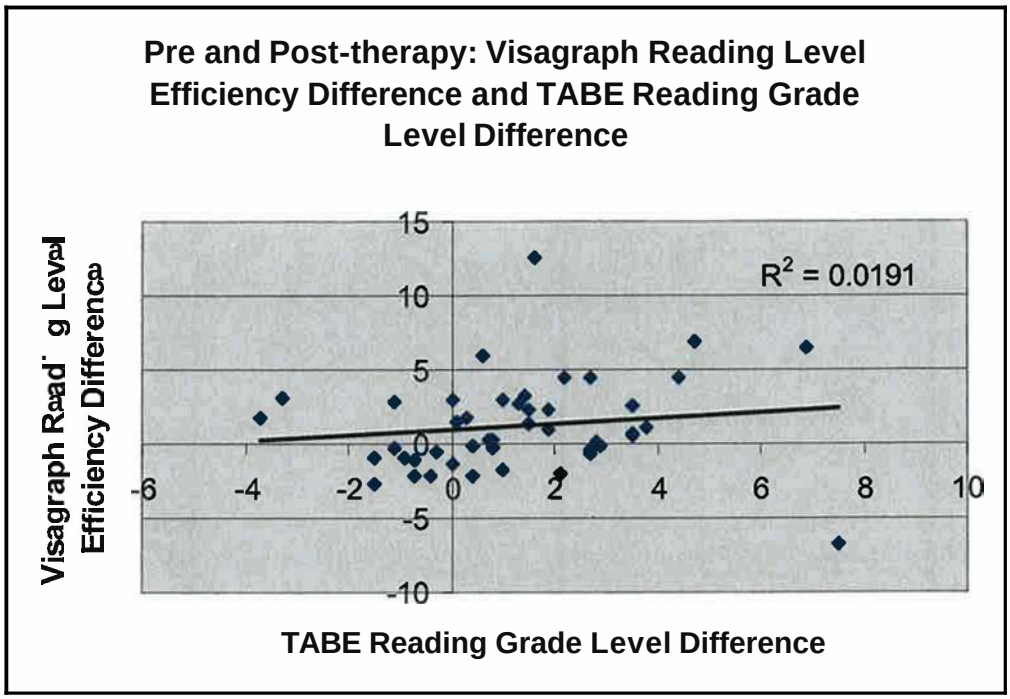

Figure 4 TABE Reading Grade Level Difference vs. Visagraph Reading Level Efficiency Difference

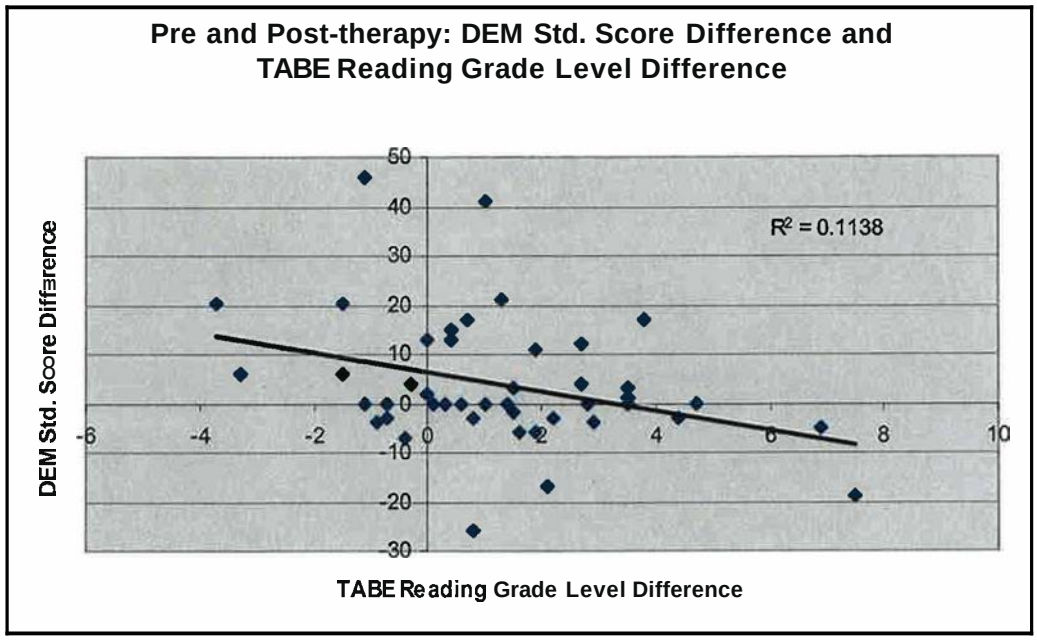

Figure 5 TABE Reading Grade Level Difference vs. DEM Horizontal Std. Score Difference

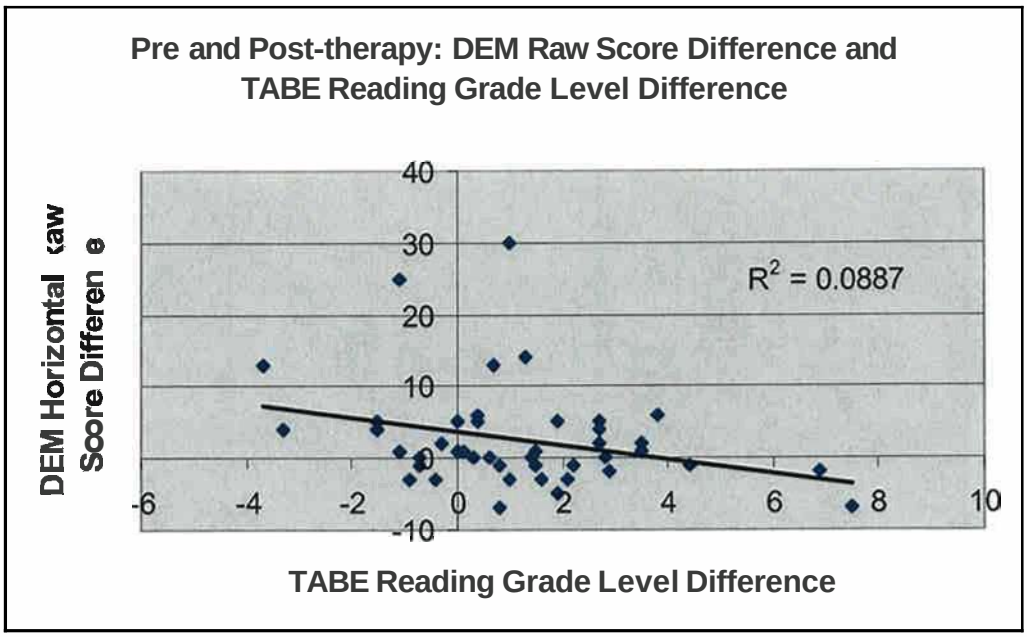

Figure 6 TABE Reading Grade Level Difference vs. DEM Horizontal Raw Score Difference

The DEM mean Horizontal Standard Score improvements were low in the Taylor Plus group (0.600) as compared to the Conventional VT group (8.00) and controls (6.86). Unpaired *t* test results for standard scores between the Reading Plus group and Conventional VT group gave a t value of 1.728 and P value of 0.095.

For Visagraph Reading W e Level Efficiency, the Conventional VT group showed the least improvement with a mean difference of 0.38 grade levels. The control group had a mean difference of 0.76 grade levels and the Reading Plus group had a mean difference of 2.37 grade levels. Unpaired *t* test results between the Reading Flus and Conventional VT for these scores gave a t value of 1.663 and a P value of 0,107.

Table 2 DEM Pre and Post-therapy Differences for Groups A and B

	Mean	Std. Deviation	Std. Error
Conventional VT Group A	8.000	14.971	3.743
Reading Plus Group B	0.600	7.337	1.894

Table 3 Visagraph Pre and Post-therapy Differences for Groups A and B

	Mean	Std. Deviation	Std. Error
Conventional VT Group A	0.375	2.707	0.677
Reading Plus Group B	2.373	3.913	1.010

DISCUSSION

This study did not show any statistical significance for our research questions for a population of teenagers classified as socially "at-risk" with known deficits in reading and visual motor skills. Although both groups, a conventional vision therapy group and a Taylor Reading Plus computer program group, showed improvement in standardized reading grade levels as determined by the TABE, there was no statistical evidence showing that either of the experimental interventions is capable of improving standardized reading grade level when compared to a control group over a 10 week period. There was also no statistically significant improvement in reading related eye movement efficiency as determined by well acknowledged eye movement assessments DEM and Visagraph for either group when compared to a control. The Conventional Vision Therapy group showed the biggest gains in the DEM, while the Reading Plus

group showed the greatest gains in the Visagraph. However, comparisons between groups for both tests have no statistical significance.

Improvements for neither the DEM nor the Visagraph scores showed a statistical correlation to improvements in TABE scores in pre and post intervention. TABE reading level improvements interestingly showed a non-significant positive correlation to Visagraph reading level improvements and a non-significant negative correlation to DEM score improvements in the entire population. This suggests that the Visagraph may be more useful than the DEM as a measure of potential gains in standardized reading level secondary to improvements in eye movement efficiency.

While the DEM is a highly valued method of testing eye movements, our concern with using this test stems mainly from the age norms. These tests were developed for an age group younger than the participants of our study. The DEM is normed for children ages 6-13.[14] Prior research has suggested that further studies are necessary to develop age norms for teenagers and adults.[24] The subjects of this study were between the ages of 16-18, leading us to believe that the DEM result interpretations should be adjusted. All of our scores were calculated as if our subjects fell in the highest age category of 13 years to 13 years 11 months. In an attempt to control for the discrepancy in age norms and actual test subject ages, both raw scores and standard scores for the DEM were used in analysis.

Bleything determined, prior to discovering the high prevalence of vision care needs in the OYCP population, that juvenile delinquents match the visual-profile of learning disabled individuals.[25] This OYCP population is considered "at risk" due to the risk factors they share with delinquents. The opportunity to provide a positive impact on adolescents who are making an effort to get "back on track" and better their futures

brings profound satisfaction from the standpoint of a vision care provider, however, this particular study has many potential flaws for research analysis.

Comparing the effectiveness of different vision interventions in a unique population such as the Oregon Youth Challenge Program prompts questions about how applicable the results of this study would be to a more randomized sample of individuals. The subjects in this study were placed in a highly disciplined setting which may not be representative of the typical vision therapy setting optometrists can expect for their vision therapy patients. In addition, one of the primary goals of the school was to improve reading by 1.5 grade levels. All subjects showed improvements over the intervention period, however with the small sample size it is difficult to determine how much of the success was due to the school and environment and how much can be attributed to the visual interventions.

Another variable that may have complicated the results was that of inter-examiner reliability. This study utilized many different examiners masked to the intervention assignments. The advantage of this was to reduce any bias in the resulting data. Although a strict protocol was provided to each examiner in order to provide consistency and reliability in testing and recording, it is still difficult to eliminate all inconsistencies.

Further potential flaws in the validity of this study stem from the use of the TABE as a standardized reading assessment. While the TABE is a helpful quantitative assessment for adult education achievement programs, we wonder if it is the most valid test to compare reading efficiency gains made by each type of therapy. Reviewers of the test, Beck, M. of Beck Evaluation and Testing Associates, and, Rogers, B., Professor of Educational Psychology, University of Northern Iowa both call into question the

technical validity of the TABE.[26,27] One of Beck's critiques is the loose language with regard to timing of the test. He states that the subtests were normed with specific time limits, while the Examiner Manual describes the time limits as "suggested times". The OYCP staff administered the TABE before and after visual intervention, and it is unknown how strictly the time limits were enforced. We feel that, because we are investigating improvements in rates and efficiencies of reading related eye-movements, strict time limits should be followed.

It came to be known after the study that, the control group began utilizing the time by reading to children when the other groups were participating in their experimental interventions. That is an excellent utilization of time in terms of morality and leadership, . but the extra reading practice could have introduced a detrimental bias to the results of the study.

Subsequent research has been conducted in collaboration of the OYCP which has taken into consideration many of the potential flaws or uncontrolled variables in the pilot study. One of the variables was reported as poor motivation to participate in therapy for the Reading Plus group. Different programs of computer based vision therapy have been implemented in the later investigations.

The results of this study are inconclusive with regard to performance in optometric reading intervention and the role of eye movements in reading level, Though this study failed to show objective support for the role of optometric reading intervention or superiority of one intervention modality over another, it is known through experience that visual training can improve reading skills subjectively. Further research and

experimental designs may better elucidate the relationship between reading related eye movements and reading level.

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