

Article

A Review of the Efficacy of Oculomotor Vision Therapy in Improving Reading Skills

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Introduction: Vision therapy has been used for years by optometrists to improve the oculomotor skills in children struggling with reading. Professionals outside of optometry have often criticized the use of vision therapy for these patients. This article reviews the published literature examining the use of orthoptic and oculomotor vision therapy to improve reading skills in patients without specific reading disability.

Procedure: Eleven studies published from 1940 to 2001 were evaluated and compared. Summaries, results, and conclusions are presented for each study, as well as a determination of the overall strength of each study.

Results: The vast majority of studies shows a weak but positive relationship between oculomotor vision therapy and improved reading skills, such as reading rate and comprehension. The evidence as a whole shows that this improvement is equivalent to that of conventional reading therapy but that the most improvement exists when both vision therapy and reading training are used with the patient.

Implications: This review endorses the use of vision therapy with patients with non-specific reading disabilities, especially when the patient is also undergoing traditional reading therapy. **Key Words:** *vision therapy, oculomotor skills, reading.*

INTRODUCTION

For well over a century, optometrists have provided “orthoptics” or visual training to straighten the eyes.¹ For over 70 years, optometrists have used orthoptic therapy to treat individuals with reading problems.^{2,3} In doing so, optometry has come under fire from other vision professionals⁴⁻⁶ who have frequently insisted that there is no relationship between visual anomalies and reading skills. Yet there has been much research conducted by optometrists and others exploring the connection between vision and reading. Despite this effort,

the divide between optometrists and other professions has not diminished. The claim is often made that this research is faulty and, thus, it cannot be concluded that vision anomalies may lead to reading problems or that reading skill may be improved with vision therapy.⁴⁻⁶ This article examines the methodology and strength of published studies of the efficacy of optometric vision therapy as a means of treating certain vision-related reading problems.

BACKGROUND

What Is Reading?

The act of reading is complex and dynamic. In addition to the frequent changes in eye position necessary to follow text, reading involves continuous cognitive processing. This can be described as a constant interplay between “bottom-up” reading, or decoding,

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Bonilla-Warford N, Allison C. A review of the efficacy of oculomotor vision therapy in improving reading skills. *J Optom Vis Dev.* 2004;35(2):108-115.

where the reader moves from word to word, deciphering the meaning of each word and “top-down” reading, or comprehension, where the reader deduces from context the meaning of a passage and then uses the following words to confirm the meaning.^{7,8}

Not only does reading require frequent short-term changes in motor control and cognitive control, it changes and evolves to serve a child as he or she grows and matures. Reading is often described in 2 phases, “learning to read” and “reading to learn.” Learning to read focuses largely on “bottom-up” reading. Focus is on word recognition, recall, and developing phonemic awareness, the linking of the sounds of language to written symbols. Visual factors that are important during this early phase are accurate oculomotor control, visual form perception, and visual memory.⁹ As children mature, they are assigned longer, more self-directed academic tasks and the child is expected to read to learn. This requires more use of “top-down” reading, focusing more on comprehension and speed of reading. At this stage, efficient oculomotor control, as well as comfortable, binocular vision and accommodative control, become more important.⁹

Definitions Pertaining to Reading Problems

The lack of a uniform set of definitions has plagued reading research throughout its history. The term “dyslexia” was first used by Berlin in 1887 to describe patients with “word blindness” and since has been used numerous ways, including as a general synonym for “reading problem”.¹⁰ A more current definition of dyslexia is as a distinct learning disability, “characterized by difficulties in single word decoding” that are “unexpected in relation to age and other cognitive and academic abilities; they are the result of generalized developmental disability or sensory impairment.”⁸ Thus, reading problems can be classified into 2 groups: specific reading disability (dyslexia) or non-specific (general) reading disability. There is evidence to suggest that specific reading disability may result from abnormal central nervous system development.¹¹ Non-specific reading disabilities can be caused by low intelligence, education deprivation, sociocultural deprivation, primary emotional problems, sensory impairment, poor

motivation, attention problems, or other problems, which may impair reading development.¹⁰ Problems with visual acuity and visual efficiency are considered sensory impairments and, therefore, can theoretically lead to or contribute to a non-specific reading disability. This article focuses on the efficacy of vision therapy to improve non-specific reading problems due to visual inadequacies.

Prevalence of Reading Problems

There can be little doubt that a significant portion of the population suffers from poor reading skills. The estimates vary widely, in part due to differences in definition, population studied, and reading skill criteria used. In a prospective study of specific reading retardation, Yule et al. found that 3.5% of 10 year olds and 4.5% of 14 year olds on the Isle of White and 6% of 10 year olds in London were 2 standard deviations below the mean for reading achievement.¹² In 1987, the Interagency Committee on Learning Disabilities reported to Congress that the prevalence of learning disabilities was between 5 and 10%.¹² In 1996, a longitudinal study in Connecticut showed that 17% of primary and middle school children were 1.5 standard deviations below the mean. It is believed that reading disabilities make up 80% of all learning disabilities.¹²

Problems with Past Research

The existing literature examining vision and its relation to reading is fraught with design problems. In 1986, Simons and Grisham¹³ published an article detailing some of the problems. Since then, others have discussed the matter as well, including Garzia¹⁴ in *Vision and Reading*, and most recently, McMonnies.¹⁴ When these problems are associated with a particular study, they significantly weaken the strength of the results, whether or not a relationship is found to exist.

The first and most common problem is that of definition.¹³⁻¹⁵ As mentioned above, it is only relatively recently that reading disorders have become well enough understood to be properly defined within a study. It is now known that there are multiple causes of reading dysfunction, both specific and non-specific.¹⁰ Although early studies grouped students by “below average reading skills,” more

recent studies may separate poor readers into groups such as non-specific and specific or separate dyslexic subjects into subgroups. With less heterogeneous groups of subjects, it is possible to study more precisely the effects of vision therapy on reading skill.

Another problem in the literature concerns the type of studies in existence.¹³⁻¹⁵ Most studies relating to visual function and reading ability are correlational-comparative studies. These studies serve a purpose in attempting to link visual anomalies and reading problems. However, they are fundamentally limited in that it is not possible to show that the former causes the latter. To show causation, a true experimental study is needed. Only by comparing the changes in reading skill between an experimental group that received vision therapy with a theoretically identical control group that does not receive therapy can causation be shown.

Problems with patient selection are common in the literature. Some studies rely on subjective teacher judgment, rather than relying on standardized testing to identify whether a child has a reading problem.¹³ The use of screening instruments to detect visual anomalies rather than vision specialists is more common in the early studies and tends to increase the probability of concluding a false negative between visual anomalies and reading problems.^{13,14}

Criteria for grouping by reading problem must also be examined closely. For example, IQ must be taken into account so as not to consider a subject with low IQ as a specific "reading problem" rather than generalized subnormal intelligence.^{13,15} If the criteria for visual anomalies are set too low,^{13,14} subjects with non-anomalous visual skills will be included in the "anomalous" group, increasing the chance of finding no relation between the "anomalous group" and "normal" group. Garzia and Franzel¹⁴ go on to say that "intra-subject" variability of the vision disorder is rarely included in studies. For example, at the beginning of a longitudinal study a young subject may qualify as emmetropic but may be myopic at the study's conclusion.

Other common problems that have been noted are inappropriate sample size, lack of appropriate statistical analysis, improperly selected comparison group, experimenter bias

or lack of appropriate masking, and improperly controlled placebo.¹³⁻¹⁵

Are Visual Anomalies and Reading Problems Related?

Several literature reviews support the relation between vision and reading. In 1986, Grisham and Simons¹⁶ published a literature review regarding the relationship between refractive error and reading skill. They included in the review only those studies with proper design and pointed to areas of weakness, as mentioned above. The authors concluded that distance acuity and myopia are not related to reading skill, but there is evidence linking hyperopia and anisometropia to reading performance. The following year, the same authors¹⁷ published a review of the relationship of binocular anomalies and reading problems. Although on the surface the evidence appears mixed, the authors felt that when examined closely, many of the studies were weakened by methodological problems cited above. They concluded that exophoria at near, reduced fusional reserves, aniseikonia, and anisometropia were strongly positively related to lower reading ability. They found that there was weak evidence relating esophoria at near, mixed evidence relating stereopsis and no evidence relating distance phoria to poor reading scores. In 1988, Simons and Gassler¹⁸ published a meta-analysis of 34 studies showing that hyperopia, exophoria at near, vertical phoria, anisometropia, and aniseikonia were related to below average reading skills.

In 2002, Bowan,¹⁹ in a response to a position paper of the Academy of Pediatrics/American Association of Ophthalmology and American Association for Pediatric Ophthalmology and Strabismus,⁶ cited numerous references establishing a positive relationship between learning and saccadic skill, convergence insufficiency, use of prism and spectacle lenses, suppression, binocular vision, visual motor skills, hyperopia, amblyopia, and visual processing. The author also cited a small number of references that did not support the relationship.

Despite the conclusions of the above literature reviews mentioned above, there are published studies that have found no relation between any visual function and reading skill. In a widely cited study, Helveston *et al.*²⁰ sepa-

rated 1,910 first, second, and third graders into groups of above average, below average or normal reading skill by subjective determination. They found no relation between reading and visual acuity, stereo, phoric posture, near points of convergence and accommodation, preferred eye, preferred hand, color vision, and refraction. This study has been criticized for the method used, the arbitrary criteria used to assess visual function, and statistical analysis.^{21,22} More recently, Kiely *et al.*²³ studied 284 children, who were grouped as normal readers, children with developmental dyslexia (2 or more years below expected age), and learning disabled. They found no relation between the groups for phoric posture, near point of convergence, accommodative facility, stereopsis, or motion coherence, although their study methods and statistical analysis have also been criticized.¹⁴

Evidence Supporting the Efficacy of Vision Therapy for Specific Visual Anomalies

In 1987 The Future Of Visual Development/Performance Task Force published a widely cited literature review of 238 references regarding benefits of vision therapy.²⁴ The report defines vision therapy as “a clinical approach for correcting and ameliorating the effects of eye movement disorders, non-strabismic binocular dysfunctions, focusing disorders, strabismus, amblyopia, nystagmus, and certain perceptual (information processing) disorders.” After elucidating the need for and role of vision therapy, citing clinical studies, the report concludes that “there is sufficient scientific support for the efficacy of vision therapy in modifying and improving oculomotor, accommodative, and binocular system disorders, as measured by standardized clinical and laboratory methods for patients of all ages for whom it is properly undertaken and employed.”

Further support for the efficacy of vision therapy is presented in “The Optometric Clinical Practice Guideline: Care of the Patient with Accommodative and Vergence Dysfunction” published by the American Optometric Association²⁵ in 1998. The Guideline cites clinical studies showing that with vision therapy: accommodation can be modified, voluntary accommodation can be taught, de-

creased accommodative amplitude and facility can be eliminated, asthenopia secondary to accommodative anomalies can be eliminated, apparent version error can be reduced, vergence ability can be improved, and vergence improvement persists over time.

REVIEW OF THE LITERATURE

Given the evidence that some vision anomalies may be related to reading skills and that these anomalies may be improved by vision therapy, it is plausible that vision therapy may improve reading skills. The early work regarding orthoptic training and reading ability was presented by Peters in a 1942 literature review.²⁵ Although much of the article contains anecdotes and quotations, Peters noted controlled studies by Taux and Pressey in 1928, Sisson in 1938, and Lee in 1939. All 3 studies indicated increased comprehension in students that had undergone fixation and rhythmic eye movement training. However, statistical significance is not reported in any of the works.

This literature review only considered studies after 1939 that met specific criteria. The studies may select or group subjects based on reading skill; however, this review did not consider studies of subjects with specific reading disabilities. The studies must use common orthoptic or oculomotor vision therapy. Studies of prisms, filters, or perceptual therapy alone were not considered. Measures of visual function within a study must be by accepted clinical tests. Case studies of 1 subject were not included.

Applying these criteria, 11 studies were reviewed (see Table 1). Overall, all but 1 showed a relation between vision therapy and reading performance. Of these, 5 studies showed statistical significance. Three studies showed equal improvement compared with conventional reading therapy. The results of many studies were weakened due to methodological problems such as too small sample size, lack of masking, and lack appropriate statistics.

In 1940, Worcester² published 2 studies that were also discussed by Peters.²⁶ In the first study, 99 college freshmen with low reading scores were divided equally into 3 groups. The first group received in-instrument orthoptic training followed by traditional reading exercises. The second group received reading

TABLE 1. Summary of Studies

Authors	Year	N	Population Studied	Treatment	Control Group	Result	Statistical Analysis
Worcester (a)	1940	99	RD college students	RT and/or VT	NT	Positive	Significant
Worcester (b)	1940	24	RD college students	VT	NT	Positive	None
Olson et al.	1953	65	College students with academic difficulty	VT and/or counseling	NT	Positive	Significant
Yvonne	1965	20	Grade school children	VT	RT	Positive	Not significant
Huelsman	1969	32	RD, VD 4 th graders	VT	RT	None	Not significant
Punnett, Steinhauer	1984	4	LD children	VT	NT	Positive	None
Atzmon	1985	109	LD /RD children		None	Positive	None
Rounds <i>et al.</i>	1991	10	Optometry students with subnormal reading skills	VT	NT	Positive	Significant
Atzmon <i>et al.</i>	1993	31	RD children	VT	RT	Positive	Significant
Sigler, Wylie	1994	3	VD children	VT	None	Positive	None
Solan <i>et al.</i>	2001	31	RD children	VT	None	Positive	Significant

LD = learning disabled; RD = reading disabled; VD = visual dysfunction; RT = conventional reading training; VT = visual therapy; and NT = no treatment.

training followed by orthoptic training, and the third group received only reading training. The results were compared with a group of 63 students who received no orthoptic or reading training. Despite some inconsistencies in testing, it was concluded that all groups improved with statistical significance in reading speed and comprehension in relation to the control and that the orthoptic training alone showed marked improvement in fixations and regressions. The second study examined the effectiveness of 3 different orthoptic instruments (the Stereoscope, the Binocular Synchronizer, and the Squint Korrektor) to improve visual and reading skills. Twenty-four college students were randomly divided into 3 equal groups and assigned a schedule for training with the 3 instruments. The results were compared with a control group of 13 college students who received no training. It was found that there was wide variability in the effect of the 3 instruments on reading skill, but all 3 did show more improvement than the control group. It was noted that the results were limited by sample size, and statistical analysis was not performed.

In 1953, Olson *et al.*,²⁷ in a study controlling for the variability of subject motivation, found that both vision therapy and vocational counseling caused an increase in reading skills. Sixty-five college sophomores, all experiencing academic difficulty, were broken equally into 4 groups, 1 receiving orthoptic

training, 1 receiving orthoptic training and vocational counseling, the third receiving counseling only, and the last serving as the control. For all subjects, mental ability, reading, and personality were assessed by standardized pre- and post-tests. Both orthoptic training groups showed a statistically significant increase in reading rate. The counseling control showed statistically insignificant increase in reading speed. Sadly, in a study designed to control for motivation, many of the subjects and a large portion of the control group were lost to follow-up.

In the 1960s, 2 studies were produced by the US Department of Health, Education, and Welfare that both showed a weak relation between orthoptic training and reading improvement. Yvonne²⁸ selected 20 patients of approximately 12 years of age and separated them in 2 groups matched by age, sex, race, and oculomotor skills. Over the course of 15 weeks, all subjects received reading therapy, whereas the 10 subjects in the experimental group received 20 minutes a week of instrument visual training. She found a positive but not statistically significant improvement in reading skills. She concluded that with a larger sample size, the results would likely show a significant relation. Huelsman²⁹ selected from 10,071 students 32 fourth graders having a reading age 1 or more years below their mental age. Half of the subjects received optometric vision training, whereas all sub-

jects received remedial tutoring. The tutors were not aware which subjects were receiving the vision therapy. It was found that although both groups showed equal improvement in reading skills, they also showed an equal increase in reading disability as defined as reading age behind mental age. Despite the elaborate and careful study design, its strength is seriously reduced by the small sample size and the attrition of the subjects.

In an interesting 1984 study, Punnet and Steinhauer, both psychologists,³⁰ investigated the effect of verbal feedback on vision therapy used to improve reading eye movements and comprehension. Two students received vision therapy with verbal reinforcement, 2 without reinforcement, and 2 served as a control. They found that the verbal reinforcement group showed a positive but not significant improvement over the non-reinforcement group and suggested that the results would have been stronger with more accurate measurement of eye movements and reinforcement contingent upon correct responses. Furthermore, it was found that although the 4 subjects with vision therapy improved in comprehension and reading level, they declined in accuracy. The control group declined in all 3 areas. With such a small sample size, lack of statistical analysis and possible experimenter bias, it is difficult to put much weight in the results. However, this is the only study that attempted to address the social implication of vision training, and their results underscore the need for a control group.

In 1985, Atzmon³¹ an orthoptist, investigated how improvement of fusional vergence ranges through binocular training relates to reading skills of 109 students with reading problems. She showed that 85% subjectively reported improvement in school performance, but the results were criticized due to lack of control group and statistics.³² Atzmon³³ responded to the critics in 1993 with a well-designed study of the same subject; 120 children in regular education, but of below average reading level, were tested for visual and reading skill by standard techniques and then matched and randomly divided into 3 equal groups. One group received orthoptic training, 1 received conventional reading therapy, and 1 received no therapy. The reading teachers, orthoptists, and first author were all masked

to limit bias. Unfortunately, the control group was lost because it was discovered that many subjects were receiving uncontrolled academic and/or visual training to improve reading scores. It was found that both groups improved equally and significantly in technical reading and comprehension. It was noted that members of the orthoptic group reported less asthenopia, whereas members of the conventional training group reported equal or greater discomfort after the reading therapy. Although this is likely the best-designed study in this review, the results would have been stronger if the control group had been retained as planned. This finding underscores the difficulty in conducting studies of this nature.

In 1991, Rounds *et al.*³⁴ selected a group of 19 optometry school freshmen who failed a standardized reading test. These subjects were matched for reading performance and randomly separated into an experimental group of 10 and control group of 9. The experimental group received 4 weeks of office and home oculomotor vision training, whereas the control group received no training. Pre- and post-experiment Visagraph scores showed statistically significant improvement of the experimental group in comprehension, relative efficiency, regressions, fixations per words, speed, and span of recognition. The experimental group improved significantly more than the control group in relative efficiency, number of regressions, and span of recognition. It seems little was done to provide placebo for the control group or blind the investigators to minimize bias.

In a very small 1994 pilot study, Sigler and Wylie³⁵ assessed the effect of vision therapy on reading rate for 3 grade school subjects. They found that after vergence, accommodative, and suppression therapy, the reading rate, as measured by the words per minute read from a randomized list of age appropriate words, of all 3 subjects increased. Two of the 3 students continued to improve in reading rate 90 days after the study, during which no reading or vision therapy occurred. Some of the limitations in interpreting the pilot study are the extremely small sample size, use of a non-standardized reading assessment, lack of control group, no statistics reported beyond net percentage increase in reading rate, and no effort reported to prevent bias.

The most recent study, by Solan *et al.*³⁶ in 2001 consisted of crossover study to determine whether the sequencing of both eye movement therapy and comprehension therapy affected improvement in reading skills. Thirty-one sixth grade students were divided into 2 groups matched by reading scores. One group began with eye movement training and the other with comprehension training for 24 weeks, switching training methods at the 12-week mark. It was found that both groups improved significantly in reading comprehension, fixations, regressions, and reading rate, and there was no significant difference between the 2 groups. Solan *et al.* acknowledged that they considered the need for a control group, but they did not include one, in part because of ethical issues of withholding therapy.

DISCUSSION

The use of orthoptic training to improve reading skills has been studied sporadically in the last century. Because of the inconsistent methodology discussed above and weak statistical significance of some of these studies, it is understandable that there continues to be debate. Taking this body of work as a whole, it does seem reasonable that vision therapy can be helpful for certain individuals who struggle with reading. However to strengthen this statement, future work should be done with larger sample sizes, control groups with appropriate placebos, and masking to minimize bias.

Nearly all of the studies reviewed set the criteria for inclusion of subjects as reading below grade level. It has only been relatively recently that it has been possible to diagnose specific reading disability. Therefore, it is assumed that some percentage of the studied population suffered from specific reading disability (dyslexia). Given that dyslexia appears to be neurologic in origin, pure orthoptic and oculomotor therapy will rarely, if ever, eliminate the perceptual problem. The inclusion of dyslexics in many of these studies would tend to increase the likelihood of finding no relationship between vision therapy and increased reading skills, adding weight to fact that most of these studies did find a positive relationship. However, this should not be taken to mean that dyslexics would receive no benefit

from orthoptic or oculomotor vision therapy. Indeed, vision therapy may help them greatly by reducing or eliminating asthenopia so that they may focus their energy on their perceptual challenges.

Several of the studies^{31,35,36} fail to include any control group. With these studies it is possible to show significant improvement, but it is impossible to show that improvement was the result solely of vision therapy and not by maturation of the subjects or that the patients benefited from attention. Many think that it is not ethical to deprive a child with reading problems of proper instruction, so studies are conducted conventional reading training as a placebo.^{8,29} In some of these studies^{29,33,36} it has been found that both vision therapy and conventional therapy improve reading skills equally. There is some evidence^{2,28} that when vision therapy and reading therapy are used in conjunction, reading skills improve the most.

The issue³⁷ has been raised that for a technique to be considered a treatment of choice, it is not enough to show that vision therapy improves reading skill; it must be shown that it is superior to all other therapies. The clinical validity of this statement is debatable, but it can be said that from the literature presented here, this stricter mandate has not been reached. However, for patients who have reading problems, the issue is not which method stands alone as the treatment of choice. Caring doctors ensure that these patients receive a variety of therapies. Vision therapy would always be used in conjunction with conventional reading therapy, and there is evidence that this is the most effective in improving reading scores.

CONCLUSION

This review reached the following conclusions:

- Evidence shows that orthoptic or oculomotor vision therapy improves reading skills.
- When vision therapy is used in conjunction with convention reading therapy, the gains are the greatest.
- More and larger studies should be done to strengthen these conclusions.

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