Vision Therapy

Policy

*Please see amendment for Pennsylvania Medicaid at the end of this CPB.*

Note: Some Aetna plans specifically exclude benefits for vision therapy (orthoptic training). Please check benefit plan descriptions. Under these plans, charges for orthoptic and/or pleoptic training (eye exercises) and training aids or vision therapy for any diagnosis should be denied based on this contractual exclusion.

Under plans with no such exclusion, Aetna considers up to 12 vision therapy visits or sessions medically necessary for treatment of convergence insufficiency. Aetna considers vision therapy experimental and investigational for all other indications (e.g., concussion, intermittent exotropia, and traumatic brain injury).

Requests for vision therapy exceeding 12 visits for this indication is subject to medical review. Members should be transitioned to a home program of exercises for convergence insufficiency (e.g., pencil push-ups).

Note: This policy addresses active vision therapy. This policy does not address use of passive orthoptic or pleoptic devices, such as occlusion which is considered medically necessary for amblyopia, and prism adaptation that is considered medically necessary prior to surgery for strabismus.

Note: Orthoptic or pleoptic devices are considered durable medical equipment.
Aetna considers vision restoration therapy, alone or in combination with transcranial direct current stimulation, for the treatment of visual field deficits following stroke or neurotrauma experimental and investigational because its clinical value has not been established.

Aetna considers the use of visual information processing evaluations experimental and investigational because its clinical value has not been established.

Note: In addition, most Aetna benefit plans exclude coverage of services, treatment, education testing or training related to learning disabilities, or developmental delays. Please check benefit plan descriptions.

See also CPB 0078 - Learning Disabilities, Dyslexia, and Vision (../1_99/0078.html), CPB 0250 - Occupational Therapy (../200_299/0250.html), CPB 0469 - Transcranial Magnetic Stimulation and Cranial Electrical Stimulation and (0469.html)

**Background**

Vision therapy encompasses a wide variety of non-surgical methods to correct or improve specific visual dysfunctions. It may include eye exercises, as well as the use of eye patches, penlights, mirrors, lenses, prisms, and patches. Other modalities in use by vision therapy proponents include sensory, motor, and perceptual activities.

Orthoptics and pleoptics are common forms of vision therapy. Orthoptics are exercises designed to improve the function of the eye muscles. Proponents consider these exercises particularly useful in the treatment of strabismus and other abnormalities of binocular vision. Pleoptics are exercises designed to improve impaired vision when there is no evidence of organic eye diseases.

There is a broad range of vision therapy techniques and methods among practitioners who perform vision therapy making the practice of vision therapy difficult to standardize and evaluate. The National Eye Institute (NEI) of the National Institutes of Health (NIH) acknowledges the need for clinical trials of non-invasive
treatments (such as orthoptics and vision training) to determine the presence of improvement in eye alignment and visual function in patients with early vision abnormalities such as amblyopia and impaired stereoscopic vision. The American Academy of Ophthalmology (AAO) accepts eye exercises and other non-surgical treatments, usually provided by an orthoptist (a professional eye specialist who works under the supervision of an ophthalmologist), as beneficial for individuals who have eye muscle problems. However, the AAO believes that these treatments should not be confused with vision therapy. The American Academy of Pediatrics (AAP), American Association for Pediatric Ophthalmology (AAPOS), and the AAO issued a joint statement in July 1992 stating that there is no scientific evidence to support the claim "that the academic abilities of dyslexic or learning-disabled children can be improved with treatment based on (a) visual training, including muscle exercises, ocular pursuit, tracking exercises, or 'training' glasses (with or without bifocals or prisms); (b) neurological organizational training (laterality training, crawling, balance board, perceptual training): or (c) tinted or colored lenses. It is the opinion of these organizations that any claims of improved reading and learning with the use of these methods usually are based on poorly controlled studies. Thus, there are no eye or visual causes for dyslexia and learning disabilities, and there is no effective treatment."

The AAO and American Optometric Association (AOA) (1997) issued a joint policy statement on vision, learning, and dyslexia, maintaining that vision therapy does not treat learning disabilities or dyslexia directly, but is a treatment to improve visual efficiency and visual processing to allow an individual to be more responsive to educational instruction. However, there is little data available on the efficacy of vision therapy for treating learning disabilities or dyslexia.

Vision therapy (orthoptics) has been defined by the AOA as the "art and science of developing, enhancing and remediating visual abilities to achieve optimum visual performance, efficiency and comfort" (AOA, 1985). It involves the use of lenses, prisms, and specialized testing and vision training procedures. Vision training, or "eye exercises," are used, not to strengthen the eye muscles, but rather to improve coordination, efficiency, and functioning of the vision system.

Vision therapy is a term used to refer to a variety of non-surgical approaches to the treatment of a variety of visual dysfunctions. This policy addresses the effectiveness of active vision therapy or "vision training", a term used to refer to a variety of eye movement and eye focusing exercises that have been used to remediate vision

http://www.aetna.com/cpb/medical/data/400_499/0489.html
problems. This policy does not address the medical necessity of so called “passive” vision therapy, i.e., treatment of visual problems with eye patches, miotics, prisms, red filters, or lenses.

Active vision therapy has primarily been used in the treatment of strabismus, as well as other disorders of binocular function and ocular motility. A wide variety of equipment and techniques are used, including penlights and mirrors, biofeedback, video games, tracing pictures, puzzle completion, etc. In some instances, electronic or computerized optical instruments are used to enhance the treatment. These activities are directed at stimulating proper function of the visual system or building compensating systems to alleviate insufficiencies.

Vision therapy has been prescribed to alleviate a wide variety of visual symptoms, including diplopia (double vision), blurring, and “asthenopia.” Asthenopia is a term used for discomforts attributable to visual dysfunctions, including headaches, visual fatigue, and excessive rubbing of the eyes. Active vision therapy has also been advocated as a treatment for learning disabilities and for improvement of sports performance in normal individuals.

Professional opinion is divided on the effectiveness of vision therapy. The stated positions of the AOA and the College of Optometry in Vision Development are not consistent with those of the AAO, the AAP, and other medical professional organizations.

The term vision therapy is, for practical purposes, synonymous with the term orthoptics, and the terms will be used interchangeably. Both vision therapy and orthoptics refer to eye movement and eye focusing exercises. Vision therapy is performed by optometrists, whereas orthoptics is typically conducted by certified orthoptists who practice under the supervision of ophthalmologists. A primary difference between optometric vision therapy and ophthalmologic orthoptics is that optometrists conduct vision therapy mostly in the office, whereas orthoptists usually prescribe exercises to be performed at home.

Several general conclusions about vision therapy can be drawn from a review of the literature.
- The effectiveness of vision therapy has been extremely difficult to assess, due to the small number and generally low quality of the clinical studies of the effectiveness of vision therapy.

- Assessment of the effectiveness of vision therapy is made difficult by the lack of standard treatment methods or protocols. Often, studies do not adequately specify the patient selection criteria or the methods and duration of treatments that were used.

- Most of the literature on the effectiveness of vision therapy is based on the expert opinions of optometrists and ophthalmologists and on unsystematic retrospective reviews of cases seen in a particular practice. Few studies of the effectiveness of vision therapy have employed comparison groups, and with the exception of vision therapy for convergence insufficiency, virtually no adequate randomized controlled clinical trials of vision therapy have been published. There is also little evidence on the long-term effectiveness and durability of these treatments.

- Almost all published studies have small sample sizes, and most studies lack statistical analysis of the data.

- Many of the studies cited to support the effectiveness of vision therapy are antique. Studies that were published prior to the development and adoption of modern methods of clinical investigation fail to provide basic information on the criteria used to select subjects for study, adequate descriptions of the treatments that were performed, or descriptions of the criteria used to determine the success or failure of treatments.

- Reviews of the literature by proponents of vision therapy have been particularly uncritical of the evidence. These reviews frequently fail to describe important weaknesses in the studies used to support the efficacy of vision therapy, such as selection biases and poorly reported results. Because of the poor methodology and reporting of these older studies, conclusions about effectiveness usually could not be drawn from them.

- Many reviews of vision therapy cite abstracts, unpublished manuscripts, and doctoral dissertations. These documents have not been peer reviewed, are usually not widely available, and frequently do not meet rigorous research standards and the findings are often ambiguous and equivocal.

- Authors of studies of vision therapy have failed to recognize and point out important weaknesses in their study design and important limitations on the conclusions that could be drawn from their studies. Frequently these studies fail to report on patient selection criteria, previous treatment, range, intensity, and duration of activities. Little attempt is made to control for
confounding variables such as previous types of treatment. In most studies, the research design does not include a control group.

Most controlled studies of the effectiveness of vision therapy have not used random assignment, and the comparison groups that are used in nonrandomized studies have not been carefully matched for factors affecting the outcome of therapy. These studies also typically lack masking of therapists and observers, independent statistical design and analysis, and independent evaluation of effects. Some fail to provide statistical analysis of the data, and many fail to control for confounding variables. Controls in several of the studies did not receive any sham or placebo treatments. The studies also reported their findings in terms of averages, and fail to provide subgroup or cluster analysis to allow one to identify the characteristics of patients that most likely to respond to vision therapy. Furthermore, many of the studies reported large drop-out rates, and these studies failed to employ intention-to-treat analysis of results.

The lack of standardization of vision therapy techniques and methods, as well as differences in the frequency and length of vision therapy make it difficult to make generalizations about the effectiveness of vision therapy from the results of any single study (Beauchamp, 1986).

Many vision therapy regimens have incorporated non-optometric interventions, such as general body movements, exercise, diet, and importantly, standard remedial educational techniques. Studies reporting the results of such vision therapy regimens are difficult to interpret because the effectiveness of these regimens may be due to the non-optometric interventions, such as standard remedial educational techniques, that are employed, rather than due to the vision therapy itself. Moreover, these other elements may be better provided by professionals who are not optometrists, such as remedial educational specialists. Beauchamp notes that “[o]ne may legitimately question the ability of an optometrist to function in such complex substantive areas” outside of optometry (Beauchamp, 1986).

Vision Therapy for Accommodative Disorders

The term “accommodation” refers to the adjustment of the eye for seeing at different distances, and is accomplished by changing the shape of the lens through action of the ciliary muscle, thus focusing a clear image on the retina. Deficiencies of accommodation include accommodative excess, accommodative infacility, accommodative insufficiency, ill-sustained accommodation (Suchoff, 1986) and
accommodative paresis (Scheinman and Wick, 1994). Accommodative paresis, spasm, and ill-sustained accommodation are relatively rare, and accommodative insufficiency and infacility are the two most common types of accommodative deficiencies.

Accommodative excess (also known as accommodative spasm) is a grater accommodative response than is considered to be normal of a given stimulus (Suchoff, 1986). Accommodative infacility (also called accommodative inertia) is defined as sluggishness in changing from one level of accommodation to another (Suchoff, 1986).

Accommodative insufficiency is a condition where the patient’s amplitude of accommodation is below that expected for his or her age (Suchoff, 1986). The clinical diagnosis may be made by direct measurement of the amplitude, such as with the “push up” method, where small print is brought closer to the eye until the print appears blurred. The clinical diagnosis may be made indirectly using certain forms of dynamic retinoscopy.

Ill-sustained accommodation is a form of accommodative insufficiency where the amplitude of accommodation is normal under usual testing conditions, but becomes reduced or “insufficient” over time (Suchoff, 1986). Clinical diagnosis is made by symptoms along with certain dynamic retinoscopy techniques that sample the accommodative response over time as the patient maintains fixation and accommodation on a target.

Accommodative paresis (also called accommodative palsy) is the absence of an ability to produce an accommodative response (Scheiman and Wick, 1994). The disorder is usually the consequence of disease or trauma.

Symptoms common to all types of accommodative dysfunctions are reduced nearpoint acuity, a general inability to sustain nearpoint visual acuity, asthenopia, excessive rubbing of the eyes, headaches, periodic blurring of distance vision after prolonged near visual activities, periodic double near vision, and excessive fatigue at the end of a day (Suchoff, 1986).

The optometric literature suggests a variety of tests for detecting the presence of accommodative dysfunctions. Standardized test methods, normal values, and controlled studies of many of these tests are lacking. The sensitivity, specificity, and
positive and negative predictive values for tests of accommodation remain undefined. Beauchamp (1994) notes that “[a]commodative deficiencies/infacility’, convergence abnormalities, and tracking or smooth pursuit deficiencies have not been defined or demonstrated beyond vague allusion. Indeed carefully controlled studies do not demonstrate these purported deficiencies.”

These tests may not adequately distinguish between abnormal and normal children. For example, a New York State Vision Screening Battery that tests visual efficiency and perceptual function identified as “abnormal” 53% of an unselected group of 1,634 school children (Visual Development Task Force, 1988). The literature on vision therapy for learning disabilities has been undermined by a “poor appreciation of what constitutes normal variation” (Levine, 1984).

Press (1993) described the tests used to evaluate accommodative function in a school-aged child. These include tests of the amplitude of accommodation, which is determined clinically by either push-up or minus lens to blur method. The lag of accommodation, an index of nearpoint accuracy, is principally determined by the monocular estimate method (MEM) of nearpoint retinoscopy. While the child reads words binocularly on a target clipped onto a retinoscope, the examiner interposes lenses briefly in front of one eye to confirm the estimate of motion. Other methods of testing lag are Book retinoscopy, which is essentially the same as MEM except that the examiner is noting the response as the child continues to read a story; and Bell retinoscopy, in which the examiner watches the change in reflex as a slivered bell is brought close to the child and is then receded. Tests of facility and stamina are done with +/-2.00 diopter lens flippers and 20/30 numbers. The diagnosis of accommodative infacility depends on the number of cycles of lens flips that can be cleared within a given amount of time.

Scheiman and Wick (1994) described the general treatment strategies for patients with accommodative dysfunction. First, the optometrist must correct any refractive error, including hyperopia (far-sightedness), myopia (near-sightedness), anisometropia (marked difference between refractive power of each eye), and astigmatism. Although any refractive errors that are found should be corrected to improve visual acuity, there is little evidence that refractive errors are the cause of problems of visual efficiency. Studies in age-matched populations have failed to show significant differences in the prevalence of refractive errors between children with reading problems and those without such problems (Coleman, 1972; Helveston, 1985; Hoffman, 1980).
Second, added lenses are used to correct accommodative dysfunction (Scheiman and Wick, 1994). Accommodative insufficiency and ill-sustained accommodation are thought to respond to added plus lenses, because these are thought to stimulate accommodation. Patients with accommodative infacility and accommodative excess are less likely to benefit from added lenses.

Third, vision therapy is used to restore normal accommodative dysfunction. According to Scheiman and Wick (1994), vision therapy is generally necessary in the management of accommodative excess and accommodative infacility, and is also important in many cases of accommodative insufficiency and ill-sustained accommodation.

Press (1993) outlined the components of vision therapy for accommodative dysfunction. He noted that the primary technique for remediating accommodative disorders is “accommodative rock”. This may be accomplished by alternating lens powers, or by alternating fixation distance. Accommodative rock with lenses is typically done with loose, round plastic lens blanks (best used in the monocular phase) or with lenses inserted into flippers (best used in the binocular phase). Rocking with lenses is thought to bolster the child’s ability to sustain focus when reading for extended periods of time.

Accommodative rock through changing the fixation distance is done with large and small Hart charts, consisting of ten rows, each with ten letters (Press, 1993). The letters of the large Hart chart have a visual subtense of 20/20 at a distance of 20 feet. The small Hart chart is a small version of the large Hart chart. Children using these charts practice keeping their places when switching from far to near. Rocking in this manner is thought to bolster the child’s ability to sustain accurate focus when alternatively stimulating and inhibiting accommodation, as occurs when a child copies from a blackboard.

The general progression in therapy is to begin with monocular activities and then proceed to biocular and then binocular activities (Press, 1993). Monocular activities are done with a patch. Biocular activities are done with a loose plus or minus lens held in front of one eye, and a loose prism lens in front of the other eye to dissociate the Hart chart. Binocular activities are usually done using lenses inserted into flippers.
Symptoms of accommodative insufficiency include blur, headaches, eyestrain, double vision, reading problems, fatigue, difficulty changing focus from one distance to another, and sensitivity to light (Scheiman and Wick, 1994). Patients may also complain of an inability to concentrate, a loss of comprehension over time, and words moving on the page. All of these symptoms are associated with reading or other close work. Some patients with accommodative insufficiency are asymptomatic. In such cases, the most likely explanation is avoidance of reading or other close work. In such a case, avoidance should be regarded as a symptom, and according to Scheiman and Wick, is as important a reason for recommending therapy as any of the other symptoms associated with accommodative insufficiency.

The most characteristic sign of accommodative insufficiency is an accommodative amplitude below the limit of the expected value for the patient's age. To determine the lower limit for a patient, Scheiman and Wick (1994) suggested using Hofstetter's formula, which states that the lower limit is equal to 15 - 0.25 (age of patient). If the amplitude is 2 diopters or more below this value, it is considered abnormal.

Duane, in 1922, was the first to describe vision therapy as a method of curing "subnormal accommodation" or accommodative insufficiency, as it is now called. In 1942, Hofstetter recommended that "exercises" should be used to enhance function where there was evidence of poor control of accommodation. Neither of these papers, however, provided information on the methods or efficacy of treatment. As Suchoff and Petito (1994) noted, until relatively recently, many clinicians trained various accommodative functions in spite of lack of other than anecdotal evidence or simple case reports that accommodative function could be improved.

Three lines of evidence have been used to support the claim that vision therapy is effective in improving deficiencies of accommodation: (i) evidence that normal subjects can be trained to control their accommodation; (ii) evidence that vision therapy is able to improve signs and symptoms related to deficiencies of accommodation; and (iii) evidence that vision therapy is able to improve performance. Each of these lines of evidence will be analyzed in turn.

Several studies have been cited as evidence that subjects can be taught to control accommodation voluntarily (Marg, 1951; Cornsweet and Crane, 1973; Randle and Murphy, 1974; Provine and Enoch, 1975). Each of these studies involved a small number of normal subjects. Because these studies involved normal individuals, they do not demonstrate that persons with accommodative dysfunction can improve their
accommodative abilities with training. Furthermore, the results of these studies may not even apply to most normal individuals because the subjects for the studies were chosen from groups that would be expected to have maximal accommodative abilities. In one study, subjects were selected based on their "professed ability to change voluntarily their accommodation" (Marg, 1951). The other studies (Cornsweet and Crane 1973, Rundle and Murphy 1974, and Provine and Enoch 1975) involved young, college-age subjects, whose accommodative abilities would be expected to be normal.

In 1951, Marg noted the existence of voluntary stimulation and inhibition of accommodation. Seven subjects were instructed to look closer and then further than an object placed between 0.20 diopter and 5.00 diopter lenses. Six of the 7 subjects were able to exhibit varying degrees of voluntary accommodation. A number of study subjects reported symptoms when they attempted to stimulate accommodation. Marg (1951) interpreted these findings to support the theory that symptoms arose from the need to exert effort to reinforce the accommodation reflex. He posited that training of voluntary control of accommodation may relieve symptoms in patients with defective reflex accommodation.

Cornsweet and Crane (1973) used audio and visual biofeedback to train individuals to control accommodation voluntarily. In the first experiment, 2 subjects were fitted with headphones. A tone, whose pitch was set by the investigators, was delivered to one ear, while a second tone, whose pitch was controlled by the subjects accommodative response (measured by an infrared optometer), was delivered to the other ear. The subjects were asked to match the pitch of the tone between the 2 ears. After about 3 hours of practice, both subjects could perform the task. Using the 2 subjects who participated in the first experiment, Cornsweet and Crane (1973) performed a second experiment to determine whether they could voluntarily control accommodation in a different situation. The subjects viewed 2 horizontal lines on an oscilloscope screen. The position of one of the horizontal lines was set by the experimenter, and the position of the other horizontal line was controlled by the subject's accommodative response, as measured by an optometer. The subjects were asked to position one line over the other. Both subjects were able to perform this task after only a few seconds demonstrating that learned control of accommodation could be transferred easily to new stimulus conditions.
Subsequently, Randle and Murphy (1974) conducted an experiment to determine which components of voluntary control of accommodation can be improved using visual biofeedback. Four college students were asked to practice tracking sine or square wave stimuli of varying lengths. The students' were tested every 3 waking hours over 7 days. Although the latency (reaction time) of the accommodative response remained constant over the 7 days, some students were able to increase the velocity (speed) of their accommodative response with practice. The students were able to improve the gain (magnitude) and phase lag (reduced difference between stimulus and response waves) of their responses. Thus, Randle and Murphy showed that the velocity, gain, and phase lag of the accommodative response can be improved with practice.

Provine and Enoch (1975) also conducted an experiment to show that individual's can learn to control their accommodative responses. Subjects were fitted with -9.00 diopter contact lens in one eye while they viewed a distant target, and were instructed to concentrate on the target until they could see it clearly. After practice, all subjects were able to focus on the target through the lens. They found that once voluntary accommodation was learned, it could be elicited on command, even in total darkness.

A second line of studies have attempted to determine whether patients with deficiencies of accommodation improve after vision therapy (Liu et al, 1979; Bobier and Sivak, 1983; Daum 1983a; Daum, 1983b; Duckman, 1984; Hung et al, 1986; Cooper et al, 1987; Russell and Wick, 1993; Al-Qurainy, 1995). Most of these studies involved small numbers of patients, and none included a control group. Because these studies were uncontrolled, there is no way of knowing whether the results could be accounted for by various sources of bias, such as regression, the natural history of disease, placebo effects, investigator bias, or the patient’s desire to report improvements to please the therapist.

Liu and colleagues (1979) monitored the accommodative response of 3 patients undergoing vision therapy for accommodative insufficiency and infacility. The accommodative responses were measured by means of a dynamic infrared optometer, an instrument that measures the various dynamic components of accommodation electronically. Each patient was prescribed standard optometric vision therapy for 20 to 30 mins daily. The patients’ accommodative responses were measured before treatment and weekly thereafter. After 4 to 7 weeks of training, all 3 patients reported significant improvement in the accommodative amplitude and
facility, and a reduction or elimination of symptoms. Patients were found to have an increase in the velocity of the accommodative response to changing stimuli, as measured by the dynamic optometer. One patient was found to have a decrease in response latency as well.

Bobier and Sivak (1983) conducted a similar experiment, using a different objective means of measurement of the accommodative response. Five patients with accommodative infacility were included in the study. Four patients were prescribed standard vision therapy for 20 mins a day at home, and the fifth patient was an untreated comparison. Dynamic photo-refraction was used to measure objective improvements before the training period and weekly thereafter. Clinical findings were monitored weekly as well. Training was stopped after the subjects achieved a pre-determined minimum performance criterion. Three of the 4 treated patients were found to have statistically significant improvements, whereas the untreated patient was found to have no improvement.

Duam (1983) reviewed medical records of 114 patients referred to a university binocular vision clinic and subsequently diagnosed with accommodative deficiency. Ninety-six percent of these patients were diagnosed as having either accommodative insufficiency or accommodative infacility. Most patients were diagnosed with other visual problems as well. Patients were given standard in-office vision therapy once every 1 or 2 weeks, and prescribed vision therapy exercises to perform at home 3 times per week. The average duration of treatment for treating only the accommodative symptoms was 3.7 weeks; the total duration of treatment for all of the patients’ visual problems was not provided. Ninety-four of the patients completed treatment. Of those patients completing treatment, 53 % were considered totally successful (defined as elimination of symptoms and signs of accommodative deficiency), 43 % were partially successful (where there was at least some reduction in either signs or symptoms), and 4 % were considered unsuccessful (no relief of signs or symptoms).

To determine whether the results obtained were durable, the investigator examined mean accommodative amplitude data on 24 patients followed-up for various durations after completing vision therapy (Daum, 1983). The mean accommodative amplitude had fallen 2 diopters on average (from a mean of 12 diopters to a mean of 10 diopters), but the mean amplitude of these patients was higher than that for patients before vision therapy (8 diopters).
Duckman (1984) reported on the results of vision therapy on 60 children with cerebral palsy, all of whom were unable to clear (focus through) a +2 diopter lens and 31 of whom were unable to clear a -2 diopter lens. (An inability to clear +/- 2 diopter lenses is a sign of accommodative insufficiency). Patients received 1 year of standard vision therapy conducted 3 to 4 days per week for 10 to 30 mins. Of the 60 children, only 36 completed therapy. The study did not report whether drop-outs were due to lack of improvement. Of the children who completed therapy, 20 could clear both the +2 diopter and -2 diopter lenses. Thirty-four of the 36 children were reported to show a significant increase in accommodative amplitude. The author concluded that the results suggested that accommodative amplitude and facility could be improved in children with cerebral palsy by standard vision therapy techniques, although he admitted that this study had important deficiencies.

A third line of studies have sought to prove that the improvements in accommodation brought about by vision therapy translate into improvements in performance on various tasks. Weisz (1979) examined the results of vision therapy on nearpoint performance in children with deficiencies in accommodation. A total of 28 children who were diagnosed with some type of accommodative dysfunction were divided into 2 groups that were matched for age and school grade. One group received accommodative vision therapy and the other received perceptual-motor training without accommodative therapy. Both groups were given two 30-min sessions per week, and were treated for an equal length of time. A pen and paper task requiring fine nearpoint discrimination was given to all patients before and after training to assess transfer effects of accommodative therapy on this task. The group provided with accommodative therapy reached normal levels of accommodation within an average of 4.5 sessions, and showed a significant decrease in the number errors on the pen and paper task after therapy compared to the group that received perceptual-motor training.

Although this study has been cited to support the conclusion that accommodative training improves accuracy on tasks involving nearpoint performance, there are a number of problems that make the study by Weisz difficult to interpret. First, subjects were selected for the study if they met any 2 or more of 9 criteria for the diagnosis of accommodative deficiencies. We do not know, therefore, whether the results could be biased due to differences in the type or magnitude of accommodative deficiencies between the 2 groups. Second, the children were not randomly assigned to the 2 groups, raising the question about whether the systematic assignment of children to the 2 groups affected the outcome. Third, the
outcome measures were not adequately described; for example, one outcome measured was the reduction in time for completion of the test “adjusted for” the number of errors on the test; the paper, however, does not define how that adjustment was made. Fourth, there is no demonstration that the pen and paper test used to measure progress has a valid relationship between practical reading and writing tasks.

Hung and colleagues (1986) measured several parameters before vision therapy in 21 symptomatic college students diagnosed with accommodative and/or vergence disorders, and compared them to those measured in 22 visually normal asymptomatic college students. The 22 normal asymptomatic college students were tested merely to establish the range of normal measurements for the tests of accommodative and vergence disorders used in the study. Symptomatic patients were divided into 3 vision therapy groups: (i) accommodation only training, (ii) vergence-only training, or (iii) accommodation and vergence training -- depending on their symptoms and what type of clinical test abnormality they had.

The symptomatic patients were then given vision therapy and then retested after its completion. Three of the symptomatic patients dropped out before vision therapy was started, and 1 did not complete the vision therapy program, leaving 17 symptomatic patients for analysis. Symptomatic patients with disorders of accommodation or vergence were given weekly 30-min in-office vision therapy sessions, supplemented with daily 15-min at-home exercises, for 8 to 16 weeks. Symptomatic patients who had both accommodation and vergence disorders were given twice as much weekly vision therapy and daily at-home therapy. Following vision therapy, a statistically significant proportion of symptomatic subjects shifted toward the mean for asymptomatic subjects for tonic accommodation (a measure of bias of the accommodation system) and slope of the fixation disparity curve (related to the vergence “gain” or amplitude). For a large but statistically insignificant number of symptomatic patients, the slope of the accommodative response/stimulus curve (related to accommodation gain), the CA/C ratio (related to gains in accommodation/vergence interaction) changed toward the mean for normal asymptomatic subjects. All symptomatic patients had had higher monocular accommodative flipper rates (a measure of accommodative facility) following vision therapy. Significant reductions in symptoms were reported in 9 patients. To determine whether the changes in these parameters persisted, 3 symptomatic patients were retested 6 to 9 months following vision therapy (Hung, 1986). For
each of the 3 subjects, all but 1 of the measured parameters remained close to the value obtained immediately after completing vision therapy. The parameter that changed after long-term follow-up was different for each of the 3 subjects.

However, the study by Hung and colleagues had serious limitations. The study lacked an appropriate control group (the asymptomatic college students were used merely to establish norms for the parameters examined in the study, and the symptomatic college students were not assigned to treatment and comparison groups), and only 3 patients were followed to determine whether the changes in accommodative ability after vision therapy were long-lasting. Also, the measures of accommodative ability that changed after vision therapy were not the same as the measures of accommodative ability that were found to be significantly different between asymptomatic and symptomatic subjects. Different measures of accommodative ability were found to persist in each of the 3 subjects followed long term.

Scheiman et al (1998) showed that accommodative infacility was substantially less common in older children than younger children, suggesting either that this condition resolves spontaneously with age in most afflicted children, or that measurement of accommodative deficiency in younger children is unreliable. The fact that the verbal and numerical format of the tests of accommodative facility caused problems for younger children suggested that pre- and post- training measures of accommodative deficiency were more reliable in older children and young adults than in younger children.

The literature on the effectiveness of vision therapy for ocular motor disorders and for deficiencies in accommodation has largely been characterized by anecdotes, case reports, or case series with small sample sizes. Because case series are by definition uncontrolled, their results to not allow one to determine whether any improvements that occur are due to therapy or whether they are an artifact of maturational effects, test-retest effects, and the non-specific gains accrued simply by bestowing more attention on a child (Levine, 1984). The interpretation of these case series is also made difficult by the relative lack of knowledge about the natural history of untreated disorders of visual efficiency.

Non-Strabismic Disorders of Binocular Vision

According to Hoffman and Rouse (1987), the visual abilities that optometry is concerned with can be roughly divided into 3 areas: (i) visual acuity, which is largely
dependent upon eye health, refractive status and normal development of the visual system; (ii) visual skills efficiency, including oculomotor (eye tracking), accommodative (eye focusing), and binocular (eye teaming) skills; (iii) visual perceptual-motor development, representing the ability to recognize, discriminate and organize visual stimuli and to interpret them correctly in light of previous experience.

The diagnosis of binocular vision dysfunction is a problem of visual skills efficiency.

A non-strabismic disorder of binocular vision is defined as a condition where an individual must exert an undue amount of effort in sustaining continuous singular binocular vision (Suchoff, 1986). Non-strabismic disorders of binocular vision are related to deficiencies of accommodation, problems with fusional vergences (i.e., divergence and convergence), or both. Binocular vision dysfunction always occurs secondary to these diagnoses. A diagnosis of binocular dysfunction is secondary to diagnoses of convergence, divergence, or accommodative function.

A non-strabismic disorder of binocular vision is distinguished from intermittent strabismus, a condition where there is overt eye turn at least some of the time. In practice, a patient who has comfortable and continuous single binocular vision may exhibit a non-strabismic disorder of binocular vision when fatigued or because of the optical or cognitive demands of a particular situation. Similarly, a patient with a non-strabismic disorder of binocular vision may exhibit intermittent strabismus in demanding situations, such as prolonged reading.

The major consequence of a patient having a non-strabismic disorder of binocular vision is asthenopia, a feeling of ocular or visual discomfort (Suchoff, 1986). The patient with asthenopia may complain of eyestrain, soreness of the eyes, frontal and occipital headaches, and eyes that easily fatigue.

According to the optometric literature, non-strabismic disorders of binocular vision are related to deficiencies of accommodation, problems with fusional vergences (i.e., divergence and convergence), or both (Suchoff, 1986). Thus, vision therapy is directed toward improving binocular vision by increasing the efficiency of the accommodative system and/or improving fusional vergences. Thus, the efficacy of vision therapy for a non-strabismic disorder of binocular dysfunction would depend upon its efficacy for the underlying causative disorder.
Convergence Insufficiency

Randomized controlled clinical trials have demonstrated the effectiveness of vision therapy for convergence insufficiency. Convergence insufficiency describes a difficulty in converging the eyes on a nearpoint target. Pickwell (1989) explained that, in the diagnosis of convergence insufficiency, 2 tests are of particular value: (i) the near point of convergence and (ii) the jump convergence. The near point of convergence is the distance at which one eye ceases to converge (as observed by the practitioner), and corresponds to the point at which the patient reports a doubling of the target as it approaches the eye. The normal near point of convergence is less than 10 cm from the eyes (about 4 inches). A second critical test is jump convergence, where the patient is asked to look at a distant object, and then to change fixation to one held at about 15 cm from the eyes and the median line. Normally, a prompt and smooth convergence movement from distance fixation to near is seen.

There is consensus in the optometric and ophthalmologic professions that vision therapy/orthoptics is an effective treatment for convergence insufficiency. Early uncontrolled studies had shown that convergence insufficiency rapidly and reliably responds to simple exercises, such as "push-ups", in almost all cases (Mann, 1940; Cushman, 1941; Lyle, 1941; Hirsch, 1943; Duthie, 1944; Mayou, 1945; Mellick, 1950; Passmore, 1957; Norn, 1966; Hoffman, 1973; Wick, 1977; Dalziel, 1981; Kertesz, 1982; North, 1982; Patano, 1982; Cohen, 1984; Daum, 1984; Deshpande, 1991a; Deshpande, 1991b). The rapidity and consistency of this response made it less likely that the outcomes of these uncontrolled studies could be due to bias, such as regression toward the mean, the natural history of the disease, or placebo effects, although these sources of bias as well as bias due to test-retest phenomena can not be ruled out. More recently, controlled clinical studies have demonstrated the effectiveness of vision therapy for convergence insufficiency.

The published clinical studies of orthoptics/vision therapy for convergence insufficiency show that a limited number of office visits are required for resolution of convergence insufficiency. Published clinical studies of vision therapy/orthoptics for convergence insufficiency show that the average number of office visits for convergence insufficiency is usually less than a dozen. Only Hoffman (1973) reported a much higher average number of office visits (24); all vision therapy exercises were conducted in the office. The orthoptic (ophthalmology) literature reports successful treatment of convergence insufficiency with fewer office visits.
than are reported in the optometric vision therapy literature. Orthoptists/ophthalmologists rely more on home exercises, whereas optometric vision therapists tend to perform more in-office therapy.

Although not all of these studies described the particular vision therapy methods that were used, many reported successful treatment using simple exercises that can be performed at home after brief instruction.

Multiple office visits on a single day are not medically necessary for treatment of convergence insufficiency. Caloroso and Rouse (1993) state that each office vision therapy session usually consists of 3 parts: (i) the patient's activities over the previous week are assessed; (ii) the patient carries out office vision therapy emphasizing techniques and procedures that cannot be done at home; and (iii) changes in home vision therapy are discussed, and any new techniques taught to the patient. Office vision therapy can typically be prescribed on a 1 session per week basis, or 2 to 3 times per week if the patient is especially difficult or home training cannot be performed.

Griffin and Grisham (1995) recommend office visits once per week to monitor the patient's progress, prescribe and teach new training procedures, and to continue motivating the patient. The authors reported that, in their experience, most exophoric convergence insufficiency patients can be treated in 6 to 8 weeks with an in-home training program with periodic office visits, and that most exotropic convergence insufficiency patients typically require longer training periods, perhaps 8 to 10 weeks or more. Grisham et al (1991) investigated the effectiveness of vision therapy in 4 patients with convergence insufficiency and 2 controls, and found that, in the treated patients, the vergences improved to normal levels within a period of 5 to 8 weeks.

Treatment of convergence insufficiency can be completed in less than 12 weeks. Christenson reported on a case example of a patient with convergence insufficiency who was treated with weekly office visits and home exercises over a 10-week period (cited in Griffin and Grisham, 1995). Patano (1982) reported successfully treating 207 convergence insufficiency patients with 20-min daily home exercises for 1 month. Cohen and Soden (1984) reported treating patients with convergence insufficiency with weekly 45-min office sessions accompanied by home therapy. The average number of office therapy sessions was 12.
Daum (1984) analyzed the results of vision therapy in 110 convergence insufficiency patients, ranging in age from 2 to 46 years. Most of the training in this patient series was completed at home. The average training time was 4.2 weeks. Dalziel (1981) reported on the success of treating 100 convergence insufficiency patients with weekly office visits and daily home exercises. The investigators reported that the average duration of therapy was 6 weeks, and ranged from 2 to 16 weeks, but noted that the average patient received only two 45-min office sessions.

Exercises for convergence insufficiency can be accomplished at home, and patients with convergence insufficiency should be transferred to a home program. The comparative efficacy of home therapy versus office treatments was studied by Deshpande and Ghosh (1991), who reported on the success of vision therapy in 2,162 patients with convergence insufficiency. Patients received either 10 office visits or 3 weeks of home exercises. They concluded that response to therapy was "comparably equal" between the 2 therapies.

**Convergence Excess**

The AOA defines convergence excess as "a sensory and neuromuscular anomaly of the binocular vision system, characterized by an excessive amount of convergence" (AOA, 1995). Convergence excess is a vergence anomaly where the esophoria or esotropia is greater at near than at far. Diagnosis generally includes the presence of an eso deviation at near of at least 2 to 6 prism diopters (Shorter, 1993). Patients may have a higher than normal accommodative convergence to accommodation ratio (AC/A).

Symptoms of convergence excess include diplopia, headache, asthenopia (eye strain), blurred vision, and avoidance or inability to sustain near visual tasks. Symptoms are often elicited after prolonged near vision tasks (AOA, 1995).

Vision therapy has been advocated as a treatment for convergence excess in textbooks and in anecdotal reports (see Shorter, 1993). The AOA guideline on convergence excess states that convergence excess is often successfully managed by therapeutic lenses and/or prisms, but that orthoptics/vision therapy may also be required (AOA, 1995).
The AOA states that 28 to 36 hours of vision therapy are usually required, but that longer durations of treatment may be required for convergence excess complicated by esotropia, oculomotor dysfunction, an accommodative disorder, other visual anomalies, or associated conditions such as stroke, head trauma, or systemic diseases (AOA, 1995).

Few clinical reports have been published on the effectiveness of vision therapy for convergence excess. In one of the few reports, Shorter (1993) described an uncontrolled retrospective study of the optometric records of 12 non-presbyopic patients with convergence excess (Shorter, 1993). Subjects received different types and durations of vision therapy treatment, and were treated by different clinicians. Subjects received vision therapy office visits at a frequency ranging from once per week to once per month, with home exercises prescribed for 4 to 6 days per week in addition to office therapy. Three of the subjects were also treated with bifocals. Median duration of vision therapy was 4 months. Of 11 subjects for whom post-treatment symptom status was recorded, 8 (73 %) reported improvements in symptoms of headache, blurred vision, eye strain, intermittent diplopia and/or trouble reading (Shorter, 1993). However, there was no statistically significant improvements in vergence ranges after vision therapy.

Because of the limitations of the study design, no conclusions could be reached about the effectiveness of vision therapy for convergence excess. Given the lack of a control group, we are unable to determine whether the improvements in the subjects could have been due to placebo effects, regression phenomena, and/or the natural history of the condition (Shorter, 1993).

**Oculomotor Dysfunction**

The term oculomotor dysfunction refers to difficulties in eye movements. Vision therapy has been used in patients with problems with saccades and pursuits.

According to Hoffman and Rouse (1987), the visual abilities that optometry is concerned with can be roughly divided into 3 areas: (i) visual acuity, which is largely dependent upon eye health, refractive status and normal development of the visual system; (ii) visual skills efficiency, including oculomotor (eye tracking), accommodative (eye focusing), and binocular (eye teaming) skills; and (iii) visual perceptual-motor development, representing the ability to recognize, discriminate and organize visual stimuli and to interpret them correctly in light
of previous experience. Oculomotor dysfunctions are problems of visual skills efficiency.

Eye movements have been a concern of optometrists because of their importance in the act of reading. Eye movements include saccades and pursuits. Saccades are eye movements that enable us to rapidly redirect our line of sight so that the point of interest stimulates the fovea (Scheiman and Wick, 1994). Saccadic eye movements are made in reading, as the reader moves along a line of print.

Most symptoms related to deficient saccadic movements are thought to be associated with reading, such as head movement, frequent loss of place, omission of words, skipping lines, slow reading speed, and poor comprehension (Scheiman and Wick, 1994). Short attention span is also alleged to be related to problems with saccadic movements.

Pursuits involve eye tracking, and allow us to have continuous clear vision of objects moving in space (Scheiman and Wick, 1994). Pursuits may be stimulus-generated or voluntary. Stimulus-generated pursuits are elicited when a child is instructed to follow a moving target, whereas voluntary pursuits are elicited when the child is instructed to track a stationary path.

Although pursuit difficulties have been reported in children who have reading problems, pursuit dysfunction is probably more likely to interfere with activities such as sports (Scheiman and Wick, 1994).

Press (1993) described the tests used to diagnose ocular motility problems in a school-aged child. Tests of ocular motility are concerned with saccadic fixations and pursuits.

There are several tests for evaluating the child’s saccadic ability (Scheiman and Wick, 1994). These include objective eye movement recording devices like the Visagraph and Eye-Trac, standardized tests such as the Developmental Eye Movement (DEM) test, and direct observations by the clinician. Although eye movement recording devices like the Visagraph and the Eye-Trac provide objective and precise measurements of eye movement, they are expensive, time consuming, and difficult to use with young children. The DEM and other tests using a visual-verbal format assess oculomotor function on the basis of the speed in which a series of numbers can be seen, recognized, and verbalized with accuracy; these tests are
inexpensive, easily administered and provide a quantitative evaluation of eye movements in a simulated reading environment. Evaluation of the child’s eye movements by direct observation by the clinician is highly subjective, and results are difficult to quantify.

Procedures have been developed to measure stimulus-generated and voluntary pursuit eye movements. The most commonly used procedure for eliciting stimulus-generated pursuit movement is to ask the child to follow a penlight or a bright object (Scheiman and Wick, 1994). Movements are made horizontally, vertically, diagonally, rotationally, and in-out (z-axis). The examiner notes how accurately the child tracks the target.

A commonly used clinical test of voluntary pursuit movement is Groffman Visual Tracings. This test, in which the child must trace a path visually between a letter on one side of the page and a number on the opposite side of the page, involves a significant degree of visual-perceptual skill. A shortcoming of the Groffman Visual Tracings test, however, is that there has been no study of its reliability and validity.

Press (1993) described the vision therapy techniques used to improve oculomotor performance. These include pursuit training and saccadic activities. Pursuit training involves oculorotatory exercises, such as pie pan rotations, where the child follows the circular path of a marble tilting about the inner axis of a pie pan, and the Marsden ball, where the child tracks the perpendicular path of a ball suspended from the ceiling. Another commonly used pursuit training exercise is the vertical rotator, where the child tracks a visual target, placed on a tripod stand, which rotates in clockwise or counterclockwise directions.

Saccadic activities are done with the large Hart chart (Press, 1993). The child begins with large angle saccades by calling out the first letter and last letter on each line. The child then does smaller angle saccades by reading each letter aloud in sequence.

Both pursuits and saccades may be trained with activities involving hand-eye coordination (Press, 1993). There are a large number of such activities, such as the Wayne Saccadic Fixator and the pegboard rotator. The Wayne Saccadic Fixator involves a central fixation point and a circular array of lights. The child is asked to touch the button adjacent to whichever light is illuminated. The pegboard rotator
involves a rotating board with holes into which pegs are inserted. The child is instructed to align the peg visually over the hole and follow it for one revolution before placing the peg into the hole.

Scheiman and Wick (1994) noted that vision therapy for eye movement skills generally involves more than simply treatment techniques for saccades and pursuits. As a general rule, accommodative and binocular vision techniques are incorporated into the therapy program because eye movement anomalies are usually associated with accommodative, binocular, or visual-perceptual disorders.

Wold and colleagues (1978) evaluated the records of a series of 100 consecutive patients with learning disabilities who had completed a course of vision therapy for a variety of problems including deficiency in accommodation, binocular dysfunction, and oculomotor dysfunction. Vision therapy consisted of three 1-hour visits per week, which were continued for 22 to 53 weeks. Eye movements were rated on the Heinsen-Schrock scale, a 10-point ordinal scale for observing and scoring pursuit and saccadic eye movement performance. The investigators found that before therapy, only 6 % of children had saccadic and pursuit function judged as adequate, whereas after vision therapy, 96 % had adequate eye movement functions. Almost all of the patients, however, had accommodative and binocular vision problems in addition to eye movement disorders. The study by Wold was a retrospective uncontrolled study of consecutive cases seen in a private practice; the uncontrolled and retrospective nature of the study makes it subject to substantial bias. Possible sources of bias include maturation effects, test-retest bias, placebo effects, and regression toward the mean. The author was able to report statistically significant results by inappropriately using statistical tests that apply to ratio or interval scales to the 100-point ordinal scale of visual functioning that the author created. As Andersen explained, “parametric statistical tests [such as Student’s t-test], which use means and standard deviations (i.e., which require operations of arithmetic on the original scores), ought not to be used with data on an ordinal scale.” Finally, the results were reported for 100 consecutive vision therapy cases with various types of binocular dysfunction, without any breakdown of the cases by specific diagnosis. Hence, we are not sure of the effectiveness of these techniques on patients who have the specific diagnosis of oculomotor dysfunction. Finally, there is no information on whether any of these learning disabled patients had symptoms related to vision, or the effects of vision therapy on these symptoms.
Solan (1967) studied the results of vision therapy on 63 normal high school students. Subjects received twelve 2-hour group sessions of treatment consisting of work with a tachistoscope, a controlled reader, vocabulary, skimming and scanning, and study skills. Although the investigators found increased reading rate, less fixations, and less regressions after treatment, the subjects received other forms of treatment along with vision therapy. There is no information in this report on the efficacy of vision therapy for alleviation of symptoms related to oculomotor dysfunction. Subsequent papers by Solan (1985a; 1985b) have been cited to support the efficacy of vision therapy in oculomotor disorders; these papers report on small numbers of selected cases, thus no conclusions about the efficacy of vision therapy in oculomotor dysfunction can be drawn from them.

Rounds and colleagues (1991) examined reading eye movements before and after eye movement therapy in 12 adults with reading problems, and compared these results to that for 9 adults with reading problems who received no interventions. The eye movement therapy consisted of 3 hours per week of oculomotor skill enhancement for 4 weeks. The investigators used a Visagraph to assess reading eye movements before and after therapy. Although the treatment group showed significant improvements in certain eye movement measures compared to the untreated group, there were no statistically significant differences between the treated and untreated groups at the end of the study in terms of reading efficiency and comprehension. The fact that measures of “eye movement efficiency” showed significant improvement without corresponding significant improvements in reading comprehension and efficiency also raises the question of whether eye movement efficiency is related to reading ability at all. Other problems with the study have to do with the fact that the control group was given no treatment, rather than sham treatment. First, there was no masking of subjects, observers or therapists. Second, the lack of a sham treatment raises the possibility that any differences between the 2 groups at the end of the study were due to the extra attention bestowed on the treatment group. Third, this study examined improvements in reading efficiency from vision therapy; this study does not address whether vision therapy is effective in alleviating symptoms from oculomotor dysfunction.

Young (1982) assessed the impact of vision therapy on 13 children from a learning center who had failed a vision screening. There is no report that any of these children reported any symptoms related to vision. Each child received three, 5-min vision therapy sessions per day, 4 days per week, for 6 weeks. Exercises were administered by a school teacher. Eye movement were recorded before and after
therapy using and Eye-Trac. After therapy, the schoolchildren were found to have a significant decrease in the number and duration of fixations and an increase in their reading speed. Two major flaws of this study were the lack of a control group and the fact that the investigators measured eye movement efficiency, and not reading comprehension and reading efficiency. Also, this study sought to measure the efficacy of vision therapy on improving reading ability, not on alleviating symptoms related to oculomotor dysfunction.

Fujimoto and colleagues (1985) tested the effectiveness of eye movement vision therapy on 27 children ages 6 to 12 attending an optometric clinic who were found to have poor saccadic performance. No information is provided about whether these children had any symptoms related to poor saccadic performance, or whether they were referred to optometry clinic for treatment of learning disabilities, dyslexia, or some other problem. Subjects were assigned to 3 groups: (i) 9 subjects to standard eye movement vision therapy, (ii) 10 subjects to a newly developed saccadic training videocassette program, and (iii) 13 subjects to no treatment. Treated subjects received 15 mins of saccadic therapy per week for 1 to 4 weeks, with the mode being 3 weeks. Both groups receiving eye movement vision therapy had significant and equal improvements in saccadic ability, whereas the untreated group showed no significant changes in saccadic ability. The authors concluded that video tape saccadic training is as effective as saccadic training performed by a vision therapist. (The video tape saccadic training could be carried out at home.) There are several problems in interpreting the results of this study. First, the 3 groups were not randomly assigned; thus the non-random assignment of groups may have biased the outcome of the study. Second, the outcomes of the group receiving standard treatment were determined retrospectively, whereas the outcomes of the other groups were analyzed prospectively. Third, the control group did not receive sham treatment, raising the possibility of bias due to Hawthorne effects. Fourth, the study measured improvements in tests of saccadic ability, and not the alleviation of symptoms.

Hung and colleagues (1986) measured several parameters before vision therapy in 21 symptomatic college students diagnosed with with accommodative and/or vergence disorders, and compared them to those measured in 22 visually normal asymptomatic college students. The purpose of measuring vision parameters in the asymptomatic subjects was to establish norms for the dynamic tests developed by the authors. Statistically significant differences between symptomatic subjects and asymptomatic subjects were identified for only one variable: the slope of the fixation-
disparity curve with accommodation open-looped. There was a statistically insignificant difference between symptomatic and asymptomatic subjects in the slope of the accommodative response to stimulus. The symptomatic patients were then given vision therapy, and were retested after completion of therapy. The asymptomatic subjects, however, were not later retested at the end of the study, and hence were not a true control group.

Symptomatic patients in the study by Hung and colleagues (1986) were divided into 3 vision therapy groups: (i) accommodation-only training, (ii) vergence-only training, or (iii) accommodation and vergence training, depending on their symptoms and what type of clinical test abnormality they had. Three of the symptomatic patients dropped out before vision therapy was started, and 1 did not complete the vision therapy program, leaving 17 symptomatic patients for analysis. Symptomatic patients with disorders of accommodation (n = 6) or vergence (n = 1) were given weekly 30-min in-office vision therapy sessions, supplemented with daily 15-min at-home exercises, for 8 to 16 weeks. Symptomatic patients who had disorders of both accommodation and vergence (n = 10) were given twice as much weekly vision therapy and daily at-home therapy. Following vision therapy, there were statistically significant shifts towards the means for normals in 2 variables: tonic accommodation (a measure of bias of the accommodation system) and slope of the fixation disparity curve (related to the vergence “gain” or speed). There were statistically insignificant shifts toward the means for normals in 2 other variables: the slope of the accommodative response/stimulus curve (related to accommodation gain) and the CA/C ratio (related to gains in accommodation/vergence interaction). All symptomatic patients had had higher monocular accommodative flipper rates (a measure of accommodative facility) following vision therapy. Significant reductions in symptoms were reported in 9 patients.

There are several problems with the study by Hung and colleagues (1986) that make its results difficult to interpret. First, because this study is uncontrolled, we do not know whether improvements in symptoms were attributable to vision therapy. Second, the variables found to be significantly different between asymptomatic and symptomatic subjects were not the ones that changed significantly with orthoptic therapy. Third, symptom severity was measured on an exponential ordinal scale, and a reduction in symptoms was judged to be “significant” if it fell by an arbitrarily chosen number of points; we are not able to tell, however, whether this reduction in
symptoms was clinically significant. Finally, although this study has been cited as support for the effectiveness of vision therapy for oculomotor dysfunction, the study only measured changes in accommodation and vergences with vision therapy.

Punnett and Steinhauer (1984) compared the results of eye movement vision therapy with and without feedback in 6 children, aged 9 to 12, who were found to have oculomotor problems and were reading substantially below their grade level. Four of the children were assigned to vision therapy with reinforcement, and 2 were assigned to a control group that received no sham treatment. The children's eye tracking, reading comprehension, accuracy, and reading levels were measured before and after treatment. Although reading comprehension and reading level appeared to increase more in the children who received vision therapy, no statistical analysis could be performed because of the small number of subjects in each group. The study did not specify whether the children were randomly assigned to the groups, and the children in the control group did not receive placebo or sham treatment. The study examined the effectiveness of vision therapy in improving the reading abilities of learning disabled children with oculomotor dysfunction, and did not examine the effectiveness of vision therapy in alleviating symptoms related to oculomotor dysfunction.

Busby (1985) examined the efficacy of vision therapy in improving eye-movement control, eye-hand coordination, and figure and form copying capabilities in 59 special education students, aged 7 to 10 years, who had neurological impairments and language difficulties. Students received twice-weekly, 30-min group vision therapy sessions over a 9-month period. Vision therapy was performed by teachers in the classroom. Students generally improved on each of the tests after vision therapy. But performance on reading and in the classroom after 1 year was only measured qualitatively. During this period, students were also attending other classes, so it is uncertain how much of the improvement on these tests can be attributed to vision therapy. There was no control group, so one does not know whether the improvements could be due to maturational effects. Finally, the study examined the effectiveness of vision therapy on eye-movement control, eye-hand tasks, and visual-motor skills, and not on symptoms from oculomotor dysfunction.

Heath and colleagues (1976) examined the effectiveness of oculomotor and convergence exercises on 80 second- and third-grade children who had scored below the 40th percentile on a reading test and in the deficient range on an
oculomotor tracking examination. Subjects were randomly assigned to 4 groups: group 1 received oculomotor and convergence exercises with proprioceptive (touch) reinforcement; group 2 received exercises without reinforcement; group 3 received perceptual exercises (sham treatment); and group 4 received no treatment. Seventeen of the 80 subjects dropped out before the end of the study; however, intention-to-treat analysis was not performed. Subjects were treated over a 12-week period; the frequency of vision therapy visits was not specified. Group 1 (exercises with proprioceptive showed significantly larger improvements in measurements of pursuits and convergence than the other groups, including group 2 which received vision therapy exercises alone. On tests of reading and eye tracking, group 1 scored significantly better than the group receiving no treatment (group 4); differences in improvements in reading between group 1 and groups 2 and 3 were not statistically significant. The study did not determine whether the group receiving vision therapy alone (group 2) scored statistically significantly better on each of these variables than the group receiving sham treatment (group 3) and the group receiving no treatment (group 4). It is unclear whether the improvements in group 1 were a result of convergence exercises or exercises to improve oculomotor function. Finally, this study examined the effectiveness of vision therapy in improving skills related to reading ability, and not the effectiveness of vision therapy in relieving symptoms related to oculomotor dysfunction.

Two studies by Schroeder and Holland (1968; 1969) have been cited in support of the effectiveness of biofeedback to improve oculomotor ability. Both of these uncontrolled studies involve normal undergraduate student volunteers, 3 in 1 study, and 6 in the other. None of these students had oculomotor dysfunctions. Thus, no conclusions can be drawn from these studies about the effectiveness of vision therapy for patients with oculomotor dysfunction.

Other investigators have used biofeedback to improve oculomotor ability in patients with nystagmus and eccentric fixation, which is discussed in separate sections below.

The literature on the effectiveness of vision therapy for ocular motor disorders has largely been characterized by anecdotes, case reports, or uncontrolled studies with small sample sizes. These case series are unable to determine whether bias has occurred due to maturational effects, test-retest effects, and the non-specific gains
accrued simply by bestowing more attention on a child (Levine, 1984). The interpretation of these case series is also made difficult by the relative lack of knowledge about the natural history of untreated disorders of visual efficiency.

In a review of the literature on vision therapy for reading problems, Beauchamp (1986) found that oculomotor pursuit or "tracking" deficiencies are alleged. However, there is evidence that these "deficiencies" disappear when content is corrected for reading level, and "oculomotor control of dyslexic children is similar to that of normal children" (Black, 1984). Reports that show abnormal pursuit in samples of children having reading problems provide no unbiased sample measurements of abnormal pursuit problems in the general population for comparison (Sherman, 1973).

Most controlled studies of the effectiveness of vision therapy have not used random assignment, and the comparison groups that are used in non-randomized studies have not been carefully matched for factors affecting the outcome of therapy. These studies also typically lack masking of therapists and observers, independent statistical design and analysis, and independent evaluation of effects. Some fail to provide statistical analysis of the data, and many fail to control for confounding variables. Controls in several of the studies did not receive any sham or placebo treatments. The studies also report their findings in terms of averages, and fail to provide subgroup or cluster analysis to allow one to identify the characteristics of patients that most likely to respond to vision therapy. Furthermore, many of the studies reported large drop-out rates, and these studies failed to employ intention-to-treat analysis of results.

The lack of standardization of vision therapy techniques and methods, as well as differences in the frequency and length of vision therapy make it difficult to make generalizations about the effectiveness of vision therapy from the results of any single study (Beauchamp, 1986).

According to Keogh, there is also "inconsistency and confounding in the nature of the samples used" in studies of vision therapy (Keogh, 1985) that limits the inferences that can be drawn from research on vision therapy in children with reading problems. In addition, the investigators frequently fail to demonstrate and quantify the visual dysfunctions in patients undergoing treatment (Beauchamp, 1986).
Many vision therapy regimens have incorporated non-optometric interventions, such as general body movements, exercise, diet, and importantly, standard remedial educational techniques. Studies of such vision therapy regimens are difficult to interpret, because effectiveness of these regimens may be due to the non-optometric interventions, such as standard remedial educational techniques, that are employed, rather than due to the vision therapy itself. Moreover, these other elements may be better provided by professionals who are not optometrists, such as remedial educational specialists. Beauchamp notes that "one may legitimately question the ability of an optometrist to function in such complex substantive areas" outside of optometry (Beauchamp, 1986).

There is also a paucity of information on whether the results achieved with vision therapy are durable (i.e., persist over time), or whether the effects of therapy are transient and ephemeral.

Beauchamp (1986) concluded that it is insufficient to recommend an intervention, such as optometric vision therapy for reading disabilities, on a speculative basis because "time and financial resources are finite." "Concentrating efforts on educational methods is not unlikely to be a more direct and cost-effective intervention" (Beauchamp, 1986).

The AAO, the American Association for Pediatric Ophthalmology and Strabismus, and the AAP (March 1992) concluded that vision therapy is not an effective treatment for reading problems and other learning disabilities.

The AOA concluded that up to 18 hours of vision therapy are needed for the most common oculomotor dysfunction. However, the AOA has provided no evidence or rationale to support this conclusion. As the above review shows, most clinical trials of vision therapy for oculomotor dysfunctions have employed far fewer than 18 hours of office therapy.

In most of the studies of vision therapy for oculomotor dysfunction, home exercises were emphasized. Optometric orthoptic therapy has focused on office therapy, whereas orthoptist orthoptic therapy has emphasized home exercises. However, there is no evidence that office orthoptics are superior to home exercises. Therefore, patients being treated for oculomotor dysfunction may be transferred to a regimen that emphasizes home exercises.
Esotropia

Esotropia, or convergent strabismus, is a manifest inward deviation of the eye(s). It may be present at birth (congenital) or appear later in life (acquired). Esotropia may be constant or intermittent. Alternating esotropia refers to shifting of esotropia from one eye to the other. Vision therapy/orthoptics has been used in the treatment of esotropia.

Active vision therapy (also called vision training, orthoptics, eye training, and eye exercises) includes a variety of non-therapeutic approaches, including biofeedback, eye movement exercises, and more complex training involving optical and electronic instruments (Hoffman, 1987).

Strabismus is a manifest deviation of the visual axes, commonly referred to as turned eyes or crossed eyes. Esotropia is a type of strabismus where there is manifest inward deviation of the eyes. The deviation in strabismus may occur in various directions, may occur at distance, near, or both, and may be intermittent or constant.

A pediatric ophthalmology panel of the AAO Quality of Care Committee published a Preferred Practice Pattern on esotropia (AAO, 1992). Treatment modalities for this disorder include correction of refractive error (75% successful -- should be employed for clinically significant astigmatism, anisometropia, hyperopia, and/or a distance-near disparity), miotics (anti-cholinesterases agents that reduce accommodative effort by stimulating ciliary muscle contraction), prism therapy (for small symptomatic eso-deviations and to alleviate diplopia for older children who have acquired esotropia following surgery for exotropia), surgery (should be performed only when more conservative methods fail -- about 25% of patients).

There is a lack of evidence of the effectiveness of vision therapy for esotropia. In the clinical practice guideline on the management of esotropia, the AAO (1992) concluded that active vision therapy/orthoptics "is no longer considered effective" in the treatment of esotropia and "its use should be discouraged."

Studies of vision therapy for esotropia have been uncontrolled and retrospective, with the resultant potential for bias in the interpretation of results. The reasons for our inability to draw valid conclusions about the effectiveness of therapy from uncontrolled case series are well known (Anderson, 1990). Andersen (1990) explained that "[there are many reasons why patients or observations may change"
during, but not because of, an intervention. The classical reasons are: (i) regression toward the mean and other variations in the natural history of the disease; (ii) test-retest phenomena; and (iii) placebo effects." Von Noorden (1996) noted that "a truly scientific validation of orthoptic treatment has never been published."

Several authors of reviews of the optometric literature on the effectiveness of vision therapy in esotropia have drawn conclusions about the overall effectiveness by adding together the success rates from observational studies of vision therapy in esotropia, grouping together studies of various designs, strengths, and weaknesses (Flax, 1978). No attempt is made to critically evaluate the inherent limitations of these studies, or the difficulties of drawing conclusions about the effectiveness of vision therapy from them. The authors make reference to "controlled" studies, implying that these studies are controlled clinical trials, whereas in actual fact, these studies were observational studies with noncontemporaneous comparison groups.

Studies should be grouped by design, with the greatest weight given to the strongest studies (i.e., those studies that, by design, have the least potential for bias) (Anderson, 1990). The only prospective randomized controlled clinical trial of optometric vision therapy in esotropia published to date has found no benefit from active vision therapy (Fletcher, 1969). This study has been ignored in reviews of the effectiveness of optometric vision therapy for esotropia.

Published case series on vision therapy for esotropia report widely varying durations of treatment and frequencies of office visits, without any consistent relationship between increased duration of treatment and frequency of office visits with improved outcomes. Cooper and Medow (1993) noted that "[o]rthoptist orthoptic therapy is primarily given to the patient to do at home while optometric orthoptic therapy utilizes both office and home therapy."

Although the AOA states that office treatment of intermittent esotropia requires 40 to 52 hours of visits, and the most commonly encountered constant esotropia usually requires 60 to 75 hours of office therapy, their guideline provides no evidence to support this assertion.

The literature on the effectiveness of vision therapy has reported on orthoptic treatment of esotropia requiring far fewer office visits are sufficient. Wick (1987), in a report on the outcomes of treatment of 57 patients with esotropia, reported a mean length of treatment of intermittent esotropia of 4.57 weeks, with basic intermittent
esotropia requiring on average 1.5 weeks longer treatment than convergence excess intermittent esotropia. He noted that "constant strabismics had a significantly longer treatment course [average 6.65 weeks] than intermittent strabismics." Forrest (1978) reported on treatment of a patient with esotropia in 5 office visits (1 every 4 months) plus home exercises. Knapp (1971), reporting on his experience in treating 139 patients with accommodative esotropia, reported that orthoptic training, when it was indicated, required as little as 1 week and up to "a few weeks." Griffin and Grisham (1995) state that most cases of convergence excess esotropia can be managed on a home training program with weekly office testing and training visits over 2 to 4 months, divergence insufficiency esotropia over 3 to 4 months, and esophoria in 8 to 12 office visits. They state that in basic esotropia, doctors can determine which patients require surgery and which do not after 1 to 2 months of vision training, and state that, "if the strabismic patient has not achieved satisfactory binocular vision result within a 6-month period of active vision training with full compliance, we suggest a surgical evaluation and support the surgeon's recommendation in most cases."

Kertesz and Kertesz (1986) report on esotropia treatment completed in 9 orthoptic therapy visits. Layland (1971) reported esotropia treated in 15 visits. Fletcher and Silverman (1966), reporting on the success rate in treatment of a series of over 1,000 consecutive cases of esotropia, stated that "no long-term orthoptics has been used." Lyle and Foley (1957) reported on cases of post-surgical esotropia requiring no more than 12 visits (13). Mann (1947) reported that treatment of esotropia averaged 9 visits. Weinstein (1972) reported needing only 5 to 6 sessions necessary for treatment of esotropia and exotropia with the opto-illuminator. Etting (1978) reported treatment of strabismus with 3 months of twice-weekly visits.

There is no evidence that optometric orthoptic therapy, performed largely in the office, is superior to orthoptist orthoptic therapy, which is primarily given to the patient to do at home. Outcomes of long-term office-based treatment of constant or intermittent esotropia have not been demonstrated to be superior to home therapy with periodic followup. Therefore, prolonged vision therapy/orthoptic treatment for esotropia is not only investigational, but is also not medically necessary. Patients with esotropia may be transferred to a home vision therapy program with periodic follow-up.

Intermittent Exotropia
Intermittent exotropia is a nonconstant outward deviation of one eye. It is a type of strabismus (cross eyes). Horizontal strabismus may be exotropic or esotropic. Exotropia is less common, and less well understood than esotropia, except in cases with an obvious cause, such as paralysis of the muscle that pulls the eye outward. As a general rule, exotropia is found most frequently at older ages, and is expressed in an intermittent fashion (Daw, 1995).

The evidence of the effectiveness of vision therapy for intermittent exotropia was reviewed by Coffey et al (1992). The investigators identified and summarized the evidence of effectiveness of treatments for intermittent exotropia, including optical correction, prisms, occlusion, strabismus surgery, and vision therapy. The investigators concluded that the pooled success rates for vision therapy were greater than for any other treatment. Coffey et al noted, however, that “almost all of the studies have been retrospective, lacked the controls necessary to determine whether the conclusions were valid, contained such small subsample sizes that interpretation of the results is questionable, suffered from selection bias in the way the patients were chosen for treatment, or reported results in such a manner as to make interpretation difficult.”

Except in certain limited situations, uncontrolled studies do not allow us to determine whether the changes seen in patients during the period of observation were due to the intervention. There are many reasons why patients or observations may change during, but not because of, an intervention. The classical reasons are: (i) regression toward the mean; (ii) test-retest phenomena; and (iii) placebo effects (Andersen, 1990).

The assessment of a patients' ability to control an intermittent exotropic deviation is usually assessed by subjective means such as observation of control in the office, questioning the patient and/or family about control at home, and reports of monocular eye closure in bright light (Stathacopoulos, 1993).

The number of office visits necessary and duration of treatment for a given indication is also significantly different between orthoptists and vision therapists. As Cooper and Medow (1993) noted in a review of intermittent exotropia, “[o]rthoptist orthoptic therapy is primarily given to the patient to do at home while optometric therapy utilizes both office and home therapy.” Despite the differences in approach, there are no consistent differences in the effectiveness of orthoptic exercises reported in the orthoptist literature and the optometric literature. The AOA, in their Clinical
Practice Guideline on Strabismus (1995) stated that optometric vision therapy generally requires 25 to 75 hours of office visits. However, treatment durations reported in the literature vary widely, with no consistent relation of number of office visits, duration of treatment, or transfer to home exercise programs, to results of treatment.

In a series of studies on the effectiveness of optometric vision therapy, Daum reported on mean durations of treatment of intermittent exotropia of 4.3 weeks (Daum, 1984a), 5.5 weeks (Daum, 1984b), and 7.6 weeks (Daum, 1984c). In the largest study of vision therapy for intermittent exotropia published to date, Patano (1982) reported an average treatment duration of 1 month. The second largest study of vision therapy for intermittent exotropia, by Cooper and Leyman (1977), reported a treatment duration ranging from 12 to 15 weeks. The longest average treatment durations were reported by Newman and Mazow (1981), who reported an average treatment time of 12 months. Their reported success rate, however, was below the average for all studies of vision therapy in intermittent exotropia.

**Vertical Deviations**

Vertical deviations refer to disconjugate movements of the eyes in the vertical (up and down) plane. They are an unusual type of strabismus (cross-eyes). Vision therapy has been used to correct vertical deviations.

Hyperphoria or hypertropia occurs if one visual line is higher than the other. It is present on the right if the right visual line is higher than on the left, and on the left if the left visual line is on the right. A hypertropia is also known as a vertical strabismus.

The symptoms of vertical deviation include asthenopic symptoms (headache, fatigue, drowsiness, blurred vision), loss of place while reading, vertigo, nausea, and motion sickness (Cooper (1988), citing Amos (1987) and Scobee (1950)). Large vertical deviations may cause loss of binocular vision, a cosmetically objectionable hypertropia, and frank diplopia. In vertical deviations due to superior oblique muscle palsy, compensatory torticollis is common, with the face turn or the head tilt toward the opposite shoulder. Chronic torticollis can result in asymmetrical facial development and postural plagiocephaly (“banana face” deformity).
Von Noorden (1996) cited Adler (Moses, 1970) in reporting that hyperphoria of 1 prism diopter of either eye produces symptoms; hence, only 0.5 prism diopter of hyperphoria can be considered to be within the physiologic range. These values are clinically significant and require treatment, however, only if they produce symptoms. Von Noorden noted, however, that the clinical significance of vertical deviations and other heterotropias depends not so much on their absolute values as on correlated findings, for example, the fusional amplitudes.

Caloroso and Rouse (1993) stated that 2 characteristics of a deviation -- the magnitude and the frequency -- are the primary factors determining which patients to refer to surgery. As a general guideline, they stated that, if the patient's smallest deviation, measured with best correction, is greater than 10 prism diopters for a vertical tropia, surgery is expected to be necessary to reduce or eliminate the vertical deviation so that the patient can comfortably align both eyes in open space.

Regarding vertical deviations and cosmesis, Flom (1958) stated that vertical strabismus is generally not noticeable to a lay person when it is less than about 10 prism diopters of vertical hypertropia.

The evidence on the effectiveness of orthoptic treatment for vertical deviations is sparse and contradictory. Based on his clinical experience, Layland (1971) stated that hypertropias are unlikely to respond to orthoptic treatment. Mann (1947), commenting on her experience, concluded that paralytic forms of vertical deviations never respond to orthoptic treatment, but orthoptic treatment can help some patients with non-paralytic vertical deviations.

The AOA position statement on vision therapy for strabismus only mentions its use in esotropia and exotropia (American Optometric Association, undated). There is no statement about its effectiveness in vertical deviations. The AOA's Clinical Guideline on strabismus also only mentions the use of vision therapy for esotropia and exotropia (AOA, 1995).

There are few published clinical studies on the effectiveness of orthoptics for vertical deviations. Six studies were identified; all of these studies combined reported on the results of orthoptics in fewer than 70 patients. Of these, 2 were reports of selected cases. Three of the studies involved only 3 patients each, 1 study involved 10 patients with vertical deviations, 1 study involved 13 patients with vertical deviations, and 1 study involved 37 patients with vertical deviations. All of these studies
involved retrospective review of optometric records. None of these studies employed control or comparison groups. And none of these studies provided statistical analysis of the results.

The 2 largest studies (Ettinger, 1978; Ludlam, 1960) excluded drop-outs from the analysis, and Ludlam also excluded from analysis patients who were still completing treatment. All of the patients with vertical deviations in the 3 largest studies had associated esotropias or exotropias; thus, we have almost no information on the effectiveness of orthoptics in patients with isolated vertical deviations. Zaki (1972) and Etting (1978) found lower functional cure rates in strabismus patients with than in strabismus patients without vertical deviations. Ludlam (1960) found, however, that cure rates for horizontal strabismus were the same regardless of whether there is an associated vertical deviation.

Only a few small studies have reported on the effectiveness of orthoptic treatment of vertical deviations. Cooper (1988) described 4 patients with large vertical deviations -- 3 patients with intermittent hypertropias and 1 patient with an alternating hyperesotropia (range of deviation 6 to 12 diopters of vertical tropias) -- that were treated with a combination of prismatic glasses and orthoptics. Treatments resulted in an alleviation of symptoms and a decrease in the need to wear vertical prisms, although fusional ranges improved in only 1 of the 4 subjects.

Robertson and Kuhn (1985) used orthoptics to treat 3 hyperphoric patients (range of deviation 1.5 to 4 diopters of vertical phorias). All 3 reported an alleviation of symptoms. However, although orthoptic exercises emphasized vertical fusion range extension, only 1 subject's vertical fusional ranges improved significantly. Finally, no conclusions about the effectiveness of orthoptic treatment of patients with vertical deviations can be drawn from these selected case reports.

Zaki (1972) reported on the results of orthoptic treatment of 120 children ages 5 to 7 years with less than 12 degrees of strabismus, including 10 children with hypertropia, 6 with accompanying exotropia and 4 with accompanying esotropia. The children received a total of 12 weeks of twice-weekly orthoptics (24 visits). The investigator reported a successful outcome (angle is within 0 to 5 degrees with and without glasses, with good fusion, binocularity, and stereoacuity) in only 2 of the 10 patients. The rest of the patients needed surgery.
Hoffman et al (1970) reviewed the results of orthoptics on 55 consecutive strabismus seen in a private optometry clinic over 2 years. Only 3 of the cases exhibited any vertical deviation (in all 3 cases, the vertical deviation was associated with esotropia), and their results with orthoptic treatment were not reported separately.

One of the largest study of the effectiveness of orthoptics for patients with vertical deviations was by Etting (1978), who reviewed the optometric records of 86 patients ages 6 to 40 years with strabismus who had orthoptics, including 13 patients with vertical deviation, all of whom had an associated exotropia. Subjects were excluded if the onset of strabismus occurred before age 6, or if they dropped out before completing 24 office visits were also excluded from the study. The investigators measured both functional cure rates and cosmetic cure rates. A functional cure included clear, comfortable vision, normal near point of convergence, stereopsis, and normal fusion ranges. Cosmetic cure was defined as a final angle of deviation of 15 prism diopters or less, or if less deviation was present at study entry, improved anomalous fusion.

Of 13 subjects with vertical deviations and exotropia, 6 (46.1 %) were functionally cured after vision therapy, and an additional 5 (38.4 %) achieved a cosmetic cure (Etting, 1978). This is compared to a functional cure rate of 70.9% and cosmetic cure of an additional 19.7 % among the sample as a whole. Five subjects with vertical deviations had prior surgery; 2 of these patients (40 %) achieved a functional cure, and an additional 2 patients (40 %) achieved a cosmetic cure. Six subjects with vertical deviations also had amblyopia; only 2 of these 6 subjects (33 %) achieved functional cure, and an additional 2 subjects (33 %) were cosmically cured.

The presence of normal retinal correspondence was an important determinant of functional cure: 6 of 8 subjects (75 %) with vertical phorias and normal retinal correspondence achieved functional cure with orthoptics, and 1 additional subject (12.5 %) achieved a cosmetic cure (Etting, 1978). But none of 5 subjects with vertical phorias and anomalous retinal correspondence achieved functional cure; 4 (80 %) achieved a cosmetic cure. Office therapy was provided for one-half hour, 2 times per week. In addition, up to one-half hour of home therapy was assigned. An average of 48 sessions of office therapy were used to treat patients with vertical deviations.
Ludlam (1961) reviewed the medical records of 517 patients seen at an orthoptic clinic over a 4-year period, 284 of whom had strabismus. Patients were excluded if they were still undergoing training (n = 51), if they dropped out before completing 8 orthoptic training sessions (n = 48), if they had paralytic strabismus (n = 8), if the deviation was correctable by glasses alone (i.e., accommodative esotropia) (n = 9), or if they had previous surgery (n = 19). The results of the remaining 149 cases were reported. Of the 149 patients with strabismus, 37 had a hypertropia (range of 2 to 22 prism diopters), 17 of which were associated with an esotropia (hyper-esotropia), and 20 of which were associated with an exotropia (hyper-exotropia). Patients received office orthoptic training either once or twice-weekly, supplemented in almost all cases with home exercises. Functional cures were those who had clear comfortable binocular vision, normal near point of convergence, stereopsis, and normal ranges of motor fusion. The “almost cured” category included includes patients who meet the functional cure category, except that they lack stereopsis, may exhibit strabismus with diplopia up to 5 % of the time, and/or may need significant amounts of prism to maintain binocular vision. Of the 17 patients with hyper-esotropia, 4 (23.5 %) obtained a functional cure with orthoptics, and 10 (58.8 %) were almost cured. Of the 20 patients with hyper-exotropia, 8 (40 %) were functionally cured and 7 (35 %) were almost cured. This compares to a functional cure rate of 46.5 % for exotropia and a functional cure rate of 26.6 % for esotropia. Thus, the presence of a vertical component did not appear to affect the cure rates for esotropia and exotropia. Ludlam noted that this finding contradicts previous reports that vertical deviation was an important impediment to functional cure by orthoptics. For patients achieving a functional cure, the average number of office sessions was 23 for exotropia and 32 for esotropia.

In a subsequent study, Ludlam (1965) reported on the long-term outcomes or orthoptic treatment of strabismus. In 1963, the investigator re-examined 82 patients from the earlier study who were judged to be at least moderately cured at the time of their dismissal from vision training between 1956 and 1960. Of 12 patients with hyperesotropia that returned in 1963 for re-examination, 5 had improved since dismissal from training, 5 remained unchanged, and 2 deteriorated. Of 14 patients with hyper-exotropia that returned, 6 improved since dismissal from training, 9 were unchanged, and 2 deteriorated.
There was wide variation in the number of office visits necessary for treating vertical
deviations. Zaki (1972) and Ludlam (1960) reported average treatment durations of
32 visits or less, whereas Etting (1978) reported an average treatment duration of 48
visits. Despite the greater number of office visits, Etting's success rates were lower
than Ludlam's.

In contrast to the scattered reports on the effectiveness of orthoptics for vertical
deviations, there have been published the results of larger prospective case series
of surgery for vertical deviations. Saunders (1995) reports that surgical oblique
muscle strengthening, often performed in combination with surgery of other
extraocular muscles, is effective in incomitant hypertropia due to superior oblique
muscle palsy. However, it is not known whether early strabismus surgery will
prevent or reverse the postural plagiocephaly due to chronic torticollis.

Saunders (1995) explains that patients with small-angle, vertical deviations of less
than 10 prism diopters and no torsional symptoms can sometimes be managed
successfully with prism glasses. If surgery is necessary, the superior oblique tendon
tuck is appropriate as the primary procedure in patients with less than 10 prism
diopters of hypertropia in the primary position of gaze.

Successful outcomes (elimination of torticollis and hypertropia in and around the
primary position) may be as high as 90% in selected populations (Saunders (1995),
citing Toosi (1979) and Saunders (1986)).

The majority of patients undergoing superior oblique tendon tuck for appropriate
indications will not require a second surgery (Saunders, 1995). Davis and Biglan
(1995) state that re-operation for vertical deviations is required in patients with
diplopia and vertical deviation is greater than 5 prism diopters. Other indications for
re-operation include residual head postures or tilts. If the amount of residual or new
torticollis exceeds 10 or 15 prism diopters, it is sufficient to warrant consideration of
additional surgery.

Vertical deviations may occur as a new finding after horizontal strabismus surgery,
or they may occur as a result of under-correction or over-correction of a previous
hypertropia (Davis, 1995). Vertical deviations may also occur de novo as part of the
natural history of a strabismus condition, such as dissociated vertical deviation
following horizontal correction of infantile esotropia.
Helveston (1979) has stated that, for strabismus in general, a patient needing a re-
operation will have a 30% chance of needing another operation to obtain a
satisfactory result.

Sprague (1995) reported that the Fadenoperation may be an alternative in the
treatment of patients with dissociated vertical deviations (spontaneous supraduction
of either eye when the patient is fatigued or day-dreaming). But Esswein et al
(1992) retrospectively compared the superior rectus Fadenoperation to large
superior rectus recessions for dissociated vertical deviation and found better results
with recession alone.

Buckley (1995) noted that there was little information about the effectiveness of
botulinum toxin injections in the treatment of vertical strabismus, and in some
instances, botulinum toxin would be contraindicated.

Although a comprehensive review of studies of the effectiveness of surgery for
vertical deviations is beyond the scope of this assessment, one of the early studies
of the effectiveness of surgery in vertical deviations is described below.

Lyle and Foley (1957) reported on the results of surgery, with and without orthoptics,
in 107 patients with congenital paralytic strabismus; of the 107 patients, 92 had
binocular vision preoperatively and 15 did not. The outcome of the study included
absence of symptoms, and restoration of single binocular vision, including equal
visual acuity, normal retinal correspondence, fusion, and stereopsis. Of the 15
patients with no binocular vision, 3 had palsy of the horizontally acting extraocular
muscles, 7 had a palsy of vertically acting muscles with secondary esotropia, and 5
had a palsy of vertically acting muscles with secondary exotropia. Orthoptic
treatment was not given in any case; treatment consisted only of an operation to
improve cosmetic appearance.

Of the 92 congenital paralytic strabismus patients with binocular vision, 76 had a
vertical deviation (Lyle and Foley, 1957). Of the 76 with a vertical deviation, 13 had
an associated horizontal deviation and 63 did not. Of the 63 patients with an
isolated vertical deviation, 55 complained of symptoms preoperatively. Fifty-one of
the 55 symptomatic patients had complete relief and the other 4 had partial relief of
symptoms following surgery. Of the 8 patients with isolated vertical deviations who
did not have symptoms, 7 had single binocular vision after surgery, and 1 needed
reoperation.
Of the 13 patients with a vertical deviation associated with a horizontal deviation, 9 had an associated exotropia (Lyle and Foley, 1957). Eight of these 9 patients complained of symptoms pre-operatively; 6 of these symptomatic patients (75 %) were symptom-free after operation, and the other 2 symptomatic patients improved considerably. One of the 9 children with a vertical deviation associated with exotropia had no symptoms pre-operatively, but he did have a compensatory head posture. After surgery, the child’s had single binocular vision and his head posture was normal.

Four patients had a vertical deviation associated with esotropia (Lyle and Foley, 1957). Two of these patients were symptomatic prior to surgery. Both symptomatic patients also had a compensatory head posture. Symptoms in one patient were relieved and head posture was normal after surgery. Single binocular vision was restored in the other patient after surgery, but the head posture remained abnormal. Two asymptomatic children with vertical deviations and esotropia also had a compensatory head posture; following surgery, both had single binocular vision and normal head postures.

Lyle and Foley (1957) also reported on the results of surgery with and without orthoptics in 287 children under 10 years of age with non-paralytic esotropia, 213 of whose esotropia was non-accommodative (i.e., not correctable with spectacles). Fifty of the 213 children (24 %) with non-accommodative esotropia also had a vertical deviation. Eight of 48 children (16.6 %) treated with surgery alone achieved single binocular vision, and 16 of 138 children (11.6 %) treated with surgery and orthoptics achieved single binocular vision. But none of the 27 children treated with orthoptics alone achieved single binocular vision. Although no detailed analysis was presented, the investigators concluded that the prognosis is no worse in patients with esotropia and vertical deviation, provided that the vertical deviation is corrected by surgery. Lyle and Foley (1957) also investigated the outcomes of 121 children and adults with non-paralytic exotropia. The authors did not discuss the effect of associated vertical deviations on the outcomes of these patients.

**Amblyopia**

Amblyopia is poor vision in an eye that did not develop normal sight during early childhood (AAO, 1992). It is sometimes called "lazy eye." The prevalence of amblyopia is thought to be at least 2 %. There are 3 major causes, including image deprivation (e.g., congenital cataracts, blepharoptosis, corneal scarring), anisometropia (unequal refractive error in the 2 eyes), and strabismus (misalignment
of the visual axes of the eyes). Accepted methods of treatment include optical correction, occlusion, optical blurring (also called cycloplegic defocusing or atropinization).

Amblyopia differs from strabismic suppression and anomalous retinal correspondence (ARC) which are also frequently associated sequelae of abnormal visual experience, although unlike amblyopia, they often result from intermittent strabismus. Strabismic suppression and ARC are not defects but are adaptations of binocular vision; they can help the afflicted individual by eliminating diplopia without undermining the capacity for normal visual function. In contrast, amblyopia has no value for the affected subject (Greenwald and Parks, 1994).

There is no evidence that vision training is equal to or superior to occlusion therapy in the treatment of suppression amblyopia in children.

Although the term "amblyopia" meant "impaired vision" for many centuries, the word has now become synonymous with suppression amblyopia in children. Suppression amblyopia refers to the suppression of the central vision in 1 eye when the images from the 2 eyes are so different that they cannot be fused into one.

Amblyopia is usually accompanied by strabismus, and is most effectively treated by occlusion therapy. As one authority stated, "[f]ull time occlusion of the preferred eye is the most effective method for treating strabismic amblyopia" (Greenwald and Parks, 1994). In occlusion therapy, the occluded eye is deprived of all form vision throughout the waking day except for a brief period, during which the child has an opportunity to maintain the occluded eye's ability to fixate and judge the degree of preference for one eye or the other. The usual method of occlusion is a patch that adheres to the skin around the eyelids.

Amblyopia may also accompany other causes of poor vision, such as congenital cataract, marked anisometropia, or corneal scar. For children with amblyopia and straight eyes, part-time occlusion is the preferred mode of treatment. According to Greenwald and Parks, "[p]art-time occlusion is appropriate therapy for amblyopia with straight eyes or for the maintenance of good vision following completion of primary treatment.".
In some cases, amblyopia can be effectively treated by creating optical blur in the preferred eye (Greenwald and Parks, 1994). This is most commonly accomplished by producing cycloplegia in the nonamblyopic eye by administering atropine. Blur may also be created with spectacle or contact lenses.

Occlusion and optical methods of treating amblyopia both work by forcing the patient to depend visually on one eye that has diminished acuity and allowing the otherwise unaltered experience of seeing to improve the functional capability of the amblyopic eye. "This strategy unquestionably works in the great majority of cases, even when the amblyopic eye initially functions very abnormally" (Greenwald and Parks, 1994).

Despite the effectiveness of occlusion therapy, a variety of other approaches to treating amblyopia have been proposed, including vision therapy. However, there is no reliable evidence that vision therapy is superior or equal in effectiveness to occlusion therapy in the treatment of amblyopia. As one authority concluded, "[o]cclusion therapy for amblyopia has been in use for more than 2 centuries, and despite its many drawbacks it still has no peer" (Greenwald and Parks, 1994).

The AAO concluded that vision therapy has "little clinical value" in the treatment of amblyopia (AAO, 1992). The AAO Amblyopia Preferred Practice Pattern states "[e]ye movement exercises, 'passive' occlusion, or methods designed to stimulate or suppress vision using flashing lights or high contrast rotating patterns have not been validated to be clinically effective in controlled studies."

By contrast, the AOA has concluded that vision therapy has a place in the treatment of amblyopia patients. The AOA Optometric Clinical Practice Guideline Care of the Patient with Amblyopia (1994) states: "[a]ctive monocular and binocular amblyopia therapies, as opposed to passive management (e.g., occlusion), reduce the total treatment time needed to achieve the best visual acuity," and that it "is designed to remediate deficiencies in four specific areas: eye movements and fixation, spatial perception, accommodative efficiency, and binocular dysfunction." An AOA position statement on vision therapy for amblyopia states that "[t]he most commonly encountered amblyopia usually requires 28 to 40 hours of office therapy."

Garzia (1987) and Ciuffrieda (1991) reviewed the literature on the effectiveness of vision therapy in amblyopia. Although both authors argue for the effectiveness of vision therapy for amblyopia, these reviews reveal that the evidence for the effectiveness of vision therapy for amblyopia consists almost entirely of case reports.

In a review of the treatment of amblyopia, Greenwald and Parks (1994) explained that "no rigorous evaluation of the benefits [of vision therapy] have been undertaken." The authors cited the story of the CAM stimulator for amblyopia as an example of the perils of relying on case reports and uncontrolled case series. Researchers at Cambridge University developed this device that provided visual stimulation to an amblyope undergoing treatment. Initial case series reported spectacular results. Greenwald and Parks noted, however, that, "[w]hen efforts were made to confirm early results in carefully controlled studies, however, no significant differences between treatment and control groups could be demonstrated."

Furthermore, Greenwald and Parks reasoned that vision therapy is not necessary for amblyopia treatment because "[i]t is quite possible that the everyday demands and experiences provided by the patient's environment are as effective in this regard as any that can be devised by the therapist."

**Nystagmus**

Nystagmus is a disorder characterized by rapid, involuntary, back-and-forth oscillations of the eye, usually affecting both eyes, and may be congenital or acquired (Dell’osso, 1991). It occurs in about 0.4 % of the population. There are also normal reflexive conditions of nystagmus such as optokinetic and labyrinthine
nystagmus. The movements are often from side to side (lateral nystagmus), or around the anterior-posterior axis (rotary nystagmus), sometimes up and down (vertical nystagmus). There may be a combination of lateral or vertical with the rotary movements (mixed nystagmus). On the basis of its rhythm, nystagmus is categorized into 2 types: (i) pendular and (ii) jerk. When the eyes appear to oscillate with equal speed in either direction, it is called pendular nystagmus. When movement in one direction is faster than in the other, it is called jerk nystagmus. Jerk nystagmus has a slow component away from the object of attention, followed by a rapid, corrective movement in the opposite direction. The direction of the fast component, by convention, denotes the nystagmus direction (Dell’osso, 1991).

Congenital nystagmus is a poorly defined abnormality that is present at birth or noted in the early months of life during which visual fixation develops (Dell’osso, 1991; Abplanalp, 1983). Most people afflicted with congenital nystagmus can identify a field of gaze in which nystagmus intensity, but not the frequency, is minimal. This particular position of gaze is known as the null zone which is usually stable for long periods in most patients. These individuals often adopt a persistent head turn to place their eyes in a position of least nystagmus, thus allowing them to hold their eyes relatively stable when their gaze is directed straight ahead of the midline of the body. Traditional therapies for congenital nystagmus are based on the existence of a null zone, and basically reduce the eye movements only in the position of gaze (Dell’osso, 1991; Abplanalp, 1983).

Drug-induced nystagmus is most frequently caused by alcohol, barbiturates, tranquilizers, phenothiazine, and anticonvulsive therapy. Spontaneous occurrence of nystagmus may indicate the presence of labyrinthine-vestibular, brainstem, or cerebellar disease (Dell’osso, 1991; Adams, 1989). Any recent onset of nystagmus should be examined by a neurologist and will not be improved by vision therapy or biofeedback therapy.

Vision therapy has been used to treat nystagmus. Most of the studies of vision therapy to treat nystagmus have utilized biofeedback techniques. However, several reports of the use of vision therapy to treat nystagmus preceded the development of biofeedback techniques.

Healey (1952) provided case reports on 4 children with esotropia and congenital nystagmus. The children’s nystagmus went away temporarily when fusion occurred at the patient’s angle of deviation. The author noted that the nystagmus was
reduced or abolished after exercises and/or surgery to reduce the children's esotropia. This is among the only reports in the literature, however, on abolition of nystagmus after correction of esotropia.

Stohler (1973) reported on “afterimage treatment” of 6 patients, ages 6 to 19 years, with congenital nystagmus. Each patient was seated in a darkened room, and a strobe light was flashed in front of the patient. Following the flash, a light placed behind the patient began to blink in order to create both positive and negative afterimages. The patients worked to reduce the amplitude of nystagmus by steadying the afterimages. These after-images created what was essentially a visual means of biofeedback, making the patient aware of his/her nystagmus. The patients practiced with the strobe light in the office for one hour each day for 2 consecutive days. The patients were then allowed to take the strobe light with them and practice daily at home for 2 months. After the 2-month period of exercises, at least small improvements were noted in each patient's visual acuity. Two of the patients were able reduce the frequency of nystagmus movements, but in 2 other patients, the frequency of nystagmus movements increased. Stohler concluded that “[i]t is not yet possible to draw many conclusions from the six patients we have treated because our sampling was too small and our follow-up was too short.” In reviewing Stohler’s study, Stegall (1973) noted “I would like to emphasize that the treatment presented in this paper [by Stohler] did not presume to be a cure for nystagmus, it has only altered it, which would indicate that more extensive studies are needed.”

The remaining studies of vision therapy for nystagmus have focused exclusively on the use of auditory biofeedback (Abdai et al, 1980; Ciuffreda et al, 1980; Goldrich et al, 1981; Ciuffreda et al, 1982; Kirschen, 1983; Ishikawa et al, 1985; Mezawa, 1990). In general, an auditory biofeedback apparatus for the suppression of nystagmus usually consists of an infrared eye movement monitor which detects horizontal eye movements, and following appropriate calibration, records horizontal eye position with respect to the fixation target (Abplanalp, 1983; Kirschen, 1983). The eye movement signals are collected by sensors and converted electronically into sounds which indicate the direction and amplitude of the eye position error. The direction of the error is communicated to the patient by the ear in which the sound is heard -- errors to the right are heard in the right ear and errors to the left are heard in the left ear. Additionally, the tone quality is different in the 2 ears. The amplitude of the error is signaled to the patient by the frequency of the tone -- low frequencies represent small eye position errors and high frequencies represent large errors.
deadband, the width of which is controlled by the operator, is inserted coincident with the fixation target. The deadband represents the angular distance over which the patient can move his/her eyes and not trigger the auditory feedback circuit. In other protocols, the deadband may produce a different sound such as a series of soft clicks. The objective is to keep the auditory tones silent or maintain the soft click sounds for as long as possible. In the beginning, the size of the deadband is large. As the patient gains control of his/her fixation nystagmus, the deadband is gradually reduced forcing steadier and more accurate fixation (Abplanalp, 1983; Kirsch, 1983).

Ciuffreda et al (1982) investigated the use of eye movement auditory biofeedback in the control of nystagmus. Horizontal eye position was monitored by a photoelectric technique which was employed in weekly (3 to 15 weeks), 1-hour training sessions in 5 men aged 25 to 49 years. Patients exhibited either congenital jerk (manifest or latent) nystagmus or acquired pendular nystagmus. They were asked to try to reduce the wavering quality of the tone which reflected changes in horizontal eye position. Distance visual acuity was examined before each session without attempting to control nystagmus, and after each session with patients utilizing the newly learned training strategies, but without auditory biofeedback, to decrease nystagmus and increase visual acuity as determined by Snellen letter and "tumbling E" charts.

The total time of auditory biofeedback received during therapy ranged from 53 to 342 mins (Ciuffreda, 1982). All five patients were able to reduce their nystagmus within the first or second session, and in 1 patient, after only 15 mins of training. As training progressed, patients were able to reduce nystagmus amplitude and/or frequency. Average maximum group reduction of nystagmus amplitude, peak slow-phase velocity, and frequency with auditory biofeedback was 82, 86, and 34 %, respectively. When audio signal was periodically withheld during training and testing, all of the patients were able to maintain their reduced level of nystagmus for up to several mins. Furthermore, subjects were able to reduce nystagmus upon command, without auditory biofeedback but with conscious effort, while engaging in conversation and other tasks with the experimenters. Visual acuity improvement following a subject's conscious effort to control nystagmus without the assistance of biofeedback averaged 10 % Snell-Sterling (1 to 4 lines on a standard Snellen vision test chart). Of the 2 patients who returned several months later for a post-training examination, 1 was able to reduce nystagmus, without the aid of biofeedback, to 50 % of his pre-training level within a few seconds. Both subjects were able to reduce
their nystagmus to the maximum levels achieved during training with the assistance of a few seconds of auditory biofeedback. The authors concluded that auditory biofeedback should be considered in the treatment of nystagmus either alone, or in combination with orthoptic and/or surgery.

Kirschen (1983) reported the use of auditory biofeedback in the control of congenital nystagmus in 5 patients. Horizontal eye movements were detected by an infrared eye movement monitor. The eye movement signals were converted electronically into auditory tones which assisted patients in controlling their abnormal eye movement. Less than 1 hour was needed for all the patients to learn using the auditory biofeedback. Results from 3 patients were presented.

Reductions in eye movement amplitude as measured from tracings of the eye movement monitor ranged from 41 to 73 %, but frequency was not significantly lowered (Kirschen, 1983). In fact, eye movement frequency in 1 patient increased from 2.2 to 2.8 Hz. There was an increase in Snell-Sterling visual efficiency from 48.4 to 56 % in 1 patient. For another patient, contrast sensitivity was measured before and during biofeedback. At very low spatial frequencies (1 and 2 cycles/deg), contrast sensitivity was reduced during biofeedback, but at higher spatial frequencies (4 and 8 cycles/deg), sensitivity was elevated. The reason for this discrepancy was unclear. Additionally, 1 patient was able to control his nystagmus in the laboratory 1 year after his initial training session. He was able to maintain his eye movement control for 1 min or more without the assistance of auditory biofeedback. The author suggested that auditory biofeedback of eye position may be useful in the treatment of congenital nystagmus.

Mezawa et al (1990) studied the changes in waveform of congenital nystagmus associated with biofeedback therapy in 7 patients aged 7 to 20 years (3 females and 4 males). All 7 patients had horizontal congenital nystagmus -- 4 with the jerk type and 3 with either pendular or pseudopendular type. Each subject participated in auditory biofeedback 5 to 6 times over a 6-month period for the suppression of the nystagmus. The right retina of each subject was observed with an infrared television fundus camera, and the fundus image recorded on video tape. The position of the eye during nystagmus, recorded by means of the fundus camera, was analyzed at every 1/60 second intervals. The displacement in degrees between the fixation target, projected onto the retina, and the foveola was measured for each interval.
By means of auditory biofeedback, patients could voluntarily suppress nystagmus, and prolong foveation time (Mezawa, 1990). On average, the intensity (amplitude x frequency) decreased by about 40%, and the foveation time (milliseconds) was prolonged by about 190%. Following completion of the training program, all 7 patients reported a subjective improvement in their vision when suppressing their nystagmus. These researchers concluded that it is possible that biofeedback training acts to reduce nystagmus and increase foveation time, thus, improving the ability to fixate.

Ishikawa et al (1985) also reported the use of biofeedback treatment of 30 patients with congenital nystagmus of the jerk type. Biofeedback regarding eye positions, as well as tension in the eyelid, neck, throat, shoulder, and diaphragm muscles was provided to the patients. After 1 year, results were classified as excellent in 10 subjects; moderate in 12; poor in 6; no effect in 1; and 1 patient dropped out of the study.

While there is limited evidence that biofeedback may reduce the intensity and velocity of nystagmoid eye movements, conclusive evidence of its long-term effectiveness is still lacking. Sound experimental studies with large sample size and long-term follow-up are needed before biofeedback can become an established method for the treatment of nystagmus.

In conclusion, many studies have suggested that biofeedback may be effective in treating various visual disorders such as nystagmus, strabismus, amblyopia, myopia, as well as blepharospasm. However, almost all of these reports were either in-house publications, abstracts of conference proceedings, case studies, or uncontrolled studies with small sample sizes. When sound experimental studies with control group, randomization, masking, and statistical analysis have been conducted, biofeedback has not been demonstrated to be effective in the treatment of the afore-mentioned visual disorders. Because of the lack of objective data, the effectiveness of biofeedback in the treatment of various visual disorders remains unclear. More research with better experimental design is needed to determine the effectiveness of biofeedback in the treatment of visual disorders, and the long-term effectiveness of any improvement.

**Traumatic Brain Injury**
Head trauma can be classified into 2 categories: (i) open head trauma -- a direct invasion through the skull; and (ii) closed head trauma -- a blow to the head that does not cause a direct pathway from outside through the soft tissues to the brain. The 2 most common types of closed head trauma are cerebrovascular accidents such as strokes and traumatic brain injury (TBI). Vehicular accidents, sporting accidents, and violence are responsible for the majority of TBI. They result in multi-focal lesions and diffuse brain damage with a wide range of physical and neuro-behavioral impairments.

The visual system may also be impaired in TBI patients. The most common visual problems associated with TBI are binocular dysfunction, blurred vision, ocular motility deficits, visual field loss, and visual perceptual-motor deficits. These visual deficits may be related to insults to the cranial nerves, in particular, the III (Oculomotor), IV (Trochlear), and VI (Abducens). It should be noted that patients with TBI may do poorly on visually mediated activities as a consequence of deficits in attention and problem solving, poor manual dexterity, or ataxia rather than visual-spatial deficits per se. Presently, there is a lack of research linking visual perceptual deficits to dysfunctional performance of daily living activities.

Most rehabilitation efforts are centered on patients with severe TBI (unconscious for 6 hours or longer). In the early stages of rehabilitation, inpatient services include physical, occupational, and speech therapies, and emphasize the development of cognitive skills, compensation techniques, emotional adjustment, physical fitness, and health maintenance. In the late stages of rehabilitation when a patient has returned home but continues to exhibit physical or neuro-behavioral problems, an out-patient program may be recommended. Currently, vision therapy is not an integral part of in-patient and out-patient rehabilitation programs for TBI patients.

Some optometrists have advocated that optometric therapy should play a role in the management of head trauma patients. However, data regarding the use of vision therapy and its benefits on patients with TBI are sparse. In a case study, Aksionoff and Falk (1992) reported that a 70-year old man who suffered from a left hemispheric cerebrovascular accident was helped by optometric therapy. After 1 year of weekly 45-min sessions, the patient showed improved perception and spatial relations -- he no longer complained of bumping into objects, and could successfully dial the phone again. Cohen (1992) described optometric management of binocular dysfunctions in 2 patients. The first patient was a 25-year old man who sustained a frontal, closed head injury when his bicycle was hit by a truck. He had exotropia,
poor convergence and difficulty with motor planning. After 30 sessions of vision therapy, he was able to read more accurately and comfortably, but still had considerable difficulty with sequencing and written expression. The second patient was a 20-year old man who suffered a closed head trauma in an automobile accident. He had esotropia secondary to cranial nerve VI palsy. After 50 sessions of in-office therapy, his visual acuity was 20/20 (compared to 20/50 before therapy), and his field of gaze was full in almost all directions, with a slight limitation that was evident when he looked up and to the right.

In a retrospective study, Gianutsos et al (1988) examined the impact of rehabilitative optometric services on a group of patients with TBI. A total of 55 patients were screened for visual function, and more than 50% were found to be in need of treatment. Twenty-six patients were referred to a rehabilitative optometrist who specialized in low vision. It was reported that 24/26 patients who received therapy had improved functional outcome. Unfortunately, the specifics of the outcome as well as the improvement were not disclosed in this study. As in the case reports described above, this study did not have a control group making it difficult to determine whether the observed improvements in visual functions were due to optometric therapy or other therapies in the rehabilitation program and/or spontaneous recovery. More importantly, the relevance of vision therapy to functional performance, especially on daily living activities, must be established through clinical research before this type of therapy can be considered as an integral part of a TBI rehabilitation program.

There is a scarcity of data documenting the use of vision therapy for the management of visual deficits in patients with TBI. Further investigations, especially studies demonstrating the long-term benefits of vision therapy (its impact on activities of daily living and its influence, if any, on other areas of rehabilitation) are needed before it can be considered as an integral part of a head trauma rehabilitation program.

Concussion and Traumatic Brain Injury

The American Medical Society for Sports Medicine’s position statement on “Concussion in sport” (Harmon et al, 2013) and the Ontario Neurotrauma Foundation’s guidelines for diagnosing and managing pediatric concussion (2014) do not mention vision therapy as a management tool.
Furthermore, UpToDate reviews on “Concussion and mild traumatic brain injury” (Evans, 2016a), “Postconcussion syndrome” (Evans, 2016b), and “Concussion in children and adolescents: Management” (Meehan and O’Brien, 2016) do not mention vision therapy as a management tool.

Intermittent Exotropia

The AAO’s Pediatric Ophthalmology/Strabismus Panel’s guideline on “Esotropia and exotropia” (AAO, 2012) noted that “The potential benefits of treatment for esotropia include promoting binocular vision and normal visual function in each eye. If binocularity is achieved, the number of surgical procedures over a lifetime and overall cost to society may be reduced. Fusion and stereopsis are necessary for some careers and may be useful in others as well, such as in athletic activities and activities of daily life. In addition, binocular alignment is important for the development of a positive self-image and enhances social interactions by normalizing appearance as well as eye contact. The potential benefits of treatment for exotropia include promoting binocular vision and normal visual function in each eye. Normal binocular alignment promotes a positive self-image. After strabismus surgery, adults have reported improved confidence, self-esteem, and interpersonal interactions …. Treatment with eyeglasses is generally preferred over surgery because of the risk of consecutive esotropia and diplopia after surgery. When the deviation is intermittent, many ophthalmologists defer surgery in young children with fusion to avoid complications associated with post-operative esotropia. These complications include suppression, amblyopia, and loss of binocular vision, particularly stereoacuity”. This guideline did not mention vision therapy as a therapeutic option.

Hatt and Gnanaraj (2013) noted that the clinical management of intermittent exotropia [X(T)] has been discussed extensively in the literature, yet there remains a lack of clarity regarding indications for intervention, the most effective form of treatment and whether or not there is an optimal time in the evolution of the disease at which any treatment should be carried out. In a Cochrane review, these investigators analyzed the effects of various surgical and non-surgical treatments in randomized trials of participants with X(T), and to report intervention criteria and determine the significance of factors such as age with respect to outcome. These investigators searched the Cochrane Central Register of Controlled Trials (CENTRAL) (which contains the Cochrane Eyes and Vision Group Trials Register) (The Cochrane Library, Issue 4, 2012), MEDLINE (January 1966 to May 2012), EMBASE (January 1980 to May 2012), Latin American and Caribbean Literature
Health Sciences (LILACS) (January 1982 to May 2012), the metaRegister of Controlled Trials (mRCT) (www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrials.gov) and the WHO International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/search/en). They did not use any date or language restrictions in the electronic searches for trials. They last searched the electronic databases on May 4, 2012. These investigators no longer searched the UK Clinical Trials Gateway (UKCTG) for this review. They manually searched the British Orthoptic Journal up to 2002, and the proceedings of the European Strabismological Association (ESA), International Strabismological Association (ISA) and American Academy of Pediatric Ophthalmology and Strabismus meeting (AAPOS) up to 2001. They contacted researchers who are active in the field for information about further published or unpublished studies. These researchers included randomized controlled trials (RCTs) of any surgical or non-surgical treatment for X(T). Each review author independently assessed study abstracts identified from the electronic and manual searches. Author analysis was then compared and full papers for appropriate studies were obtained. They found 1 randomized trial that was eligible for inclusion. This trial showed that unilateral surgery was more effective than bilateral surgery for correcting the basic type of X(T). The authors concluded that the available literature consisted mainly of retrospective case reviews, which are difficult to reliably interpret and analyze. The 1 randomized trial included found unilateral surgery more effective than bilateral surgery for basic X(T). However, across all identified studies, measures of severity and thus criteria for intervention were poorly validated, and there appeared to be no reliable natural history data. They stated that there is therefore a pressing need for improved measures of severity, a better understanding of the natural history and carefully planned clinical trials of treatment to improve the evidence base for the management of this condition. This review did not mention vision therapy as a therapeutic option.

Joyce et al (2015) stated that evidence of effectiveness of interventions for treatment of childhood X(T) is unclear. These investigators conducted a systematic review to locate, appraise and synthesize evidence of effectiveness, including 12 electronic databases, supplemented with hand-searches and expert contact. They included RCTs, quasi-experimental and cohort studies with a comparison group examining interventions for divergence excess, simulated divergence excess or basic type X(T) in children, up to and including 18 years of age, followed for at least 6 months. Dual data extraction and critical appraisal were conducted and a narrative synthesis undertaken. A total of 11 studies met the eligibility criteria; 7 examined the comparative effectiveness of 2 surgical procedures; 4 compared surgery with other
interventions, including botulinum toxin A therapy, orthoptic exercises, occlusion, binocular vision training and watchful waiting. The evidence retrieved was of limited extent and quality with differences across studies in terms of outcome assessment and most appropriate time-point for measuring long-term outcomes. There were mixed outcomes when comparing unilateral recession/resection (R&R) with bilateral lateral rectus recession (BLR) on improving angle of deviation, which made it difficult to recommend either surgical option with confidence. While non-surgical interventions appeared less effective in terms of improving angle of deviation, they are rarely associated with adverse outcomes. The authors concluded that given the limited evidence base, better designed studies are needed to address the question of the most effective management for treatment of childhood X(T); more importantly, consensus is needed on what constitutes a successful outcome as well as agreement on how this should be measured.

The American Association for Pediatric Ophthalmology and Strabismus (2015) stated that X(T) may be congenital or acquired. The acquired forms of X(T) include intermittent X(T), sensory X(T), and consecutive X(T) (exotropia that develops after surgery to treat crossed eyes). Non-surgical treatment of X(T) may include glasses and in some instances, patching therapy may be recommended. If the eyes are misaligned more often than they are straight, surgery on the eye muscles may be recommended in order to realign the eyes. Exercises or vision therapy have been suggested for treating some cases of intermittent X(T), however, they have not been shown to effectively treat intermittent X(T).

Other Indications

Optometrists have used vision therapy techniques for improving sports performance in normal individuals. These include use of binocular strings (Brock String), flip-card exercises, ball on a string (Marsden Ball), tachistoscopic exercises, eye-hand and eye-body coordination exercises, and use of complicators (Kirscher, 1993).

Vision therapy to improve sports performance is not considered medically necessary because, when used in this context, it is not for the diagnosis, prevention, or treatment of a disease or medical condition, but is used to improve the performance of normal individuals.

Furthermore, the effectiveness of vision therapy in improving athletic performance remains unproven. In a review of the use of vision therapy in sports medicine, Vinger (1994) explains that "[t]he controversy surrounding visual training and athletic
performance does not center around whether other visual parameters are important for athletic performance -- they clearly are. The matter of contention is the claim, by some, that visual training can improve athletic performance." Vinger found that the literature on vision therapy for sports medicine lacks standardized testing methods, normal values, and controlled studies. He found that, in the literature on vision therapy and sports, "there is a rash of case reports that claim extraordinary results, the use of unstandardized test methods, and reporting results in a way that does not permit statistical validation."

There is no evidence that optometric vision training is effective in the treatment of learning disabilities. Beauchamp (1994) reviewed the literature on vision training for learning disabilities, and concluded that "[t]here is ... little definitive evidence for [the] effectiveness" of vision training in children with learning disabilities."

The term "vision therapy" or "vision training" encompasses diverse practices related to manipulation of the eyes using optical aids and ocular movements, often in conjunction with proprioceptive exercises, biofeedback, cognitive style modeling, nutritional counseling, family system counseling, psychology, and reading tutorials. As one authority explained, "[t]he necessary and sufficient components of optometric vision training have not been specified (practices being remarkably diverse), precluding scientific assessment of these practices" (Beauchamp, 1994).

Furthermore, there is no reason to expect that visual training would be an effective treatment for learning disabilities. This is because studies have shown no differences in ocular function between learning disabled and non-learning disabled children, and because there is no evidence that ocular dysfunction causes learning disabilities (Beauchamp, 1994).

In discussing the role of eyes and vision in learning disabilities, Beauchamp concluded that "[t]here is consensus that refractive errors, strabismus, and other ocular diseases are not associated with academic function."

Specifically with respect to problems with visual tracking, studies have found no increased incidence of tracking or smooth-pursuit deficiencies or other ocular motility abnormalities in children with learning disabilities. Carefully controlled studies have shown "no increased incidence of peripheral ocular, optical, or ocular motility abnormalities" in learning disabled children (Beauchamp, 1994).
Visual perceptive deficits in children with learning disabilities are symptoms of a generalizable disorder and are not causative of the learning disabilities. As Beauchamp explained, "[t]he group of persons in whom learning disability is accompanied by perceptual deficits relating to visual input probably manifests a symptom of a generalized process rather than a primary or causative deficit" (Beauchamp, 1994).

Also, there is also the question of whether optometrists are adequately trained to provide the non-ophthalmologic elements of vision training, as "the ability of optometrists to function independently in such complex substantive areas has been questioned" (Beauchamp, 1994).

Beauchamp concluded that "in the absence of evidence for effectiveness [of vision therapy], the ophthalmologist will likely recommend that the child and family's resources -- time and money -- be applied to efforts most likely to yield positive results."

The primary reason many children have been prescribed vision therapy is to treat reading problems (dyslexia) and learning disabilities by improving visual efficiency. There are no adequate studies, however, to support the contention that visual, perceptual, or gross motor exercises aid the poor reader. Helveston and colleagues (1985) found that there are no relationships demonstratable between academic performance and visual function. Other population-based studies have failed to find differences in visual function between normal and learning-disabled individuals (Beauchamp, 1994). Thus, there is little rationale for vision training of dyslexics and other learning-disabled individuals.

Another problem in the vision training literature is the tendency to interpret findings narrowly, so that difficulty sustaining concentration while reading, for example, may be regarded as a symptom of a defect in visual efficiency, rather than a broader manifestation of attentional weakness in all modalities (Levine, 1984).

In addition, literature on vision therapy focuses on a single aspect of vision, such as oculomotor pursuit, and interprets an association or relationship as a problem, such as dyslexia, as if it had causal implications. The evidence, however, of such a causal relationship between visual efficiency and reading problems is "less than
compelling" (Beauchamp, 1986). In a review of vision training, Keogh and Pelland (1985) explained that "[i]f visual inefficiency is not the cause of any reading problems, vision training is not the treatment of choice ..."

Beauchamp (1986) concluded that it is insufficient to recommend an intervention, such as optometric vision therapy for reading disabilities, on a speculative basis because "time and financial resources are finite." "Concentrating efforts on educational methods is not unlikely to be a more direct and cost-effective intervention" (Beauchamp, 1986).

The AAO, the American Association for Pediatric Ophthalmology and Strabismus, and the AAP (2009) has issued a joint position statement that concludes that vision therapy is not an effective treatment for dyslexia or learning disabilities.

Vision Restoration Therapy

According to Nova Vision, vision restoration therapy (VRT), a home-based program, targets the vision center of the brain and is intended to improve visual function in patients with visual field deficits that may result from stroke or TBI. Patients employs a computer screen to focus on a displayed central point and respond every time they see light stimuli appear. The light stimuli are presented in the area most likely to recover visual function, an area that will change as treatment progresses and vision is improved.

McFadzean (2006) reviewed the controversial findings for NovaVision's VRT. It has been claimed that NovaVision's computerized therapy results in expansion of the visual field in optic nerve and occipital lesions, but the outcome has been challenged on the grounds of unsatisfactory perimetric control of central fixation and disputed mechanisms. The author stated that in clinical practice, NovaVision's VRT should not currently gain acceptance in view of unacceptable perimetric standards and equivocal results. Possible effects on a relative scotoma at the edge of a lesion have not been adequately explored. In the interim, research should also be focused on compensatory eye movement strategies.

Mueller and colleagues (2007) evaluated the outcome of VRT in a large sample of clinical patients and studied factors contributing to subjective and objective measures of visual field alterations. Clinical observational analysis of visual fields of 302 patients before and after being treated with computer-based VRT for a period of 6 months at 8 clinical centers in central Europe were carried out. The visual field
defects were due to ischemia, hemorrhage, head trauma, tumor removal or anterior ischemic optic neuropathy (AION). Primary outcome measure was a visual field assessment with super-threshold perimetry. Additionally, conventional near-threshold perimetry, eye movements and subjective reports of daily life activities were assessed in a subset of the patients. Vision restoration therapy improved patients' ability to detect super-threshold stimuli in the previously deficient area of the visual field by 17.2 % and these detection gains were not significantly correlated with eye movements. Notable improvements were seen in 70.9 % of the patients. Efficacy was independent of lesion age and etiology, but patients with larger areas of residual vision at baseline and patients over 65 years old benefited most. Conventional perimetry validated visual field enlargements and patient testimonials confirmed the improvement in every day visual functions. The authors concluded that VRT improves visual functions in a large clinical sample of patients with visual field defects involving the CNS, confirming former experimental studies.

In a pilot study, Jung et al (2008) evaluated the effects of VRT on the visual function of patients (n = 10) with AION. All patients were evaluated before VRT and after 3 and 6 months of treatment by Early Treatment Diabetic Retinopathy Study (ETDRS) visual acuity, contrast sensitivity, reading speed, 24-2 SITA-standard Humphrey visual field (HVF), High Resolution Perimetry (HRP) (perimetry obtained during VRT), and vision-based quality of life questionnaire. Patients were randomized between 2 VRT strategies (5 in each group): (i) VRT in which stimulation was performed in the seeing VF of the affected eye ("seeing field-VRT"), and (ii) VRT in which stimulation was performed along the area of central fixation and in the ARV (areas of residual vision) of the affected eye ("ARV-VRT"). The results of the HRP, HVF, and clinical assessment of visual function were compared for each patient and between the 2 groups at each evaluation. Visual acuity qualitatively improved in the ARV-VRT group, however the change was not statistically significant (p = 0.28). Binocular reading speed significantly improved in the ARV-VRT group (p = 0.03). Humphrey visual field foveal sensitivity increased mildly in both groups (p = 0.059); HRP analysis showed a similar increase in stimulus accuracy in both groups (mean improvement of about 15 %). All patients reported functional improvement after VRT. The authors concluded that despite a small sample, the study showed a trend toward improvement of visual function in the ARV-VRT group. Improvement of HRP in both groups may reflect diffusely increased visual attention (neuronal activation), or improvement of an underlying sub-clinical abnormality in the "seeing" visual field of patients with optic neuropathies.
In a comparative case study, Plow et al (2011) attempted to standardize a protocol for promoting visual rehabilitative outcomes in post-stroke hemianopia by combining occipital cortical transcranial direct current stimulation (tDCS) with VRT. Two patients, both with right hemianopia after occipital stroke damage were included in this study. Both patients underwent an identical VRT protocol that lasted 3 months (30 mins, twice-daily, 3 days/week). In patient 1, anodal tDCS was delivered to the occipital cortex during VRT training, whereas in patient 2 sham tDCS with VRT was performed. The primary outcome, visual field border, was defined objectively by using high-resolution perimetry. Secondary outcomes included subjective characterization of visual deficit and functional surveys that assessed performance on activities of daily living. For patient 1, the neural correlates of visual recovery were also investigated, by using functional magnetic resonance imaging. Delivery of combined tDCS with VRT was feasible and safe. High-resolution perimetry revealed a greater shift in visual field border for patient 1 versus patient 2. Patient 1 also showed greater recovery of function in activities of daily living. Contrary to the expectation, patient 2 perceived greater subjective improvement in visual field despite objective high-resolution perimetry results that indicated otherwise. In patient 1, visual function recovery was associated with functional magnetic resonance imaging activity in surviving peri-lesional and bilateral higher-order visual areas. The authors concluded that these findings of preliminary case comparisons suggested that occipital cortical tDCS may enhance recovery of visual function associated with concurrent VRT through visual cortical re-organization. They stated that future studies may benefit from incorporating protocol refinements such as those described here, which include global capture of function, control for potential confounds, and investigation of underlying neural substrates of recovery.

To recapitulate, while there are studies assessing the clinical value of the VRT, there is insufficient evidence of effectiveness for this treatment. Drawbacks of published studies are small sample sizes and short follow-up time.

Visual Information Processing Evaluation

Visual processing entails a group of skills that are employed for interpreting and understanding visual information. Visual information processing evaluation (VIPE) identifies problems with processing of information for enhanced school and/or social development. The evaluation may encompass testing for visual spatial orientation skills, visual analysis skills, including auditory-visual integration, visual-motor integration skills ans well as rapid naming.
Goldstand et al (2005) compared visual and visual-information processing skills between children with and without mild reading and academic problems and examined the incidence of visual deficits among them. A total of 71 seventh graders classified as proficient (n = 46) and non-proficient (n = 25) readers were compared with respect to scores on an accepted vision screening, on tests of visual-perception, visualmotor integration, and academic performance. Further, academic performance and visual-information processing were compared between children who failed and passed the vision screening. Visual deficits were found in 68% of the participants, and among significantly more boys than girls. Non-proficient readers had significantly poorer academic performance and vision-screening scores than the proficient readers. Participants who passed the visual screening performed significantly better in visual perception than those who failed. The authors concluded that visual function significantly distinguishes between children with and without mild academic problems, as well as on visual-perception scores. The high occurrence of visual deficits among participants warrants consideration of vision deficits among schoolchildren with academic performance difficulties. Furthermore, these researchers noted that "[c]autions must be exercised in generalizing the results of the study since the participants represent a convenience sample of seventh-grade students from a single middle school. This type of subject selection, combined with the relatively limited number of participants, means that the findings derived are not necessarily representative of the total population. A larger sample, in which participants are selected according to randomized sampling procedures, would increase our ability of researchers to extrapolate from the findings. Furthermore, as a result of the possibility of incurring type I or II errors when utilizing t-test analyses in group comparisons, the results of our study should be interpreted cautiously". In summary, currently there is insufficient evidence to support the use of visual information processing evaluations for diagnosing reading or learning-related disabilities. Well-designed studies with larger sample sizes are needed to establish the diagnostic utility of this procedure.

Occlusion Therapy for the Treatment of Stimulus Deprivation Amblyopia

Stimulus deprivation amblyopia (SDA) develops due to an obstruction to the passage of light secondary to a condition such as cataract. The obstruction prevents formation of a clear image on the retina. Stimulus deprivation amblyopia can be resistant to treatment, leading to poor visual prognosis; and it probably constitutes less than 3% of all amblyopia cases, although precise estimates of prevalence are unknown. In developed countries, most patients present under the age of 1 year; in less developed parts of the world patients are likely to be older at
the time of presentation. The mainstay of treatment is removal of the cataract and then occlusion of the better-seeing eye, but regimens vary, can be difficult to execute, and traditionally are believed to lead to disappointing results. In a Cochrane review, Antonio-Santos et al (2014) evaluated the effectiveness of occlusion therapy for SDA in an attempt to establish realistic treatment outcomes. Where data were available, these researchers examined evidence of any dose-response effect and assessed the effect of the duration, severity, and causative factor on the size and direction of the treatment effect. These investigators searched CENTRAL (which contains the Cochrane Eyes and Vision Group Trials Register) (The Cochrane Library 2013, Issue 9), Ovid MEDLINE, Ovid MEDLINE In-Process and Other Non-Indexed Citations, Ovid MEDLINE Daily, Ovid OLDMEDLINE (January 1946 to October 2013), EMBASE (January 1980 to October 2013), the Latin American and Caribbean Literature on Health Sciences (LILACS) (January 1982 to October 2013), PubMed (January 1946 to October 2013), the metaRegister of Controlled Trials (mRCT) (www.controlled-trials.com), ClinicalTrials.gov (www.clinicaltrials.gov) and the WHO International Clinical Trials Registry Platform (ICTRP) (www.who.int/ictrp/search/en). They did not use any date or language restrictions in the electronic searches for trials. They last searched the electronic databases on October 28, 2013. These researchers included randomized and quasi-randomized controlled trials of participants with unilateral SDA with visual acuity worse than 0.2 LogMAR or equivalent. They did not specify any restrictions for inclusion based upon age, gender, ethnicity, co-morbidities, medication use, or the number of participants. Two review authors independently assessed study abstracts identified by the electronic searches. They did not identify any trials that met the inclusion criteria specified in the protocol for this review. The authors concluded that they found no evidence on the effectiveness of any treatment for SDA. Moreover, they stated that future randomized controlled trials are needed to evaluate the safety and effectiveness of occlusion, duration of treatment, level of vision that can be realistically achieved, effects of age at onset and magnitude of visual defect, optimum occlusion regimen, and factors associated with satisfactory and unsatisfactory outcomes with the use of various interventions for SDA.

Neuro Vision Technology for Traumatic Brain Injury

Rasmussen and colleagues (2018) noted that serious and often lasting vision impairments affect 30 % to 35 % of people following stroke. Vision may be considered the most important sense in humans, and even smaller permanent injuries can drastically reduce quality of life (QOL). Restoration of visual field impairments occur only to a small extent during the 1st month after brain damage,
and therefore the time window for spontaneous improvements is limited. One month after brain injury causing visual impairment, patients usually will experience chronically impaired vision and the need for compensatory vision rehabilitation is substantial. The purpose of this study is to examine if rehabilitation with Neuro Vision Technology will result in a significant and lasting improvement in functional capacity in persons with chronic visual impairments after brain injury. Improving eyesight is expected to increase both physical and mental functioning, thus improving the QOL. This is a prospective, open-label trial in which participants with chronic visual field impairments are examined before and after the intervention. Participants typically suffer from stroke or TBI and will be recruited from hospitals and the Institute for the Blind and Partially Sighted. Treatment is based on Neuro Vision Technology, which is a supervised training course, where participants are trained in compensatory techniques using specially designed equipment. Through the Neuro Vision Technology procedure, the visual problems of each individual are carefully investigated, and personal data are used to organize individual training sessions. Cognitive face-to-face assessments and self-assessed questionnaires about both life and vision quality are also applied before and after the training. Funding was provided in June 2017; results are expected to be available in 2020. Sample size is calculated to 23 participants. Due to age, difficulty in transport, and the time-consuming intervention, up to 25 % drop-outs are expected; thus, these researchers aim to include at least 29 participants. The authors concluded that this study will evaluate the effects of Neuro Vision Technology therapy on compensatory vision rehabilitation. Additionally, QOL and cognitive improvements associated to increased QOL will be explored.

CPT Codes / HCPCS Codes / ICD-10 Codes

Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+":

<table>
<thead>
<tr>
<th>Code</th>
<th>Code Description</th>
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<tbody>
<tr>
<td>CPT codes covered if selection criteria are met:</td>
<td></td>
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<tr>
<td>92065</td>
<td>Orthoptic and/or pleoptic training, with continuing medical direction and evaluation [not covered if used for visual information processing evaluations]</td>
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<tr>
<td>CPT codes not covered for indications listed in the CPB:</td>
<td></td>
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<tr>
<td>64550</td>
<td>Application of surface (transcutaneous) neurostimulator</td>
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<td>Other CPT codes related to the CPB:</td>
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<tr>
<td>Code</td>
<td>Code Description</td>
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<tr>
<td>90867</td>
<td>Therapeutic repetitive transcranial magnetic stimulation (TMS) treatment; initial, including cortical mapping, motor threshold determination, delivery and management</td>
</tr>
<tr>
<td>90868</td>
<td>subsequent delivery and management, per session</td>
</tr>
<tr>
<td>90869</td>
<td>subsequent motor threshold re-determination with delivery and management</td>
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</tbody>
</table>

ICD-10 codes covered if selection criteria are met:

- H51.11 - H51.12 Convergence insufficiency and spasm

ICD-10 codes not covered for indications listed in the CPB: (not all-inclusive):

- H50.00 - H50.18 Esotropia and exotropia
- H50.311 - H50.34 Intermittent esotropia and exotropia
- H50.43 Accomodative component in esotropia
- H50.51 - H50.52 Esophoria and exophoria
- H51.8 Other specified disorders of binocular movement
- H52.10 - H52.13 Myopia
- H53.011 - H53.039 Amblyopia
- H53.141 - H53.149 Visual discomfort [asthenopia]
- H53.30 Unspecified disorder of binocular vision [binocular instability]
- H53.31 Abnormal retinal correspondence
- H53.40 - H53.489 Visual field defects
- H55.00 - H55.89 Nystagmus
- F80.0 - F80.2 Specific delays in development
- F80.4 - F82
- F88 - F89
- H93.25 Central auditory processing disorder
- I69.998 Other sequelae following unspecified cerebrovascular disease
- R48.0 Dyslexia and alexia
<table>
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<th>Code</th>
<th>Code Description</th>
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<tr>
<td>S02.0xx+</td>
<td>Fracture of skull</td>
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<tr>
<td>S02.92x+</td>
<td></td>
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<tr>
<td>S06.0X0A</td>
<td>Intracranial injury [including concussion, traumatic brain injury]</td>
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<tr>
<td>S06.9X9S</td>
<td></td>
</tr>
</tbody>
</table>

The above policy is based on the following references:


American Optometric Association (AOA). Position Statement, Convergence...


45. Ciuffreda KJ. The scientific basis for and efficacy of optometric vision therapy in nonstrabismic accommodative and vergence disorders. Optometry. 2002;73(12):735-762.


166. Sanfilippo S, Clahene AC. The effectiveness of orthoptics alone in selected cases of exodeviation: The immediate results and several years later. Am Orthopt J. 1970;20:104-117.


221. Evans RW. Postconcussion syndrome. UpToDate [online serial]. Waltham, MA: UpToDate; reviewed February 2016b.


224. Rasmussen RS, Schaarup AMH, Overgaard K. Therapist-assisted rehabilitation of visual function and hemianopia after brain injury: Intervention study on the effect of the Neuro Vision Technology
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Amendment to
Aetna Clinical Policy Bulletin Number: 0489 Vision Therapy

The following references to possible benefit exclusions do not apply to Medicaid:

“Some Aetna plans specifically exclude benefits for vision therapy (orthoptic training). Please check benefit plan descriptions. Under these plans, charges for orthoptic and/or pleoptic training (eye exercises) and training aids or vision therapy for any diagnosis should be denied based on this contractual exclusion.”

“In addition, most Aetna benefit plans exclude coverage of services, treatment, education testing or training related to learning disabilities, or developmental delays. Please check benefit plan descriptions.”

Please contact Member Services for specific details regarding the individual member’s covered benefits under Medicaid. Most services may be covered for adults. There are no benefit limitations for children under age 21 years.