

A SUMMARY OF RESEARCH AND CLINICAL STUDIES ON VISION AND LEARNING

The importance of good vision to reading and learning has been the subject of considerable study. Numerous clinical and research studies have shown that good visual abilities are beneficial to learning to read and to read with understanding. Children with normal eyesight (20/20) can have visual problems which affect how their eyes focus, team together, or move along a line of print when reading.

These learning-related vision problems cause children to struggle unnecessarily, and this can result in their being mislabeled as learning disabled or having Attention Deficit Hyperactivity Disorder (ADHD). Fortunately, effective treatment for these types of vision problems is available through vision therapy.

Vision therapy is an individually prescribed program of procedures used to change and improve visual abilities. Developmental optometrists use vision therapy and special lenses to train the eyes and the brain to work together more effectively. Improvements in visual function enable the child to become a more effective learner.

Vision therapy is a specialized area of optometric care. The following Optometric Clinical Practice Guideline includes a description of the current clinically recognized and supported approaches to the diagnosis and treatment of learning related vision problems:

- Care of the Patient with Learning Related Vision Problems. St. Louis: American Optometric Association, June 20, 2000

A complete copy of this guideline can be accessed on the American Optometric Association website at www.aoa.org

A listing of some of the research reports and clinical studies on the relationship of vision to reading and learning ability and the effectiveness of vision therapy in the treatment of learning-related vision problems is provided on the following pages.

Copies of the complete text of any article or report listed can be obtained from:

International Library, Archives and Museum of Optometry
243 N. Lindbergh Blvd.
St. Louis MO 63141
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STUDIES AND REPORTS ON THE RELATIONSHIP
OF VISION TO READING AND LEARNING

Boden C, Brodeur D. Visual processing of verbal and nonverbal stimuli in adolescents with reading disabilities. *Journal of Learning Disabilities* 32 (1): 58-71, 1999.

This study investigated whether a group of children with reading disabilities (RD) were slower at processing visual information in general (compared to a group of children of comparable age and a group of children of comparable reading level), or whether their deficit was specific to the written word. Computerized backward masking and temporal integration tasks were used to assess the speed of visual information processing. Stimulus complexity (simple, complex) and type (verbal, nonverbal) were varied. Adolescents with RD demonstrated difficulties in processing rapidly presented verbal and nonverbal visual stimuli, although the effect was magnified when they were processing verbal stimuli. The results of this study suggest that some youth with reading disabilities have visual temporal processing deficits that compound difficulties in processing verbal information during reading.

Bowan M. Learning disabilities, dyslexia, and vision: a subject review: A rebuttal, literature review and commentary. *Optometry* 73 (9): 553-575, 2002.

In 1998, the American Academy of Pediatrics, the American Academy of Ophthalmology, and the American Association of Pediatric Ophthalmology and Strabismus (AAP/AAO/AAPOS) published a position paper entitled "Learning Disabilities, Dyslexia And Vision: A Subject Review," intended to support their assertion that there is no relationship between learning disabilities, dyslexia, and vision. The paper presents an unsupported opinion that optometrists (by implication) have said that vision problems cause learning disabilities and/or dyslexia and that visual therapy cures the conditions. The 1998 position paper follows two very similar and discredited papers published in 1972 and 1981.

This article critically reviews and comments on the many problems of scholarship, the inconsistencies, and the false allegations the position paper presents. Perhaps the foremost problem is that the authoring committee has ignored a veritable mountain of relevant literature that strongly argues against their assertions that vision does not relate to academic performance. The AAP/AAO/AAPOS paper contains errors and internal inconsistencies. Through highly selective reference choices, it misrepresents the great body of evidence from the literature that supports a relationship between visual and perceptual problems as they contribute to classroom difficulties. The 1998 paper should be retracted because of the errors, bias and disinformation it presents.

Eden GF, Stein JF, Wood HM, Wood, FB. Differences in eye movement and reading problems in dyslexic and normal children. *Vision Research* 34 (10): 1345-1358, 1994.

It has been suggested that eye movement abnormalities seen in dyslexics are attributable to their language problems. In order to investigate this claim, we studied eye movements in dyslexic children during several non-reading tasks. Dyslexic children were compared to normal and backward readers on measures of fixation, vergence amplitude, saccade and smooth pursuit. The results were compared to the children's phonological ability. Dyslexic children (n = 26) had significantly worse eye movement stability during fixation of small targets than normal children (n = 30). Vergence amplitudes were lower for dyslexics than for controls. A qualitative assessment of saccadic eye movements revealed that dyslexics exhibit fixation instability at the end of saccades. Assessment of smooth pursuit revealed poor smooth pursuit in the dyslexic group, particularly when pursuing a target moving from left to right. Dyslexic children also performed significantly worse than normal children on a test of phonological awareness (Pig Latin). Eye movement results were studied in the light of the findings on phonological awareness: dyslexics with small vergence amplitudes also always have poor phonemic awareness. However, poor fixation control is found in dyslexics with or without poor phonological ability. The backward reading children performed similar to the dyslexics on all tests, suggesting that the deficiencies observed in this study are not specific to children with dyslexia. The problems experienced by the children (revealed by a questionnaire) are in agreement with those measured in terms of eye movement recording and phonemic awareness. Sex, handedness, IQ or the presence of attention deficit disorder (ADD) did not appear to influence the children's performances on any of the eye movement tasks. The presence of oculomotor abnormalities in a non-reading task strongly suggest that the underlying deficit in the control of eye movements seen in dyslexics is not caused by language problems alone.

Eden G, Stein J, Wood M, Wood F. Verbal and visual problems in reading disability. *Journal of Learning Disabilities* 28 (5): 272-290. 1995.

In a preliminary study (Eden, Stein & Wood 1993), we showed that visuospatial and oculomotor tests can be used to differentiate children with reading disabilities from nondisabled children. In the present study, we investigated a larger sample of children to see if these findings held true. Using 93 children from the Bowman Gray Learning Disability Project (mean age = 11.3 years: 54 boys, 39 girls), we compared the phonological and visuospatial abilities of nondisabled children (children whose reading at fifth grade rated a Woodcock-Johnson reading standardized score between 85 and 115), and children with reading disability (whose reading standardized score was below 85 on the Woodcock-Johnson). In addition to performing poorly on verbal tests, the children with reading disability were significantly worse than nondisabled children at many visual and eye-movement tasks. A high proportion of the variance (68%) in reading ability of both the nondisabled children and those with reading disability could be predicted

by combining visual and phonological scores in a multiple regression. These results provide further support for the hypothesis that reading disability may, to some extent, result from dysfunction of the visual and oculomotor systems.

Grisham D, Sheppard M, Tran W. Visual symptoms and reading performance. *Optometry and Vision Science* 70 (5): 384-391, 1993.

Clinical observation indicates that visual asthenopic symptoms are frequently associated with reading for long periods of time. We investigated the relation between visual symptoms and standard measures of reading performance in 78 university students. The number of asthenopic complaints increased during the reading phase of the experiment and decreased during the relaxation phase. Overall, a weak but significant negative correlation was found between number of symptoms and reading rate on the Nelson-Denny reading test. The most symptomatic subjects scored lower on vocabulary and comprehension than the least asthenopic subjects. A limited retrospective analysis revealed no reading performance differences between subjects having normal binocular vision and those showing a minimum binocular dysfunction; however, the dysfunctional subjects reported more visual symptoms. This study suggests that visual symptoms are a factor in reducing reading performance, particularly in very symptomatic individuals.

Johnson RA, Zaba JN. The visual screening of adjudicated adolescents. *Journal of Behavioral Optometry* 10 (1): 13-17, 1999.

The New York State Optometric Association Vision Screening Battery (NYOSA) and the Developmental Eye Movement Test (DEM) were administered to 50 adjudicated adolescents in order to isolate which particular visual factors are most responsible for the learning difficulties of juvenile offenders. The most significant finding was the high failure rate of juvenile offenders on both tracking tests. Forty-eight percent failed the tracking subtest of the NYOSA. Sixty-eight percent failed one or more of the DEM subtests.

Although adjudicated juveniles have received various psychological, educational, and vocational treatments most of these treatments have had limited effectiveness. It is difficult for a treatment program, particularly an academic one, to be effective if the adolescent lacks adequate visual skills. Unless at-risk adolescents with visual impairments are properly diagnosed and treated, many offenders, such as those in the current study, may end up in the criminal justice system.

Maples W.C. Visual factors that significantly impact academic performance. Optometry 74 (1): 35-39, 2003.

Both race and socio-economic status are correlated to performance in the classroom. These two factors are inter-related, since minorities, proportion-wise, are more highly represented in the lower socio-economic strata. Inefficient visual skills have been shown to be more prevalent among minority groups and in low socio-economic groups. These inefficient visual skills impact the students' learning. This study was undertaken to discover the visual skills that were significantly correlated with academic performance problems.

A total of 2,659 examinations on 540 children were administered over three consecutive school years. Socio-economic, racial and standardized academic performance data (Iowa Test of Basic Skills – ITBS) were furnished by the families and the school system. The visual and demographic data from the examinations were then compared to performance on the 21 subtests of the ITBS.

Some visual factors were found to be much better predictors of scores on the ITBS than either race or socio-economic status. Even though the significance of these two demographic variables was small, race and socio-economic variables were each significant in about a third of the 21 ITBS scores. Visual factors are significantly better predictors of academic success as measured by the ITBS than is race or socio-economics. Visual motor activities are better predictors of ITBS scores than are binocularity or accommodation. These latter skills were significant predictors also, but to a lesser degree.

Simons H, Grisham, J.D. Binocular anomalies and reading problems. Journal of the American Optometric Association. 58 (7): 578-587, 1987.

This paper reviews and evaluates the research literature on the relationship of binocular anomalies to reading problems. The weight of the evidence supports a positive relationship between certain binocular anomalies and reading problems. The evidence is positive for exophoria at near, fusional vergence reserves, aniseikonia, anisometropia, convergence insufficiency, and fixation disparity. There is some weak positive evidence for esophoria at near and mixed evidence on lateral phorias at distance is negative.

Taylor Kulp M, Schmidt P. The relation of clinical saccadic eye movement testing to reading in kindergartners and first graders. Optometry and Vision Science 74 (1): 37-42, 1997.

The relation between psychometric eye movement scores and reading skill was studied in a masked investigation with 181 kindergartners and first graders (mean age 6.25 years) from a middle class, suburban, elementary school near Cleveland, Ohio. Eye movements were evaluated with the New York State Optometric Association King-Devick and the Developmental Eye Movement tests. Digit

Knowledge was assessed with Reversals Frequency Test Execution Subtest (Gardner). Reading performance was measured with Metropolitan Achievement Test 6 (MAT6) Reading Test and teacher's assessments. The number of unknown or reversed numbers on Gardner was significantly related to test times on the NYSOA K-D and DEM, but not the DEM ratio. Outcome on NYSOA K-D, determined by errors in conjunction with test time, was significantly related to reading ability in 5-year-olds, 6-year-olds, and the entire subject group when controlling for age. Our findings suggest that performance of the NYSOA K-D is related to reading performance in 5-and 6-year-olds in kindergarten.

Taylor Kulp M, Schmidt P. Visual predictors of reading performance in kindergarten and first grade children. *Optometry and Vision Science*, 73(4): 255-262, 1996.

A masked investigation of the relation between performance on various vision tests and reading was conducted with 90 kindergartners (mean age 5.73 years) and 91 first graders (mean age 6.76 years) from a middle class, suburban, elementary school near Cleveland, Ohio.

The results revealed that accommodative facility was predictive of successful reading performance in 7-year-olds, first graders and the entire subject group when age or grade was controlled. Failure on the MCT was significantly associated with decreased reading skill in 5-year-olds. In addition, stereoacuity worse than 100 sec arc, MCT failure plus stereoacuity worse than 50 sec arc and accommodative ability were predictive of whether children of average intelligence would show successful or unsuccessful reading ability.

Thus, visual performance was significantly related to reading performance even in children of average intelligence when IQ was partially controlled. Also, the predictive value of the MCT for reading achievement could be improved by the addition of a referral criterion for stereoacuity. This would make the results of MCT screening more readily applicable to educators.

Taylor Kulp M, Edwards K, Mitchell L. Is visual memory predictive of below-average academic achievement in second through fourth graders? *Optometry and Vision Science* 79 (7): 431-434, 2002.

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.

Visual memory score was significantly predictive of below-average word decoding, total math score, and Stanford complete battery score. Visual memory

score showed a positive trend in predicting reading comprehension 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.

Taylor Kulp M. Relationship between visual motor integration skill and academic performance in kindergarten through third grade. *Optometry and Vision Science* 76 (3): 159-163, 1999.

The objective of this study was to examine the relationship between visual motor integration skill and academic performance in kindergarten through third grade. One hundred ninety-one (n = 191) children in kindergarten through third grade (mean age = 7.78 years; 52% male) from an upper-middle class, suburban primarily Caucasian, elementary school near Cleveland, Ohio were included in this investigation. Visual analysis and visual motor integration skill were assessed with the Beery Developmental Test of Visual Motor Integration (VMI) long form. The relationship between performance on the VMI and teachers' ratings of academic achievement was analyzed. The children's regular classroom teachers rated the children with respect to reading, math, and writing ability. Second and third grade children (N = 98) were also rated on spelling ability. Only experienced teachers were included in the investigation and the validity of the teachers' ratings was substantiated by significant correlations with standardized test scores. Teachers were masked to performance on the VMI until the rating was completed. The Stanford Diagnostic Reading test, 4th edition, was also used as a measure of reading ability in the first graders and the Otis-Lennon school Ability test (OLSAT), 6th edition, was also used as a measure of school-related cognitive ability in second graders.

Performance on the VMI was found to be significantly related to teachers' ratings of the children's reading, math, writing, and spelling ability. An analysis by age group revealed that performance on the VMI was significantly correlated with reading achievement ratings in the 7- 8- and 9- year- olds. VMI scores were also significantly related to performance on the Stanford Reading Test in the first graders and to performance on the OLSAT in the second graders. In order to partially control for mathematical ability, an additional analysis was performed with children who were identified by the OLSAT as having either below average, average or above average verbal reasoning scores ability (the verbal reasoning score consists of aural and arithmetic reasoning). This analysis again revealed a significant correlation between the VMI and teachers' achievement ratings in math. Finally, in order to partially control for cognitive ability related to writing, an additional analysis was performed with children who were identified by the OLSAT as having either below average, average or above average nonverbal cluster OLSAT scores. This analysis again revealed a significant correlation between the VMI and teachers' achievement ratings in writing (p=0.001 among average second grade students). *Conclusion:* Performance on a visual analysis and

visual motor integration task is significantly related to academic performance in 7- 8- and 9- year olds.

Taylor Kulp M, Schmidt P. Effect of oculomotor and other visual skills on reading performance: A literature review. *Optometry and Vision Science* 73 (4): 283-292, 1996.

Reading disability is a multifaceted problem, which requires an interdisciplinary approach. Many visual difficulties have been shown to be related to reading ability. Efficient reading requires accurate eye movements and continuous integration of the information obtained from each fixation by the brain. A relation between oculomotor efficiency and reading skill has been shown in the literature. Frequently, these visual difficulties can be treated successfully with vision therapy.

Young B, Collier-Gary K, Schwing S. Visual factors: A primary cause of failure in beginning reading. *Journal of Optometric Vision Development*, 32 (1): 58-71, 1994.

In a longitudinal study of 144 *beginning* readers in public school, data on 25 measures of visual efficiency were subjected to two-and three-way Analyses of Variance. Binocular function, visual acuity, discrepancies in acuity, and color deficiencies were all found to be statistically significant in impeding beginning reading. Significant differences were also found in the sequence of visual development between sexes, between eye and dominance for different tasks, between specific factors for 6-, 7-, and 8-year-olds and first and second grades. It was concluded that visual factors are a *primary* cause of beginning reading failure and that most current school screenings are inadequate in scope and rigor.

STUDIES THAT EVALUATE THE IMPACT OF
VISION THERAPY ON READING AND LEARNING ABILITY

Atzmon D, Nemet P, Ishay A, Karni E. A randomized prospective masked and matched comparative study of orthoptic treatment versus conventional reading tutoring treatment for reading disabilities in 62 Children. Binocular Vision and Eye Muscle Surgery Quarterly 8 (2): 91-106, 1993.

Schools need better and economical methods of treating reading disabilities. Controversies remain whether orthoptics and/or “visual training” can remedy reading disabilities. Therefore, and to extend our prior studies, we undertook a comparative and controlled study.

120 children with reading disability were tested extensively, matched and randomly divided into three groups: orthoptic, conventional (reading tutoring) and no-treatment control. Unfortunately, participants in the control group were unable to adhere to no treatment and were deleted. Each of the 40 children in the first two groups had 40 sessions, 20 minutes daily. Orthoptic treatment was directed to markedly increase fusional convergence amplitudes for both near and distance to 60 Δ . The two treatments were also carefully matched in time and effort.

Examination of subjects revealed that 100% had poor fusional convergence amplitudes by our standards and 60% had 20 Δ or less: two-thirds had a normal near point of convergence of 5 cm or less; many had a subjective reading and asthenopic symptoms in the presence of fusional convergence amplitudes said to be normal by other authorities.

Sixty-two children in 31 matched pairs completed the course of treatment and testing. The results were: equal and statistically significant ($P < .05$) marked improvement in reading performance in both treatment groups on essentially all tests.

Orthoptic treatment, to increase convergence amplitudes to 60 Δ is as effective as conventional in-school reading tutoring treatment of reading disabilities. An advantage of orthoptic treatment was that subjective reading and asthenopic symptoms virtually disappeared after orthoptics. We recommend orthoptic treatment as: 1) an effective alternate primary treatment: 2) adjunctive treatment for those who do not respond well to standard treatment: and 3) as primary treatment in any case with asthenopic symptoms of/or convergence inadequacy.

Fischer, Hartnegg, Klaus. Effects of visual training on saccade control in dyslexia. Perception 29: 531-542, 2000.

This study reports the effects of daily practice of three visual tasks on the saccadic performance of the 85 dyslexic children in the age range of 8 to 15 years. The

children were selected from among other dyslexics because they showed deficits in their eye-movement control, especially in fixation stability and/or voluntary saccade control. The eye movements were measured in an overlap prosaccade and a gap antisaccade task before and after the training. The three tasks used for the training included a fixation, a saccade, and a distractor condition. In any of these tasks, the subject had to detect the last orientation of a small pattern which rapidly changed its orientation between up, down, right, and left, before it disappeared after some time. The task was to press one of four keys corresponding to the last orientation. The visual pattern was presented on an LCD display of a small hand-held instrument given to the children for daily use at home. The results indicate that daily practice improved not only the perceptual capacity, but also the voluntary saccade control, within 3 to 8 weeks. After the training, the group of dyslexics was no longer statistically different from the control group.

Halliwell, J., Solan, H., The Effect of a Supplemental Perceptual Training Program on Reading Achievement. *Exceptional Children* 38: 613-22, 1972.

At the beginning of the first grade, 105 students designated as potential reading problems were divided into three groups of 35 children each: experimental I, which received supplementary perceptual training in addition to the regular reading program; experimental II, which received traditional supplementary reading instruction in addition to the regular reading program; and the control group, which received no supplementary instruction. The Metropolitan Achievement Test (MAT) was administered at the end of May. The statistical analysis of the data indicated that, of all the groups, only the experiment I total group and the experimental I boys read significantly better than the respective control groups on the reading subtest of the MAT.

Harris P. Learning-related visual problems in Baltimore City: A Long-Term Program. *Journal of Optometric Vision Development* 33 (2): 75-115, 2002.

A longitudinal, single-masked, random sample study of children at a Baltimore City Public Elementary school documents the prevalence of learning-related visual problems in the inner city of Baltimore and tests the effectiveness of vision therapy. Vision therapy was provided to one of the randomly selected groups and data were collected on optometric tests, visual performance tests, and standardized achievement tests before and after treatment was provided. Data presented show that the vision therapy program has made a significant difference in the demand level of reading that could be read for understanding, in math achievement on standardized testing, and in reading scores on standardized testing, as well as on infrared eye-movement Visagraph recordings, which show significant changes on nearly all mechanical aspects of the reading process.

McKane F, et al. A comparison of auditory/ language therapy with school visual support procedures in a public school setting. Journal of Optometric Vision Development 32 (2): 83-92, 2001.

Some hold that poor reading eye movements are caused by poor language skills and if the auditory/ language skills were improved that reading and eye movements during reading would also improve. Twenty-nine third grade children who had previously been identified as being below average in some academic area were the subjects of this study. The experimental group contained 18 subjects, equally distributed between genders. After screening evaluations, all children were enrolled in an auditory/language enrichment program and the experimental group also received school based vision techniques which were individually programmed and administered by school personnel, in the school setting daily for 30 minutes a day for 3.5 months. Both groups improved significantly over pre-test scores on the reading aspect of the WRAT and reading rate with comprehension as measured by the –Visagraph. The experimental group also demonstrated a significant improvement in reading eye movements as measured by the Visagraph, but the control group did not. The authors concluded that both visual and auditory/language intervention has a positive effect on the reading WRAT scores as well as the reading rate with comprehension. Reading eye movements, however, were significantly improved only with visual intervention and not with auditory/language therapy.

Orfield A, Basa F, Yun J. Vision problems of children in poverty in an urban school clinic: Their epidemic numbers, impact on learning, and approaches to remediation. Journal of Optometric Vision Development 32 (3): 114- 141, 2001.

The Mather School pilot study explores the relationship between vision and learning by analyzing clinical vision data gathered in an urban school eye clinic from fall 1993 to spring 1999, and relating the vision findings with available standardized test scores and teacher grades. There were 1544 vision evaluations on 801 students, 226 extended functional vision exams on students who failed the initial evaluation, 79 children who received some vision therapy and 116 who received glasses, mostly for close work, and another 85 who received prescription for glasses. Our in-school evaluations found a higher incidence of vision problems than reported in previous studied. Without counting the visual tracking test, 41% failed: adding the tracking test, 53% failed. The majority of the vision problems we found were related to near vision, including a great deal of hyperopia, and were associated with lower average test scores. Our treatments of reading glasses and vision therapy improved visual function on specific tests, with those who had the poorest findings on individual measures improving the most. Correlated with these treatments are improvements in teacher grades, percentiles, and grade equivalents on standardized tests in reading and mathematics. Even with our limited study, the data suggests that there is a high incidence of these problems, that some of these problems are correlated with lower scores in reading and math, that they can be treated in a school setting, that school screenings should be

expanded to include more near point tests, that detailed functional vision exams should be required of all children falling behind in school, and that The Developmental Eye Movement test, which 24.5% of the children failed, is an excellent predictor of a significant percent of reading failure risk and should be administered to all school children in the early grades so that help can be given early. Remediation for poor visual skills is as important as remediation for learning failure, because lack of many of these skills correlate with learning problems.

Rounds BB, Manley CW, Norris RH. The effect of oculomotor training on reading efficiency. Journal of American Optometric Association 62 (2): 92-99, 1991.

The purpose of this study was to record and measure, by means of a microcomputer, the reading eye movements and reading efficiency of a sample of “poor readers” from an adult, professional school population. A program of oculomotor skill enhancement training was given to 10 students who also failed the reading test, but received no such training. All subjects’ eye movements were monitored and recorded individually while reading, using a Visagraph eye-Movement Recording System. The subjects were split into an experimental group (Receiving training) and a control group (receiving no training). Following a 12-hour program of “in office” and “home” training, the group receiving oculomotor training showed trends toward improved reading eye movement efficiency (number of regressions, number of fixations and span of recognition), compared to that of the untrained group.

Seiderman A. Optometric vision therapy- results of a demonstration project with a learning disabled population. Journal of American Optometric Association 51(5): 489-492, 1980.

Thirty-six children attending a private school for learning disabled children were diagnosed as having visual and /or perceptual disorders. The experimental group received individual programming in visual and perceptual development at their appropriate developmental levels. The control group received instruction in physical education, art or music classes. Both groups received individualized reading assistance. Statistical analysis of the two year demonstration project, which included nine months of actual training, indicated that the experimental group made significant gains in reading as compared to the control group. The improvement in basic instructional level of The Informal Reading Inventory (Temple University), and the Word Reading and Paragraph Meaning subtests of the Stanford Achievement Tests, and the actual classroom reading levels were all statistically significant. The Informal Word Recognition Invention (Daniels) and the spelling subtest of the Stanford Achievement Tests showed a definite trend approaching statistical significance.

Sigler G, Wylie T. The effect of vision therapy on reading rate: A pilot study. Journal of Behavioral Optometry 5 (4): 99-102, 1994.

Three subjects, two aged 8 and one age 10, with identified visual system disorders were selected as subjects to evaluate the effects of vision therapy on reading efficiency as measured by reading rate. Reading rate measures were taken prior to initiation, at the conclusion, and 90 days post-visual therapy. The results were that all subjects had accelerated reading rate gains during the period of vision therapy and that the reading rates for two of the three subjects continued to increase in the post-therapy (maintenance) period. All three subjects experienced positive gains over the period (180 days) of the study.

Solan, H., Shelley-Tremblay, J., et al. Effect of Attention Therapy on Reading Comprehension. Journal of Learning Disabilities 36(6): 556-563, 2003.

This study quantified the influence of visual attention therapy on the reading comprehension of Grade 6 children with moderate reading disabilities (RD) in the absence of specific reading remediation. Thirty students with below-average reading scores were identified using standardized reading comprehension tests. Fifteen children were placed randomly in the experimental group and 15 in the control group. The Attention Battery of the *Cognitive Assessment System* was administered to all participants. The experimental group received 12 one-hour sessions of individually monitored, computer-based attention therapy programs; the control group received no therapy during their 12-week period. Each group was retested on attention and reading comprehension measures. In order to stimulate selective and sustained visual attention, the vision therapy stressed various aspects of arousal, activation, and vigilance. At the completion of attention therapy, the mean standard attention and reading comprehension scores of the experimental group had improved significantly. The control group, however, showed no significant improvement in reading comprehension scores after 12 weeks. Although uncertainties still exist, this investigation supports the notion that visual attention is malleable that the attention therapy has significant effect on reading comprehension in this often neglected population.

Solan H, Larson S, Shelley-Tremblay J, Ficarra A, Silverman M. Role of visual attention in cognitive control of oculomotor readiness in students with reading disabilities. Journal of Learning Disabilities 34 (2): 107-118, 2001.

This study investigated eye movement and comprehension therapy in Grade 6 children with reading disabilities (RD). Both order of therapy and type of therapy were examined. Furthermore, the implications of visual attention in ameliorating reading disability are discussed. Thirty-one students with RD were identified using standardized reading comprehension tests. Eye movements were analyzed objectively using an infrared recording device. Reading scores of participating children were 0.5 to 1 SD below the national mean. Testing took place before the start of therapy (T1) and was repeated after 12 weeks (T2) and 24 weeks (T3) of

therapy. One group of students had eye movement therapy first, followed by comprehension therapy; in the other group, the order was reversed. Data were evaluated using a repeated measures MANOVA and post hoc tests. At T1, mean reading grade was 2 years below grade level, and eye movement scores were at about Grade 2 level. Mean growth in reading comprehension for the total sample was 2.6 years at T3: equally significant improvement was measured in eye movements. Learning rate in reading comprehension improved from 60% (T1) to 400% (T3). Although within group differences were statistically significant at T2 and T3. Eye movement therapy improved eye movements and also resulted in significant gains in reading comprehension. Comprehension therapy likewise produced improvement both in eye movement efficiency and in reading comprehension. The results support the notion of a cognitive link among visual attention, oculomotor readiness, and reading comprehension

Sterner B, Abrahamsson M, Sjöström A. Accommodative facility training with a long term follow up in a sample of school aged children showing accommodative dysfunction. Documenta Ophthalmologica 99: 93-101, 1999.

The primary aim of this project was to study the effect of flip lens-training on the accommodative function in a group of children with accommodative dysfunction and subjective symptoms such as asthenopia, headache, blurred vision, and avoidance of near activity. We also wanted to measure the accommodative facility among the children in comparison with a control group. Another aim of the study was whether flip lens-training increased accommodative facility, and to find out if it also had a positive effect on their asthenopia and related problems also in long term. Following the training period the accommodative facility and accommodative function significantly increased and two years after finishing the training period no child had regained any subjective symptoms and the objective findings were almost the same as at the end of facility training period. These results suggest that accommodative facility training is an efficient method built on loss of symptoms among children with accommodative infacility.

Streff JW, Poynter HL, Jinks B, Wolff B. Changes in achievement scores as a result of a joint optometry and education intervention program. Journal of the American Optometric Association 61 (6): 475-81, 1990.

This study tested the effect of a visually directed intervention program on changes in standardized test results of intelligence quotient and achievement during kindergarten. Two groups of 19 kindergarten children from equivalent schools were matched for intelligence quotient, age, and sex. Fall and Spring measurements were made in the following areas: intelligence quotient, academic achievement tests, and paper and pencil perceptual tests. A visually based intervention program involving both optometry and education was provided for the experimental group. Kindergarten children in the experimental group who received the visually directed optometry and education intervention program showed significant differences in the rate of change in four of the eight tested areas when matched to the control group.