Visual Information Processing Evaluation and Orthoptic and Vision Therapy

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Instructions for Use

Table of Contents **Page**

Related Commercial/Individual Exchange Policy

- Cognitive Rehabilitation and Coma Stimulation

Community Plan Policy

- Visual Information Processing Evaluation and Orthoptic and Vision Therapy

Application

UnitedHealthcare Commercial

This Medical Policy applies to UnitedHealthcare Commercial benefit plans.

UnitedHealthcare Individual Exchange

This Medical Policy applies to Individual Exchange benefit plans.

Coverage Rationale

The following are proven and medically necessary:

- Occlusion Therapy or Pharmacologic Penalization Therapy for treating Amblyopia
- Orthoptic Therapy or Vision Therapy for treating Convergence Insufficiency
- Prism Adaptation Therapy for treating Esotropia

The following are unproven and not medically necessary due to insufficient evidence of efficacy:

- Orthoptic Therapy or Vision Therapy for treating all other indications not listed above
- Virtual perception therapy for treating any type of learning disability or language disorder
- Vision Restoration Therapy for treating visual field deficits following stroke or neurotrauma
- Visual information processing evaluation to diagnose reading or other learning disabilities
- Remote, online, and/or digital therapy for Amblyopia

Definitions

Amblyopia: Amblyopia is a decreased vision in one or both eyes due to abnormal vision development in infancy and childhood. In the first few years of life, the brain must learn to see or interpret the images provided by the eyes. In Amblyopia, the brain receives a poor image from one eye and thus does not learn to see well. Vision loss occurs in this case because nerve pathways between the brain and the eye are not properly stimulated. Amblyopia is often referred to as lazy eye [American Association for Pediatric Ophthalmology and Strabismus (AAPOS) 2019].

Convergence Insufficiency: Inability to maintain binocular function (keeping the two eyes working together) while working at a near distance. Typically, one eye will turn outward (intermittent Exotropia) when focusing on a word or object at near distance (AAPOS, 2020).

Esotropia: A form of Strabismus (eye misalignment) characterized by an inwards turn of one or both eyes. It may be intermittent or constant and may occur with near fixation, distance fixation, or both. The crossing may occur mostly with one eye or may alternate between eyes. It is the opposite of crossed eyes, or Exotropia. Esotropia may occur at any age (AAPOS, 2019).

Exotropia: A form of Strabismus in which one or both eyes turn outward. It is the opposite of crossed eyes, or Esotropia. Exotropia may occur from time to time (intermittent Exotropia) or may be constant, and is found in every age group (AAPOS, 2019).

Occlusion Therapy: Patching or Occlusion Therapy is the mainstay of Amblyopia treatment. Patching the unaffected, or good eye provides monocular stimulation to the amblyopic eye, promoting visual development. Occlusion Therapy is prescribed to improve vision, and as a rule, does not eliminate Strabismus (AAPOS, 2021).

Orthoptic Therapy: A series of exercises, usually weekly over several months, performed in the optometric office. Orthoptic eye exercises (orthoptics), as used by pediatric ophthalmologists and orthoptists, are eye exercises to improve binocular function and are taught in the office and carried out at home. Orthoptics is a well-established profession performed by orthoptists who work within the sub-specialty of ophthalmology. Orthoptists evaluate and measure eye deviations, manage Amblyopia treatment and treat small intermittent symptomatic eye deviations (AAPOS, 2020). Also referred to as Vision Therapy. The profession of orthoptics includes the evaluation and treatment of disorders of the visual system, particularly involving binocular vision and eye movement [American Association of Certified Orthoptists (AACO) 2018].

Pharmacologic Penalization Therapy: The instillation of pharmacologic drops (e.g., atropine) to penalize the better seeing eye by forcing the brain to pay attention to the image coming from the weaker eye, prompting the brain to learn to see better from the weaker eye (AAPOS, 2021).

Prism Adaptation Therapy: The use of clear, triangular shaped objects that bend light to permit alignment of the visual axes, simulating the absence of Strabismus. It is also proposed to determine the angle of deviation or the target angle more accurately to determine the angle of deviation or the target angle for Strabismus surgery [American Academy of Ophthalmology (AAO), 2018].

Strabismus: Misalignment of the eyes. Strabismus is most commonly described by the direction of the eye misalignment such as Esotropia, Exotropia, and hypertropia (AAPOS, 2020).

Vision Restoration Therapy (VRT): An in-home computer-based program designed to strengthen the visual information processing of residual neuronal structures that have survived following acute lesions of the nervous system resulting from trauma, stroke, inflammation, or elective surgery for removal of brain tumors. It is argued that by repeated activation through the course of the therapy, individuals use the program to train and improve their impaired visual functions and thus regain useful vision in the visual field deficit (NovaVision, 2021).

Vision Therapy: Optometrists define Vision Therapy as an attempt to develop or improve visual skills and abilities; improve visual comfort, ease, and efficiency; and change visual processing or interpretation of visual information. An optometric Vision Therapy program consists of supervised in-office and at home reinforcement exercises performed over weeks to months. In addition to exercises, lenses (“training glasses”), prisms, filters, patches, electronic targets, or balance boards may be used (AAPOS, 2020).

Applicable Codes

The following list(s) of procedure and/or diagnosis codes is provided for reference purposes only and may not be all inclusive. Listing of a code in this policy does not imply that the service described by the code is a covered or non-covered health service. Benefit coverage for health services is determined by the member specific benefit plan document and applicable laws that may require coverage for a specific service. The inclusion of a code does not imply any right to reimbursement or guarantee claim payment. Other Policies and Guidelines may apply.

CPT Code	Description
0687T	Treatment of amblyopia using an online digital program; device supply, educational set-up, and initial session
0688T	Treatment of amblyopia using an online digital program; assessment of patient performance and program data by physician or other qualified health care professional, with report, per calendar month
0704T	Remote treatment of amblyopia using an eye tracking device; device supply with initial set-up and patient education on use of equipment
0705T	Remote treatment of amblyopia using an eye tracking device; surveillance center technical support including data transmission with analysis, with a minimum of 18 training hours, each 30 days
0706T	Remote treatment of amblyopia using an eye tracking device; interpretation and report by physician or other qualified health care professional, per calendar month
92065	Orthoptic training; performed by a physician or other qualified health care professional
92066	Orthoptic training; under supervision of a physician or other qualified health care professional
92499	Unlisted ophthalmological service or procedure

Benefit Considerations

Certain UnitedHealthcare plans exclude benefits for Vision Therapy (orthoptic training). Refer to the member specific benefit plan document for details.

Description of Services

For purposes of this policy, Orthoptic or Vision Therapy does not include the use of refractive treatment, including refractive lenses.

Vision Therapy is also referred to as eye exercise therapy, Visual Therapy, visual training, vision training, Orthoptic Therapy, orthoptics, orthoptic Vision Therapy, or optometric Vision Therapy. It is a term used by optometrists and is defined as an attempt to develop or improve visual skills and abilities; improve visual comfort, ease, and efficiency; and change visual processing or interpretation of visual information. An optometric Vision Therapy program consists of a series of supervised in-office and at home reinforcement exercises performed over weeks to months (AAPOS, 2020).

Behavioral/visual perceptual therapy is a psychoeducational intervention intended to correct visual-motor or perceptual-cognitive deficiencies that are claimed to contribute to a delay in speech and language development in preschool children. It involves eye exercises to improve visual processing and perception (AAPOS, 2020).

Visual information processing evaluation (VIPE) identifies problems with the processing of information for enhanced school and/or social development. Visual processing refers to a group of skills used for interpreting and understanding visual information. The evaluation may include testing for visual spatial orientation skills, visual analysis skills, including auditory-visual integration, visual-motor integration skills, and rapid naming.

Clinical Evidence

Orthoptic Therapy or Vision Therapy (VT) for Treating Convergence Insufficiency (CI)

A 2023 Hayes Health Technology Assessment evaluated VT for treating children and younger adults with accommodative dysfunction with or without concomitant CI. The assessment concluded that there is an overall low-quality body of evidence indicating that VT is safe and expected to correct the symptoms and measures of accommodative dysfunction compared with baseline and alternative treatments. Some studies considered results beyond the end of VT to see if outcomes were sustained, and two studies gauged an individual's symptoms, with most counting on intermediate/surrogate results of accommodative function to assess success. In addition, there was a sizable variation in the precise indications for therapy and the types of VT provided. In the 2024, updated Hayes health technology assessment, there were no new relevant published studies that met the inclusion criteria set, and no change in the previous overall assessment. There is a need for additional well-designed studies to outline the modes and treatment schedules that would be most effective and address the comparative efficiency of VT with clinical alternatives.

In 2022, Li et al. conducted a pilot randomized controlled trial (RCT) to compare the effectiveness of virtual reality-based VT and office-based vergence/accommodative therapy in young adults with CI or accommodative dysfunction. Individuals were randomly assigned in a 1:1 ratio to participate in one of two groups, the virtual reality-based VT group, or the office-based vergence/accommodative therapy group. Both groups received 12 weeks (one hour a week) of VT. A subjective questionnaire-based assessment was performed at baseline and after six and 12 weeks of therapy, binocular vision (BV) functions were also measured. After 12 weeks of treatment, 33 participants with CI and 30 with accommodative dysfunction completed the study. The study demonstrated significant improvements in both groups after 12 weeks of therapy with a Convergence Insufficiency Symptom Survey (CISS) score of ($F = 13.704$, $p < 0.001$), near point of convergence (NPC) ($F = 21.774$, $p < 0.001$), positive fusional vergence (PFV) ($F = 71.766$, $p < 0.001$), and near horizontal phoria ($F = 16.482$, $p < 0.001$). Furthermore, improvements in the monocular accommodative amplitude ($F = 22.154$, $p < 0.001$) and monocular accommodative facility ($F = 86.164$, $p < 0.001$). Between the two groups a statistically significant difference was seen in monocular accommodative facility ($F = 8.140$, $p = 0.009$), however not in other vergence and accommodative functions ($0.098 < p < 0.687$). The study's limitations included the lack of a placebo/sham control group, small sample size, and short follow-up. From the trial, the authors concluded that virtual reality-based VT significantly improved BV functions and symptoms for individuals with CI and accommodative dysfunction, suggesting the therapy as a new optional or additional treatment for young adults with these conditions (Included in the 2023 Hayes Technology Assessment).

Alvarez et al. (2020) conducted a double-masked, RCT to study the neuro mechanism of CI in (n = 50) adult participants. The participants were randomized into two groups. Group one received office-based vergence/accommodative therapy and group two received office-based placebo therapy (OBPT). Office-based therapy was administered by a trained therapist during a biweekly, 60-minute office visit. The participants were prescribed additional procedures to be performed at home for 10 minutes a day, three times per week during the duration of the therapy. Home therapy was to be conducted on days when office-based therapy was not conducted. The objective was for participants to attend two 60-minute therapy sessions per week for 6 weeks. The home therapy was all computer based through [Home Therapy System (HTS), visiontherapysolutions.net]. The HITS program was used for the vergence/accommodative therapy group and a custom designed HTS program was used by the placebo. Outcomes measured were near point convergence, PFV and self-reported symptoms through a CISS score. The mean NPC improved by 6.0 and 3.1 cm in both the office-based vergence/accommodative and OBPT groups. With a MD of −2.9 cm; 95% CI, −4.6 to −1.0 cm; $p < .01$. The mean PFV increased by 17.3 and 7.4Δ in both the office based vergence/accommodative and OBPT groups. With an MD of 9.9Δ; 95% CI, 4.9 to 16.0Δ; $p < .001$. The mean CISS score improved by 12.4 and 10.1 points in both the office-based vergence/accommodative and OBPT groups. With an MD of 2.3 points; 95% CI, −8.3 to + 4.6 points; $p = .56$. The authors concluded that after twelve one-hour sessions that the office-based vergence/accommodative therapy group outcomes were significantly more effective than group of OBPT for improving clinical outcomes of NPC and PFV in the participants. However, the CISS measurements were not significantly different between the two groups.

In a Cochrane Database Systematic Review and network meta-analysis (NMA), Scheiman et al. (2020) analyzed twelve RCTs that included both children and adults (n = 1289) with symptomatic CI. The study measured the effectiveness of non-surgical interventions for CI. The outcomes measured required both clinical measures of convergence to be normal and show a pre-specified degree of improvement. The seven interventions measured were as follows: 1.) office-based vergence/accommodative therapy with home reinforcement; 2.) home-based pencil/target push-ups; 3.) home-based computer vergence/accommodative therapy; 4.) office-based vergence/accommodative therapy alone; 5.) placebo vergence/accommodative therapy or other placebo intervention; 6.0 prism reading glasses; and 7.0 placebo reading glasses. This systematic review and NMA found with a high-certainty of evidence that office-based vergence/accommodative therapy with home reinforcement increases the chance of a successful outcome, compared with home-based computer vergence/accommodative therapy [risk ratio (RR) 1.96, 95% CI 1.32 to 2.94], home-based pencil/target push-ups (RR 2.86, 95% CI 1.82 to 4.35); and placebo (RR 3.04, 95% CI 2.32 to 3.98). However, there was no evidence of any treatment difference between home-based computer vergence/accommodative therapy and home-based pencil/target push-ups (RR 1.44, 95% CI 0.93 to 2.24; low-certainty evidence), or between either of the two home-based therapies and placebo therapy to be considered effective treatment. The authors concluded that office-based vergence/accommodative therapy with home reinforcement is more effective than home based pencil/target push-ups or home-based computer vergence/accommodative therapy for children. The evidence is unclear in adults as to which of the therapies is more effective. The findings are limited by the indirect comparisons of NMA.

An RCT (CITT-ART Investigator Group, 2019) was designed to determine whether treating symptomatic CI would lead to better reading fluency and comprehension. Three hundred eleven children aged 9 to 14 years with symptomatic CI were randomly assigned to 16 weeks of office-based vergence/accommodative therapy or placebo therapy. Improvements in (1) NPC, (2) PFV, and (3) self-reported symptoms CISS score were compared after 16 weeks of treatment. The results showed mean NPC improvement of 10.4 cm in the vergence/accommodative group, and 6.2 cm in the placebo therapy, mean PFV increased 23.2 and 8.8 in the vergence/accommodative and placebo therapy groups, respectively as well as a

mean CISS score improvement of 11.8 and 10.4 points in the vergence/accommodative and placebo therapy groups, respectively. The authors concluded that these results demonstrate that office-based vergence/accommodative therapy is effective for improving the NPC and PFV in children with symptomatic CI. However, given that both treatment groups had a similar reduction in self-reported symptoms, it may not be prudent to use the CISS alone as a measure of successful treatment. (Included in the Scheiman et al. 2020 systematic review). In 2024, Morrison et al. assessed the long-term stability of clinical measures of convergence and in participants enrolled in the CITT-ART who received 16 weeks of office based vergence/accommodative therapy. A total of 310 children, (9-14 years old), with symptomatic CI were enrolled in CITT-ART. A total of 270 participants completed both their 16-week primary outcome visits followed by a 1-year follow-up visit. Of those 270, 181 (67%) were randomised to the vergence/accommodative therapy. Of the 181 in the vergence/accommodative group, 121 (67%) reported not receiving any additional treatment after the 16-week primary outcome visit. The mean change in NPC, PFV and percentages of children classified by the predetermined success criteria of convergence [normal NPC (< 6 cm) and/or improved by ≥ 4 cm; normal PFV (passing Sheard's criterion and base-out break > 15Δ) and/or improved by ≥ 10Δ] were compared at the 16-week primary outcome visit and 1 year later. The trial demonstrated results that included 121 participants that returned for their 1 year follow up visit and no significant change in mean adjusted NPC was seen. There was a statistically significant decrease in mean-adjusted PFV (-4.7Δ; 95% CI: -6.5 to -2.8Δ) at 1 year. There were similar percentages of participants classified as 'normal' ($p = 0.30$), 'normal and/or improved' ($p > 0.50$) and 'normal and improved' ($p > 0.14$) based on NPC and PFV at the 1-year visit compared with the 16-week primary outcome visit. The limitation of this study is that one-third of the original trial participants were excluded because they either received additional treatment or did not report whether additional treatment was received between treatment cessation and their one year follow up visit. The authors concluded that the improvements in NPC and PFV following 16 weeks of vergence/accommodative therapy (with no reported additional treatment thereafter) in children with symptomatic convergence insufficiency persisted 1-year post-treatment.

In a systematic review of the literature on orthoptic therapy for CI, Rucker & Phillips (2018) reported that convergence exercises reduce symptoms and improve signs of CI in otherwise healthy people. Those with learning disabilities (LD), poor reading ability, dyslexia, or Attention Deficit Hyperactive Disorder (ADHD) do not consistently have unique ocular motor deficits, nor do people who acquire ocular motor deficits develop these conditions, and there is insufficient evidence that shows treatment consisting of repetitive ocular motor tasks improves LD, reading, dyslexia, or ADHD. The most efficacious convergence tasks and the optimal duration and frequency of these tasks remain unknown.

The National Eye Institute sponsored the Convergence Insufficiency Treatment Trial (CITT) study was an RCT comparing the effectiveness of different treatment options for the condition in 221 children (age 9 to 17 years). Three types of VT were compared with a placebo therapy intervention. VT included: (1) office-based VT with at-home exercises; (2) home-based pencil push-ups with additional computer vision therapy (HBCVAT+); and (3) home-based pencil push-up (HBPP) therapy alone. The placebo therapy group was given placebo vision activities that simulated office-based therapy. The study found that after 12 weeks of treatment, nearly 75% of children who received office-based VT with at-home reinforcement achieved normal vision or had significantly fewer symptoms of CI. In comparison, only 43% of participants who completed home-based therapy alone showed similar results, as did 33% of those who used HBCVAT+ and 35% of people who underwent OBPT (Convergence Insufficiency Treatment Trial Study Group, 2008).

Occlusion or Pharmacologic Penalization for Amblyopia

In 2025, Hernández-Andrés et al. conducted a randomized trial study to compare the results of three treatments, two combining patching with active therapy and one with patching alone, in a sample of 52 children with amblyopia. The protocols developed were: (a) perceptual learning with a computer game designed to favor the medium-to-high spatial frequency-tuned achromatic mechanisms of parvocellular origin and (b) VT with a specific protocol and 2-h patching. The third treatment group used patching only. There were Fifty-two children with amblyopia (aged 4-12 years) that were randomly allocated to three monocular treatment groups: 2-h patching (n = 18), monocular perceptual learning (n = 17) and 2-h patching plus vision therapy (n = 17). Visual outcomes were evaluated after 3 months and compared with a control group (n = 36) of individuals with normal vision. Through the study, the authors found that visual acuity (VA) and stereoacuity (STA) improved significantly following treatment for the three groups with the greatest outcomes favoring patching plus VT, followed by monocular perceptual learning, with patching only least effective. The change in the interocular difference in VA was significant for monocular perceptual learning and then patching. The differences in STA amongst groups were not significant. The final outcomes for VA and interocular differences were influenced by the baseline VA and interocular difference, respectively, with superior improvements in those with poorer initial values. The limitations of the study included a lack of adherence to treatment, inability of the Preschool test to measure greater disparities accurately, that is, poorer STA or minor changes due to the reduced number of STA steps, and the potential for bias. The authors concluded that VA and STA improved with the two most active treatments, that is, VT followed by perceptual learning. The worst outcome was seen with patching alone. According to the authors, these outcomes advocate for VT including monocular accommodative exercises, ocular motility and central fixation exercises where the fovea is more active.

Yeritsyan et al. (2024) aimed to evaluate the efficacy of newly developed treatments for amblyopia in children aged seven years and younger while comparing them to the current industry standard of patching. A search of RCTs, systematic reviews, meta-analysis, and narrative reviews relating to amblyopia treatment completed within the last five years uncovered 14 articles for the review. Of the 14 articles, we had eight RCTs, two systematic reviews, one comparative interventional study, and three narrative reviews. Seven of the articles contained data reinforcing the effectiveness of patching while comparing it to other treatment modalities. Findings from five articles backed the use of pharmacologic therapy, specifically atropine when used alongside patching as a more effective alternative to patching alone. However, levodopa plus patching had no advantage over patching alone. Dichoptic training also improved amblyopic-eye VA when used independently or in conjunction with spectacles. Furthermore, dichoptic movie therapy was found to be more effective than patching. Limitations of this review included studies involving young cohorts, some expressed limitations, and dropouts due to poor adherence to protocol by the children. Further studies with larger population pools should consider adherence to treatment and strategies to enhance treatment compliance. Additional studies should consider prescribing these treatments to larger cohorts. In addition, more needs to be learned about these treatments' potential adverse side effects, especially for pharmaceutical therapy. The following publications, discussed in more detail below, were reviewed as part of this systematic review: Zhang et al. 2023; Xiao et al. 2022; Wang et al. 2021; Song et al. 2023; Li et al. 2019; Jost et al. 2022.

Wang et al. (2021) conducted a single center RCT to compare the efficacy of combined atropine and patching therapy (CAPT) versus patching alone in children aged three to 12 years with severe amblyopia. Participants with severe amblyopia resulting from strabismus, anisometropia, or both were randomly assigned to CAPT or patching therapy. Change of the amblyopic eye VA from baseline to six months was the primary outcome measure, and the VA examiner was masked to the treatment groups. Follow-up visits were conducted at three and six months. In total, 53 individuals were randomized to CAPT and 55 to patching therapy. The average baseline amblyopic eye VA was 0.95 (0.22) Logarithm of the Minimum Angle of Resolution (logMAR). At the three-month follow-up visit, the amblyopic eye VA in the CAPT group was more improved than in the patching alone group resulting in an average difference of 0.13 log MAR; 95% CI, 0.4-0.22 log MAR; p = 0.004. The six-month follow-up visit showed the CAPT group with an average improvement in amblyopic eye VA of 0.72 logMAR compared with 0.58 logMAR in the patching alone group resulting in a difference of 0.14 logMAR greater in the CAPT group; 95% CI, 0.05-0.22 logMAR; p = .002. Limitations of the study included a small sample size of children aged 7 to 12 years and the single center design. The study concluded that CAPT and patching alone were efficacious for children aged three to 12 years with severe amblyopia. The differences in improvement of amblyopic eye VA were relatively small; however, CAPT resulted in more significant improvement.

Li et al. (2020) conducted a systematic review and network meta-analysis (NMA) of 23 studies (n = 3279) to establish a comparative efficacy between refractive correction, patching, atropine, atropine weekly plus Plano lens, optical penalization, and binocular therapy for treatment of amblyopia. Only RCTs comparing two or three of the following treatments were included in the NMA: refractive correction, patching for two-hours a day, six hours a day, 12 hours a day and two-hours a day plus doing near activities, patching for two hours plus doing distant activities, atropine daily, atropine weekly, atropine weekly plus a Plano lens over the sound eye, optical penalization, and binocular therapy. Optical penalization was the least effective of all the treatments for the change of VA, refractive lenses [mean difference (MD), 2.9 logMAR lines; 95% credibility interval (CrI), 1.8–4.0], patch two-hours (MD, 3.3; 95% CrI, 2.3–4.3), patching six hours (MD, 3.6; 95% CrI, 2.6–4.6), patch 12 hours (MD, 3.4; 95% CrI, 2.3–4.5), patching two hours plus near activities (MD, 3.7; 95% CrI, 2.5–5.0), patching two hours plus doing distant activities (MD, 3.5; 95% CrI, 2.1–5.0), atropine daily (MD, 3.2; 95% CrI, 2.2–4.3), atropine weekly (MD, 3.2; 95% CrI, 2.2–4.3), atropine weekly plus a Plano lens (MD, 3.7; 95% CrI, 2.7–4.7), binocular therapy (MD, 3.1; 95% CrI, 2.0–4.2). Patching six hours and patching two hours plus doing near activities were better than refractive correction [(MD, 0.73; 95% CrI, 0.10–1.40); (MD, 0.84; 95% CrI, 0.19–1.50)]. The authors concluded the clinical efficacy among various amblyopia treatments was comparable but did not determine any significant differences. Further high-quality RCTs are needed to determine efficacy between refractive correction, patching, atropine, atropine weekly plus Plano lens, optical penalization, and binocular therapy for treatments. The following publications, discussed in more detail below, were reviewed as part of this systematic review: Manh et al., 2018; Herbison et al., 2016; Wallace et al., 2013.

In a Cochrane Database Systematic Review, Li et al. (2019) aimed to synthesize the available evidence regarding the efficacy and safety of conventional occlusion therapy compared to atropine penalization in treating amblyopia. Data was collected and analyzed by two reviewer authors who independently screened abstracts and full-text articles, abstracted data, and assessed the risk of bias. The review included five RCTs and two quasi-RCTs that compared conventional occlusion to atropine penalization for amblyopia. The trials were conducted in six countries with a total of 1,177 amblyopic eyes studied. The investigation resulted in evidence from six trials demonstrating that atropine penalization is as effective as conventional occlusion in improving VA. No evidence indicated a difference in ocular alignment, stereo acuity, or sound eye VA between occlusion and atropine penalization groups. The authors also discovered that both treatments are well tolerated, although atropine was associated with better adherence and quality of life. Atropine had a higher report of AEs

such as reduction in the VA of the good eye not requiring treatment and light sensitivity. AEs in the participants receiving patching were skin, lid, or conjunctival irritation, most commonly than those receiving atropine. Limitations of the search were the clinical heterogeneity and the methodological quality of the included trials, the small number of trials, and differing follow-up examination times. In conclusion, the investigation showed improvements in VA in the amblyopic eye using both conventional occlusion and atropine penalization, and atropine penalization appeared to be as effective as conventional occlusion; however, the magnitude of improvement was different among the trials analyzed.

In a meta-analysis of part-time occlusion (PTO) versus full-time occlusion therapy (FTO) for treatment of amblyopia, Yazdani et al. (2017) included six studies (3 RCTs and 3 non-RCTs). Pooled standardized difference in the mean changes in the VA was 0.337 (lower and upper limits: 0.009, 0.683) higher in the FTO as compared to the PTO group; however, this difference was not statistically significant [p = 0.056, Cochrane Q value = 20.4 (p = 0.001), I2 = 75.49%]. Egger's regression intercept was 5.46 (p = 0.04). The pooled standardized difference in means of VA changes was 1.097 (lower and upper limits: 0.68, 1.513) higher in the FTO arm (p < 0.001), and 0.7 (lower and upper limits: 0.315, 1.085) higher in the PTO arm (p < 0.001) compared to PTO less than two hours. The authors concluded that this meta-analysis showed no statistically significant difference between PTO and FTO in treatment of amblyopia. However, their results suggest that the minimum effective PTO duration, to observe maximal improvement in VA is six hours per day.

In a prospective, multicenter RCT, the Pediatric Eye Disease Investigator Group (PEDIG) evaluated the effectiveness of increasing prescribed daily patching from 2 to 6 hours in children with stable residual amblyopia. The study group consisted of 169 children aged 3 to < 8 years (mean, 5.9 years) with stable residual amblyopia (20/32–20/160) who had received 2 hours of daily patching for at least 12 weeks. The main outcome measure was best-corrected-visual acuity (BCVA) in the amblyopic eye after 10 weeks. Ten weeks after randomization, amblyopic eye VA had improved an average of 1.2 lines in the 6-hour group and 0.5 line in the 2-hour group (difference in mean VA adjusted for acuity at randomization = 0.6 line; 95% CI, 0.3–1.0; p = 0.002). Improvement of 2 or more lines occurred in 40% of participants patched for 6 hours versus 18% of those who continued to patch for 2 hours (p = 0.003). The authors concluded that when amblyopic eye VA stops improving with 2 hours of daily patching, increasing the daily patching dosage to 6 hours results in more improvement in VA after 10 weeks compared with continuing 2 hours daily.

Repka et al. (2014) published a follow up study of a randomized trial using atropine vs. patching for treatment of moderate amblyopia. The VA of individuals at 15 years of age who were younger than 7 years when enrolled in a treatment trial for moderate amblyopia was reported in the original multicenter clinical trial, 419 children with amblyopia (VA, 20/40 to 20/100) were randomly assigned to patching (minimum of 6 h/d) or pharmacologic penalization with atropine sulfate eyedrops, 1% (1 drop daily), for 6 months. Treatment after 6 months was at the discretion of the investigator. Two years after enrollment, an unselected subgroup of 188 children were enrolled into long-term follow-up. At 15 years of age, most children treated for moderate amblyopia when younger than 7 years had good VA, although mild residual amblyopia was common. The authors found the outcome to be similar regardless of initial treatment with atropine or patching. Better VA at the 15-year examination was achieved in those who were younger than 5 years at the time of entry into the RCT (mean logMAR, 0.09) compared with those aged 5 to 6 years (mean logMAR, 0.18; p < .001). When the authors compared subgroups based on original treatment with atropine or patching, no significant differences were observed in VA of amblyopic and fellow eyes at 15 years of age (p = .44 and p = .43, respectively). The authors concluded that the results indicate that improvement occurring with amblyopia treatment is maintained until at least 15 years of age.

In an RCT, Rutstein et al. (2010a) evaluated whether VA improvement with Bangerter filters is similar to improvement with patching as initial therapy for children with moderate amblyopia. The study enrolled 186 children, 3 to < 10 years old, with moderate amblyopia. Children were randomly assigned to receive either daily patching or to use a Bangerter filter on the spectacle lens in front of the fellow eye. Study visits were scheduled at 6, 12, 18, and 24 weeks. At 24 weeks, amblyopic eye improvement averaged 1.9 lines in the Bangerter group and 2.3 lines in the patching group. The authors concluded that because the average difference in VA improvement between Bangerter filters and patching was less than half a line and there was lower burden of treatment on the child and family, Bangerter filter treatment is a reasonable option to consider for initial treatment of moderate amblyopia. The authors indicated that although the MD between groups was only 0.38 line, the end of the CI on the difference was 0.76 line, and thus, treatment with Bangerter filters did not quite meet the prespecified definition of non-inferiority to patching when initiating therapy for moderate amblyopia. However, the authors also did not find that patching was statistically superior to Bangerter filters. Therefore, the authors could not conclude that the Bangerter filter treatment effect is similar to that seen with patching (based on our predefined definition of non-inferiority).

A 2009 multicenter RCT by PEDIG compared weekend atropine sulfate use augmented by a Plano lens for the sound eye (optical penalization/study group) with weekend atropine use alone (pharmacologic penalization/control group) for moderate amblyopia in 180 children aged 3 years to younger than 7 years. Primary outcome measured was masked assessment of amblyopic eye VA using the Amblyopia Treatment Study HOTV testing protocol at 18 weeks. The

researchers concluded that optical penalization was not substantially better than pharmacologic penalization in this population.

Remote, Online, and/or Digital Therapies or Vision Therapy (VT) for Amblyopia

Only limited quality clinical evidence was found to support the superiority of remote, online, or digital orthoptic or VT for amblyopia over conventional treatments. Existing studies are limited by single-arm design, insufficiently long follow-up for a chronic condition, and a large dropout rate.

Ming et al. (2025) conducted a systematic review and meta-analysis on perceptual learning and video game training for adults with monocular amblyopia to analyze the effectiveness of perceptual learning and video game training. To carry out the review, data on interventions, sample size, and log MAR visual acuity (VA) were extracted and analyzed. The review resulted in the identification of 6439 studies with 22 meeting the inclusion criteria. The analysis showed a statistically significant standardized mean difference (SMD) of -0.68 in the experimental group (EG) compared with controls, indicating an improvement in VA ($p < 0.05$). Subgroup analyses indicated that perceptual learning and video game training also resulted in visual improvement ($p < 0.05$). In addition, the results indicated a significant improvement in VA with dichoptic training or monocular training, reaching VA improvement ($p < 0.05$). The authors concluded that targeted visual training facilities neural plasticity reduces interocular suppression, and reinforces neural pathways associated with visual processing. This review is limited by the limitation of the included studies and the heterogeneity in device used. Future research that focuses on refining training protocols to enhance both monocular and binocular visual function most effectively is necessary.

In 2023, Hayes conducted an evolving evidence review on Luminopia One (Luminopia Inc.) for treating amblyopia in children. The review found minimal support from clinical studies, no/unclear support from systematic reviews, and weak support from guidelines for Luminopia One for treating amblyopia in children aged 4 to 7 years of age. Although Luminopia One may improve VA in children aged 4 to 7 years with amblyopia and be more appealing than patching and atropine which could lead to better treatment adherence, future studies are necessary to compare with the current standards of care, and post treatment VA. Additionally, the technology requires internet access and devices, which may be costly and can lead to possible treatment disparities. This review was updated in 2025 resulting in no newly published studies that may meet the inclusion criteria set out in the 2023 report.

In an ECRI clinical evidence assessment published in 2024; the CureSight System (NovaSight, Inc.) was explored for treating amblyopia. The publication concluded that CureSight is safe and may work as well as patching to improve VA at up to one-year follow-up for children with amblyopia, based on evidence from two RCTs and one pre-post study. However, the available studies are small, and added studies are necessary to support firm conclusions about how well CureSight works compared with patching. The existing studies report comparative outcomes at only short-term follow-up. Longer-term studies (e.g., ≥ three years) are needed to consider CureSight's permanent benefit and amblyopia recurrence. One ongoing trial is not likely to address evidence gaps due to the small sample size and single-arm design but will provide outcomes for individuals ages two through 20.

Tsani et al. (2024) explored the use of binocular digital therapy for amblyopia when compared to standard treatments or placebo therapy. The review comprised of randomized controlled trials (RCTs), including individuals with unilateral amblyopia who received binocular therapy or standard amblyopia or placebo treatment for more than two weeks and who had VA assessment pre- and post-treatment. The results of this exploration included 20 RCTs with 1769 individuals incorporated into the review. Two main types were identified: presentation of low-contrast images in the fellow eye, including stimuli presented only in the amblyopic eye and the second type combines the approach with complementary dichoptic deficits in the images presented to both eyes to encourage their simultaneous use. The authors concluded that binocular amblyopia treatment has shown promising results in addressing unilateral anisometropic, strabismic or mixed type of amblyopia. Nevertheless, further RCTs are essential to prove the exact dosage, type, and duration of binocular therapy as a standard component of amblyopia care. The following publications, discussed in more detail below, were reviewed as part of this systematic review: Manh et al., 2018; Pang et al. 2021; Roy et al. 2023; Herbison et al. 2016; Elhusseniny et al. 2021; Jost et al. 2022; Wygnanski-Jaffe et al. 2023; Kadhum et al. 2024).

Through an RCT, Kadhum et al. 2024 sought to compare the efficacy and effectiveness of supervised dichoptic action-videogame play to occlusion therapy in children with amblyopia. The trial, conducted after 16 weeks of refractive adaptation, involved participants who were randomized to gaming one hour a week and supervised or electronically monitored occlusion two hours a day. The primary outcome measured was VA change from baseline to 24 weeks. The results of the trial showed a median VA improvement by 0.30 logMAR (IQR 0.20-0.40) after gaming, 0.20 logMAR (0.00-0.30) after occlusion ($p = 0.823$). Treatment effectiveness was 1.25 logMAR/100 h (range 0.42-2.08) with gaming, 0.08 (-0.19-0.68) with occlusion ($p < 0.001$). The authors concluded that dichoptic gaming presents a promising and practical alternative for older children with refractive amblyopia after glasses adaptation. Treatment efficiency with gaming under

continuous supervision was 15 times greater than with occlusion at home, offering a hopeful prospect for the future of amblyopia treatment. The findings are, however, limited by the large dropout rate and feasibility of researcher-supervised weekly gaming (Included in the 2024 systematic review by Tsani et al.).

In 2024, Wygnanski-Jaffe and associates set out to report the long-term outcomes of a noninferiority RCTs with a binocular eye-tracking-based home treatment (CureSight; Novasight, Ltd.) for those with amblyopia through a prospective, multicenter, nonrandomized, long-term follow-up observational study of an RCT. At 12 weeks post-treatment of the intervention group, improvement in amblyopic eye VA was retained vs. baseline (0.27 ±0.14 logMAR, $p < .0001$), with no change vs the end-of-treatment visit ($p > .05$). At one year there was a partial reduction in the amblyopic eye VA gain of 0.085 ±0.1 logMAR related to end-of-treatment ($p = .001$), but the residual gain of 0.20 ±0.14 logMAR compared to baseline was statistically significant ($p < .0001$). Gains in stereoacuity and binocular VA were maintained vs baseline at both 12-weeks and 1-year post-treatment ($p < .0001$), with no change vs end-of-treatment ($p > .05$). Amblyopia recurrence (a worsening of ≥ 2 logMAR levels compared with end-of-treatment) occurred in 2/38 people at 12-weeks post-treatment (5.3%), and in 5/27 people at 1-year post-treatment (20.4%). The authors concluded that VA and stereopsis gains after binocular treatment with CureSight were retained for one year without further treatment. The findings are, however, limited by lack of comparison groups.

In the 2023 prospective, multicenter, randomized, masked, controlled, noninferiority pivotal clinical trial conducted by Wygnanski-Jaffe and colleagues, the authors compared visual outcomes after the use of binocular eye-tracking based home treatment (CureSight; NovaSight Ltd) with patching. Children aged four to less than nine years with anisometropic, small-angle strabismic, or mixed-mechanism amblyopia (n = 103) were randomized 1:1 to a group getting either CureSight or patching treatment. In the CureSight group, the participants utilized the device for 90 minutes/day, five days/week for 16 weeks (120 hours), while the patching group received two hours of patching seven days a week for 224 hours. The primary outcomes measured were the improvement in the amblyopic eye VA, modeled with a repeated measures analysis of covariance, stereo acuity, binocular VA, and treatment adherence rates, which were evaluated by a 1-sample Wilcoxon test in each group and a 2-sample Wilcoxon test that compared the two groups. The safety results were calculated by the frequency and severity of the study-related adverse events (AE). The trial resulted in the CureSight group VA improvement found to be noninferior to the patching group improvement [0.28 ±0.13 logMAR ($p < 0.0001$) and 0.23 ±0.14 logMAR ($p < 0.0001$), respectively; 90% confidence interval (CI) of difference, - 0.008 to 0.076]. Stereoacuity improvement of 0.40 log arcseconds ($p < 0.0001$) and improved binocular VA (0.13 logMAR; $p < 0.0001$) were observed in the binocular treatment group, with similar improvements in the patching group in stereoacuity (0.40 log arcseconds; $p < 0.0001$) and binocular VA (0.09 logMAR; $p < 0.0001$), with no significant difference between improvements in the two groups in either stereoacuity (difference, 0; 95% CI, - 0.27 to - 0.27; $p = 0.76$) or binocular VA (difference, 0.041; 95% CI, - 0.002 to 0.085; $p = 0.07$). The binocular treatment group had a significantly higher adherence than the patching group (91% vs. 83%; 95% CI, - 4.0% to 21%; $p = 0.011$). No severe AEs were found. The limitations of the study include most individuals having anisometropic amblyopia, lack of generalizability between strabismic and mixed amblyopia populations, and lack of evaluation on the impact of dosing for the rapidity of visual improvement, durability, and effect of subgroups for treatment effectiveness. The authors concluded that the binocular treatment was well tolerated after a 16-week trial period and showed higher regimen adherence rates and parent preferences, though non-inferior to patching for children with amblyopia. Improvements were seen in stereopsis and binocular VA (Included in the 2024 systematic review by Tsani et al.).

In 2023, Roy et al. performed a prospective, randomized, interventional study to evaluate smartphone-based dichoptic video games versus occlusion therapy for children with anisometropic amblyopia. Children aged 5 to 15 with anisometropic amblyopia were included in the study (n = 55) and randomized into two groups: the video game group (n = 27) and the patching group (n = 28). The video game group played a dichoptic video game with adjusted contrast for two hours a day, and the patching group received occlusion therapy of the non-amblyopic eye for six hours a day. The outcomes measured were the BCVA, near vision, contrast sensitivity (CS), and near and distance stereoacuity at baseline, at one, two, and three months. The study's results showed that the mean distance BCVA improved from 0.74 ±0.19 and 0.70 ±0.18 logMAR in the video game and patching groups, respectively, at baseline to 0.53 ±0.19 and 0.49 ±0.19 logMAR, at three months ($p < .001$ for both). The mean near vision was 0.82 ±0.19 and 0.81 ±0.17 logMAR in the video game and patching groups, respectively, at baseline and improved to 0.60 ±0.16 and 0.63 ±0.17 logMAR at three months ($p < .001$ for both). There was no sizable difference in distance and near vision among the two groups at baseline and the last follow-up visit. CS was 1.41 ±0.20 and 1.38 ±0.20 in the video game and patching groups, respectively, at baseline and 1.74 ±0.18 and 1.61 ±0.21 at three months ($p < .001$ for both). At the final follow-up visit, CS was better in the video game group compared to the patching group ($p = .01$). Near stereoacuity notably progressed only in the video game group ($p = .006$); in contrast, distance stereoacuity did not improve in either group. The limitations of the study include the small sample size and lack of long-term follow-up. The authors concluded that dichoptic video game therapy showed better outcomes in terms of improved CS and near stereoacuity and comparable results for distance and near

vision compared to patching for children with anisometropic amblyopia. The accessibility of exciting games is necessary to support children's interests (Included in the 2024 systematic review by Tsani et al.).

In a systematic review and meta-analysis, Shao and colleagues (2023) sought to uncover how VR technology varies from conventional patching therapy's efficacy. The meta-analysis consists of eight studies and ten trials with 459 participants. The results of the review and analysis showed that overall, VR technology treatment considerably improved VA by 0.07 logMAR [95% confidence interval (CI), −0.11 to −0.02; $p < 0.001$; $I2 = 94.4\%$] versus traditional patching therapy. In addition, subgroup analyses also exposed that treatment with VR technology was more efficient when the child was younger than seven years old or when the intervention was no more than twenty hours. The studies limitations include a high degree of heterogeneity, lack of analysis on the effect of VR technology on stereo acuity, and the meta-analysis only included studies published in English. Furthermore, most included studies were of short duration (2-12 weeks), and it is unclear whether the observed benefit would be sustained after the initial interest of the child. The authors concluded that VR technology treatment substantially improved VA for children seven years of age or younger with amblyopia.

In a 2023 systematic review and meta-analysis, Yeh et al. investigated the efficacy of the Cambridge Stimulator with grating element stimulation of VA, grating acuity (GA), and CS for individuals with amblyopia. The search uncovered 1221 studies, with 24 of those studies encompassing 900 individuals included in the review. The results of the review suggested that the outcome measure of all visual indexes (VA: Hedges' g of - 0.43, 95% CI = - 0.81 to - 0.05, $I2 = 86\%$, $p = 0.02$; GA: Hedges' g of 3.79, 95% CI = 1.05 to 6.54, $I2 = 98\%$, $p = 0.01$; CS: Hedges' g of 0.64, 95% CI = 0.19 to 1.09, $I2 = 41\%$, $p = 0.00$) significantly favored in the grating group. The limitations of the study include high risk of bias and the lack of varying methodologies in the study designs. The authors concluded that grating stimulation may positively benefit visual functions for individuals with amblyopia.

In a retrospective interventional comparative study, 36 children with unilateral amblyopia were enrolled to determine the efficacy of VT for unilateral refractive amblyopia in children aged 7-10. For the study, the participants were divided into a case group and a control group. The case group received VT, optical correction, and part-time patching of the weaker eye, and the control group received optical correction and part-time patching of the weaker eye. Outcomes of VA were measured at baseline, three months, six months, nine-month visits, and three months after completion of treatment. The case group consisted of 19 individuals and 17 individuals in the control group. The study showed a mean improvement in the case group from 0.39 ±0.24 logMAR at baseline to 0.10 ±0.23 logMAR after treatment. The results for the control group demonstrated an improvement from 0.64 ±0.30 logMAR at baseline to 0.52 ±0.27 logMAR after treatment. All participants underwent follow-up examinations within six to 12 months, with no regression of VA seen in the case group three months after completion of therapy. Individuals in the case group who received VT demonstrated improved VA versus those who received optical correction and patching. A limitation of the study is the retrospective design which restricts the ability to control and randomize the participants into case and control groups. The authors concluded from the study that for children aged 7-10 with unilateral refractive amblyopia, VT combined with conventional treatment such as optical correction and part-time patching are more effective than traditional treatment alone. Furthermore, the therapy provided more significant vision gain and a shorter duration of treatment when compared to conventional treatment (Hsieh et al., 2022).

In a retrospective comparative study, individuals aged 7-10 years were enrolled to determine the effects of VT on bilateral amblyopia unresponsive to conventional treatment. The control group consisted of 16 cases with age and VA -matched bilateral amblyopes; 15 cases were included in the treatment group. The study showed no improvement in either group for VA for more than three months with part-time patching and full refraction correction. Of 22 eyes, 68.7% showed no improvement in the control group versus the treatment group, which exhibited better VA in every eye. The treatment group revealed significant improvement in BCVA, with an average gain of 0.32 ±0.15 logMAR vs. 0.003 ±0.19 logMAR in the control group. The benefits of treatment are most significant in the first three months of treatment and continue until the endpoint. Results of stereoacuity showed improvements from 190.00 ±163.34 to 85.00 ±61.24 arc seconds (a 55.26% improvement). The l limitations of the study are the retrospective design, which restricts the ability to randomize participants, small sample size, and lack of complete stereoacuity data. The authors conclude that a VT program comprising orthoptic therapy, perceptual learning, and dichoptic training successfully increases VA and stereoacuity in 7–10-year-old individuals with bilateral amblyopia that is unresponsive to conventional treatment (Huang et al., 2022).

In 2022, Jost et al. conducted an RCT to evaluate the effectiveness of dichoptic movies versus patching for treating amblyopia in children aged three to seven. After inclusion and exclusion criteria were met, 65 children were considered eligible, and enrolled in the trial, and 60 participants completed the study through the four-week visit. Children were randomized to a movie group and a patching group. During the first two weeks, the movie group watched 5.7 ±0.7 movies, and the patching group averaged 30.0 ±11.0 hours of patching. At the two-week primary outcome visit, the movie and patching groups had similar improvement in amblyopic eye BCVA (0.07 vs. 0.06 logMAR). Treatment with movie and patching significantly improved VA (0.07 ±0.05 logMAR and 0.06 ±0.05 logMAR, respectively). VA continued to advance

in the movie group after the two-week primary outcome visit, with enhancements of 0.13 ±0.11 logMAR by four weeks and 0.15 ±0.10 logMAR by six weeks. The patching group exhibited comparable improvements after crossing over to movies at two weeks. By week eight, the patching group who crossed over at two weeks gained 0.18 ±0.07 logMAR. The choice to remain in the movie treatment past the four weeks visit for up to six weeks of the movie treatment was chosen by 35 (58%) participants. After six weeks of watching contrast re-balanced dichoptic movies (six-week visit for the movie group and eight weeks visit for the patching group), 26% of children had ≤ 0.1 logMAR interocular difference in VA. The authors concluded that the at-home binocular movie treatment effectively improves amblyopic eye BCVA. Additional improvements were seen with up to six weeks of treatment, making repeated binocular visual experience with contract re-balanced dichoptic movies an additional treatment option for amblyopia. Limitations of the study include short treatment duration, the difference in VA tests, and lack of objective adherence monitoring (Included in the Shao et al. 2023, and Tsani et al. systematic reviews).

Xiao et al. (2022) evaluated the safety and efficacy of a dichoptic digital therapeutic for amblyopia. This phase three RCTs consisted of 105 children aged four to seven with amblyopia and enrolled at 21 academic and community sites in the United States. Individuals were randomized to the treatment or comparison group in a 1:1 ratio and stratified by site. The treatment group consisted of 51 participants and 54 in the comparison group. Individuals in the comparison group continued to wear glasses on a full-time basis while the treatment group used the therapeutic at home for one hour a day, six days a week, and wore glasses full-time. To determine efficacy, the change in amblyopic eye VA from baseline to 12 weeks was measured by masked examiners. The authors evaluated the frequency and severity of study-related AEs (anticipated and unanticipated) to determine the therapy's safety. The intention-to-treat population was utilized to develop a primary analysis. In the treatment group at 12 weeks, amblyopic eye VA improved by 1.8 lines (95% CI, 1.4-2.3 lines; n = 45); and in the comparison group, there was an improvement of 0.8 lines (95% CI, 0.4-1.3 lines; n = 45). The difference between groups was significant 1.0 line (0.10 logMAR; 96.14% CI, 0.33-1.63 lines; p = 0.0011). Individuals sustained high adherence to the therapeutic throughout the study, and adherence was associated with overall satisfaction. No serious AEs were reported, and the study was stopped early per protocol due to success. Limitations include the lack of comparison between patching and atropine penalization, short follow-up time, and risk of bias. The authors support the value of the therapeutic in clinical practice as an effective treatment. Additional independent studies with longer follow-up and sham interventions are warranted to confirm the long-term value of this approach over or in addition to standard treatments (Included in the Shao et al. 2023, and Tsani et al. systematic reviews).

In 2021, Roda et al. conducted a systematic review and meta-analysis of RCTs to summarize the available evidence to determine if binocular treatment is more effective than patching in children with amblyopia. VA and stereopsis were assessed as primary outcome measures. Out of five RCTs, no significant difference in VA between individuals treated with binocular treatment and patching was demonstrated at -0.12 (95% CI: -0.45–0.20; p = 0.464). Additionally, no significant difference in stereopsis was found between individuals treated with binocular treatment versus patching -0.07 (95% CI: -0.61–0.48; p = 0.809). Limitations to the study include the high heterogeneity in effect estimation, inconsistency between studies, and the lack of consideration regarding cost and availability of treatment. The authors concluded that this meta-analysis uncovered no substantial evidence that supports the efficacy of binocular therapy as an alternative to traditional patching. Although binocular treatment can be considered a good complementary therapy in particular cases, it cannot fully replace conventional treatment. The following publications, discussed in more detail below, were reviewed as part of this systematic review: Manh et al., 2018; Rajavi et al., 2019.

Elhusseiny et al. (2021) conducted a pilot, prospective, randomized, double-masked, crossover clinical trial at a single center site using (n = 20) children and young adult participants. The participants had unilateral anisometropic and/or strabismic amblyopia with amblyopia treatment failure. Eleven participants underwent eight weeks of binocular treatment using a VR headset that contained a therapeutic software application. The sham-crossover group (n = 9) underwent four weeks of sham treatment followed by four weeks of binocular treatment. Both groups underwent one hour of treatment per day. Participants and clinicians were masked to prescribed treatment. The devices were loaned to the participants and devices used were Apple iPhone 6 Plus smartphone, preloaded with the prototype therapeutic software, and a Zeiss VR One Plus VR headset that delivered the visual input to each eye dichotically. Outcomes in the full-treatment group (n = 11), the mean amblyopic eye logMAR VA at 16 weeks was 0.49 ±0.26, compared with 0.47 ±0.20 at baseline. Compared to the sham-crossover group, it was 0.51 ±0.18 at 16 weeks, compared with 0.53 ±0.21 at baseline. Stereoacuity (log arcsec) was significantly improved, from 7.3 – 2 at baseline to 6.6 – 2.3 at 8 weeks (p < 0.001) and 6.7 – 2.6 at 16 weeks (p < 0.001). No significant AEs (diplopia, asthenopia, or worsening strabismus) were noted in either group. The authors concluded that virtual reality-based prototype binocular amblyopia therapy did not significantly improve VA. Stereoacuity did improve compared to baseline measurements when all participants were combined. The study is limited by its small sample size and short follow-up. The authors report that they did not achieve the target sample size due to participant attrition (Included in the Shao et al. 2023, and the Tsani et al. 2024 systematic reviews).

Birch et al. (2020) conducted an RCT with (n = 48) children diagnosed with amblyopia. The children were randomly divided into two groups. Group one (n = 24) received binocular amblyopia game treatment for one hour a day, five days a week. Group two (n = 24) received patching treatment for two hours per day, seven days a week. The outcomes measured were changes in the amblyopic eye best-corrected VA at the two-week visit. Baseline factors examined were age at enrollment, VA, stereoacuity, and suppression. At baseline, the mean amblyopic eye best-corrected VA ±standard deviation (SD) was 0.49 ±0.16 logMAR (~20/63 ±1.6 lines), range = 0.3–0.8 logMAR (20/40–20/125). VA was 0.3–0.6 logMAR (20/40–20/80) in 38 (79%) children and 0.7–0.8 logMAR (20/100–20/125) in 10 (21%) children. After two weeks, the measurements for group one, who received binocular amblyopia game treatments showed improvement which ranged from 0.0 to 0.4 logMAR; 21 children (87.5%, CI95% = 69%–96%) improved by 0.1 logMAR or more (2 improved 0.3-0.4 logMAR, 10 improved 0.2 logMAR, 9 improved 0.1 logMAR), and three children did not improve (12.5%, CI95% = 4%–31%). Group two, who received patching treatment, showed improvement which ranged from −0.1 to 0.2 logMAR; 12 children (50%, 95%CI = 31%–69%) improved by 0.1 logMAR or more (5 improved 0.2 logMAR, 7 improved 0.1 logMAR), and 11 children (46%, CI95% = 28%–65%) did not improve, and one child (4%, CI95% = 1%–20%) decreased by −0.1 logMAR. At the 2-week visit, 35% (95%CI: 19% - 55%) of children playing the binocular game recovered normal VA for age (≤ 0.2 logMAR; 20/32 or better). Only 8% (CI95% = 2% - 26%) of the children in the patching group had recovered normal VA for age at the 2-week visit. The authors concluded that after two weeks of treatment, VA improvement was significantly greater with the binocular game treatment than patching. Children with moderate amblyopia and orthotropia had more VA improvement with binocular game play than those with severe amblyopia. Limitations of this trial include small sample size; short time duration and inability to monitor the number of hours of patching objectively. The authors relied on a calendar log completed by their parents.

Rajavi et al. (2019) conducted an RCT with 38 children diagnosed with unilateral amblyopia who received amblyopia therapy via interactive binocular treatment (I-BiT™) and others received standard patching of the dominant eye with a placebo I-BiT. Children who had BCVA less than 20/30 (0.3 logMAR) in one eye or a difference of two lines of Snellen between their two eyes were included in this study and randomly divided into the case study group (n = 19) and control group (n = 21). The case study group was recommended to play the I-BiT games using red-green glasses, 20 to 30 minutes per day for at least five days a week for one month (total hours = 6). The control group underwent two- and four-hour patching of dominant eye per a day and to play I-BiT games with no red-green glasses, 20 to 30 minutes per day for at least five days a week for one month. The authors concluded that BCVA improved significantly in both groups after one-month treatment (case: $p = 0.003$, control: $p < 0.001$). There was not a significant difference between the two groups ($p = 0.52$). Stereopsis improved in the case study group by ($p < 0.001$) and control group by ($p < 0.001$), but they did not identify large difference between the two groups pre- and post-therapy. The children engaged in playing I-BiT games for six hours total during one month in both groups. Compliance in the case study group was 87.5% and 76% in the control group. Limitations of this study include a small sample size, the short study duration, and lack of monitoring for recurrence of decreased BCVA. Additionally, some participants were excluded after randomization due to lack of compliance, which could introduce biases in the findings (Included in the Shao et al. 2023, and the Tsani et al. 2024 systematic reviews).

Manh et al. (2018) conducted an RCT to compare VA improvement of 100 participants aged 13 to < 17 years (mean 14.3 years) with amblyopia who were treated with either part-time eye patching or a binocular game on a tablet device. Participants were randomly assigned to treatment for 16 weeks of either the binocular game prescribed for 1 hour per day (n = 40) or patching of the fellow eye prescribed for 2 hours per day (n = 60). The main outcome measured was a change in amblyopic eye VA from baseline to 16 weeks. Mean amblyopic eye VA improved from baseline by 3.5 letters (2-sided 95% CI: 1.3-5.7 letters) in the binocular group and by 6.5 letters (2-sided 95% CI: 4.4-8.5 letters) in the patching group. After adjusting for baseline VA, the difference between the binocular and patching groups was -2.7 letters (95% CI: -5.7 to 0.3 letters, p = .082) or 0.5 lines, favoring patching. In the binocular group, treatment adherence data from the device indicated that only 13% of participants completed > 75% of prescribed treatment. In this population, eye patching was favored over the binocular group; however, it remains unclear whether the minimal response to binocular treatment was due to poor treatment adherence or lack of treatment effect (Included in the 2024 systematic review by Tsani et al.).

In 2016, Herbison et al. conducted a three-arm RCT that was performed on children with Amblyopia. The (n = 75) children were randomized and assigned one of three treatments I-BiT game (n = 26), Non-I-BiT game (n = 25) and I-BiT digital video disc (DVD) (n = 24). The I-BiT game being used is VR technology that uses either DVD footage or computer games that present a common background for both eyes and a foreground that contains imagery of interest for the amblyopic eye only. The assigned groups received treatment for 30 minutes weekly for six weeks. The primary outcome is the difference in VA between the group treated with I-Bit game versus non-I-Bit game which I measured by using a logMAR VA test at pretreatment (baseline), and after three, six and final treatment over 10 weeks. The secondary outcomes included changes in stereoacuity (Frisby test), safety, acceptability, and compliance during treatment. The authors concluded that modest VA improved in all three arms by approximately 0.07 logMAR in the amblyopic eye at 6 weeks. There was not a significant difference between I-BiT DVD and non-I-BiT games compared with I-BiT games in terms of improvement of vision. The limitations of the trial are short treatment times, trial was hospital based during work and school hours with

limited the duration and frequency of treatment sessions, a high number of participants with previous amblyopia treatment failures, and a high number of participants with strabismus created disadvantages for dichoptic stimulation. An adverse effect reported of diplopia which led to decreased VA and participant withdrawal from the trial. Further, I-BiT game multi-center and longer duration studies are needed with the amblyopic population. Lack of comparison with conventional amblyopia therapy is another limitation of this study (Included in the Shao et al. 2023, and Tsani et al. 2024 systematic reviews).

Prism Adaptation Therapy for Esotropia

In a 2022 single-center retrospective study, Gietzelt et al. aimed to evaluate the effects of the prism adaptation test (PAT) on the angle of squint (AOS) in decompensated esophoria (decEPH) and decompensated microesotropia (decMET). The medical records of individuals at least 12 years of age diagnosed with decEPH or decMET and treated with strabismus surgery for the first time were reviewed. To measure outcomes, the maximum AOS for far (F) and near (N) fixation, PAT results, AOS (F) and AOS (N) after surgery, and results of binocular function tests were utilized. A total of 182 participants were included in the study; 100 were included in the decEPH group and 82 in the decMET group. Results from the decEPH group AOS before surgery were 25.5 ±8.8 pdpt (F) and 23.5 ±9.8 pdpt (N). During PAT, the AOS increased significantly by 2.7 ±4.3 to 28.2 ±8.6 pdpt (F) and by 4.9 ±4.5 to 28.3 ±9.5 pdpt (N). As a whole, 82% of individuals with decEPH showed AOS (F) and/ or AOS (N) in or decreased by at least 3 pdpt. In the decMET group, AOS before surgery was 28.6 ±10.8 pdpt (F) and 30.9 ±11.8 pdpt (N). During PAT, the AOS increased significantly by 4.2 ±5.8 to 32.5 ±9.5 pdpt (F) and by 3.7 ±6.1 to 34.4 ±9.5 pdpt (N). Altogether, 51% of individuals with decMET showed AOS (F) and/ or AOS (N) increased by at least 10 pdpt. A limitation of the study is the difficulty of diagnosing decEPH and decMET due to the young age of individuals with unreliable results of orthoptic and stereo function tests. PAT demonstrated remarkable changes in AOS in both decEPH and decMET. The authors concluded that for individuals with decEPH preoperative assessment of “true AOS” utilizing PAT is essential for successful strabismus surgery (82% had dose-relevant angle changes ≥ 3 pdpt), and preoperative PAT is of great diagnostic value for individuals with decMET (51% had changes in AOS beyond the expected microtropic angle, ≥ 10 pdpt, or even a dose relevant angle decrease, ≥ 3pdpt).

In 2021, Crouch et al. conducted a prospective observational study to describe 10-week and 12-month outcomes following treatments for adult-onset divergence insufficiency-type esotropia. The study consisted of 110 adults with divergence insufficiency-type esotropia initiating a new treatment and enrolled at 28 sites. The participants had a distance esodeviation measuring 2 to 30 D and at least 25% larger at a distance than near, and binocular diplopia present at least “sometimes” at a distance. At enrollment, 10-weeks and 12-month follow-ups, diplopia was assessed using a standardized diplopia questionnaire (DQ). A successful outcome was defined as having DQ responses of ‘rarely’ or ‘never’ when looking straight ahead in the distance, with no alternative treatment introduced. The study resulted in 32 (29%) individuals being prescribed base-out prism; none had received prior treatment for esotropia. At 10 weeks, 22 of 30 participants met success criteria (73%; 95% CI, 54%-88%), and 16 of 26 at 12 months (62%; 95% CI, 41%-80%). Success criteria were met by 69 of the 74 participants who underwent strabismus surgery at ten weeks (93%; 95% CI, 85%-98%) and by 57 of 72 at 12 months (79%; 95% CI, 68%-88%). The authors concluded that strabismus surgery and base-out prism as initial therapy successfully treated diplopia for most adults with divergence insufficiency-type esotropia at a 12-month follow-up. Limitations to the study included the lack of untreated controls and lack of randomization, short follow-up period, and the risk of misclassification.

In a 2019 retrospective case control study, Choe et al. aimed to investigate the long-term outcome of prism glasses after full hypermetropic correction for partially accommodative esotropia (PAET). 124 children aged 10 or younger with a residual esotropia of ≤ 20 prism diopters (PD) after full hypermetropic correction who were fitted with prism glasses and followed for 3 or more years were included. Clinical characteristics and the angle of esodeviation were obtained at each follow-up examination. Successful motor outcome after 3 years of prismatic correction was determined if the residual angle of esotropia after full hypermetropic correction was ≤ 10 PD. The results showed 30.6% success with 7.3% weaned off prism glasses after three years of prism-wear. Smaller amount of latent esodeviation ($p = 0.001$) revealed by prism adaptation (PA) and good fusional response at near with the Worth 4-dot test were significant prognostic factors of success by multivariate analysis ($p = 0.033$). After 3 years of wearing prism glasses, the rate of improvement in stereoacuity was higher in the Success group (60.5% vs 27.9%) ($p = 0.001$), however, there was no significant difference between the prism-weaned group and prism-wearing group within the Success group ($p > 0.05$). The authors concluded that prism glasses for small angle PAET can be a treatment option for individuals who have a small angle of latent esodeviation revealed by PA and good sensory function at near, but early surgery may be better as the majority of individuals showed suboptimal outcomes even after long-term wearing of prism glasses.

In a retrospective review, Quigley et al. (2017) evaluated the PAT response and postoperative outcomes in a cohort of children with accommodative esotropia who underwent bilateral medial rectus recession. The authors reported that 36% of people showed a requirement for increased prism dosage to maintain orthotropia during PAT; these participants did better than those whose deviation was stable, with postoperative rate of motor success (defined as ≤ 10△ esotropia) of

100% versus 56%. PAT may be a useful positive prognostic test, and it also identifies a substantial population who may avoid under correction, the prism builders. The authors suggest that additional randomized studies are required to demonstrate definitive benefit of PAT.

The National Eye Institute sponsored the Prism Adaptation Study (PAS), a multicenter RCT to determine the overall effect of PA. The study randomized 333 eligible participants who were at least 3 years of age, had no previous eye surgery, and had acquired deviations of 12 to 40 PD. All participants had 20/40 or better VA in each eye, and individuals with amblyopia underwent occlusion therapy before entry. Two levels of randomization were used. Sixty percent of the individuals (n = 199) underwent PA and 40% (n = 134) did not. Those who did not have PA underwent conventional surgery for their entry angle of deviation. Of those who responded to prisms with motor stability and sensory fusion (n = 131), half (n = 67) underwent a conventional amount of surgery, i.e., surgery for angle at entry, and half (n = 64) underwent augmented surgery based on the prism-adapted angle of deviation. A successful outcome was defined as a deviation of less than or equal to eight PD of esotropia or exotropia. Success rates 6 months after surgery were highest in PA responders who underwent augmented surgery and lowest in those who did not undergo PA (89% versus 72%). The estimated overall rate of success for people who went through the PA process was significantly better than the success rate of participants who did not undergo PA but underwent surgery for their deviation at entry into the study (83% versus 72%). The investigators concluded that there was a beneficial overall effect of the PA process for those with acquired esotropia (PAS Research Group, 1990).

In 2021, the American Academy of Ophthalmology (AAO) conducted an Ophthalmic Technology Assessment on the efficacy of vergence and accommodative therapies in treating symptomatic CI in children and young adults. The AAO reviewed home- and office-based vergence and accommodative therapies for the treatment of CI through a literature search. The exploration yielded 12 full-text articles appropriate for inclusion in the assessment. Out of the 12 studies, two RCTs discovered that office-based vergency and accommodative therapies effectively improved motor results in children with symptomatic CI. The limitations of the two trials are the conflicting results on the efficacy of office-based therapy for treating symptoms of CI. The evidence found on home-based treatments was inconclusive compared to placebo in relieving symptoms of CI. The authors concluded that the evidence suggests that both therapies improve motor outcomes; however, the data is inconsistent regarding symptomatic relief. Additionally, the evidence on the efficacy of home-based treatments is insufficient (Chang et al., 2021).

In 2021, Chen et al. conducted an RCT to determine the effectiveness of office-based vergence accommodative therapy (OBVAT) for improving accommodative amplitude and accommodate facility in children with symptomatic CI and accommodative dysfunction. The trial consisted of 115 participants in vergence/accommodative therapy and 65 in placebo therapy for those with decreased accommodative amplitude. There were 71 participants in the vergence/accommodative therapy for those with decreased accommodative facility and 37 in placebo therapy. After four, eight, 12, and 16 weeks of treatment, the primary analysis was conducted using analyses of variance models comparing the mean change in amplitude and facility between the vergence/accommodative and placebo groups. Results of the study show that from baseline to 16 weeks, the mean improvement in amplitude was 8.6 diopters (D) and 5.2 D in the vergence/accommodative and placebo therapy groups, respectively [MD = 3.5 D, 95% confidence interval (CI): 1.5 to 5.5 D; p = 0.01]. The mean improvement in facility was 13.5 cycles per minute (cpm) and 7.6 cpm in the vergence/accommodative and placebo therapy groups, respectively (MD = 5.8 cpm, 95% CI: 3.8 to 7.9 cpm; p < 0.0001). Significantly superior amounts of individuals treated with vergence/accommodative therapy attained a normal amplitude (69% vs. 32%, difference = 37%, 95% CI: 22 to 51%; p < 0.0001) and facility (85% vs. 49%, difference = 36%, 95% CI: 18 to 55%; p < 0.0001) than those who received placebo therapy. Amplitude increased at an average rate of 1.5 D per week during the first four weeks (p < 0.0001), then reduced to 0.2 D per week (p = 0.002) from weeks four to 16 in the vergence/accommodative therapy group. Likewise, facility improved at an average rate of 1.5 cpm per week throughout the first four weeks (p < 0.0001), then decelerated to 0.6 cpm per week from weeks four to 16 (p < 0.0001). From this study, the authors concluded that office-based vergence/accommodative therapy effectively improves accommodative function in children with symptomatic CI and coexisting accommodative dysfunction (Included in the 2023 Hayes Technology Assessment).

In a double-masked RCT conducted in 2021, Sangoi et al. aimed to compare changes in phoria adaptation between young adult binocular normal controls (BNCs) and individuals with symptomatic CI. Those with BNC (50 participants) and CI (50 participants) were randomized to an OBVAT group or office-based placebo therapy (OBPT) group. Participants received therapies for 12 one-hour office sessions utilizing a 6Δ base-out, and 6Δ base-in phoria adaptation experiment at near (40 cm) using the flashed Maddox rod technique at baseline and the outcome. The results showed that both individuals with BNC and CI had significantly different rates and magnitudes of base-in and base-out phoria adaption (p < 0.001). Additionally, significant main effect differences in longitudinal measurements were demonstrated for the magnitude and the rate of phoria adaption for both base-in and base-out experiments (p < 0.05). Post hoc analyses using paired t-tests for the magnitude and rate of phoria adaption revealed that the CI group which received OBVAT exhibited a

significant increase compared to baseline for both base-in and base-out phoria adaption ($p < 0.01$) and not for those who received OBPT. The longitudinal study of the therapeutic interventions using paired t-tests showed that the CI group which was administered OBVAT had a significant improvement in NPC, with results showing a baseline of 10.5 ±3.7 cm compared to an outcome of 4.5 ±1.6 cm [$t(24) = 7.6$, $p < 0.0001$]; PFV demonstrated baseline of 12.2 ±3.2△ compared to the outcome of 28.9 ±10.4△ [$t(24) = 6.4$, $p < 0.0001$]; and results of the CI Symptom Survey (CISS) were baseline of 34 ±9 points compared to the outcome of 21.6 ±8 points [$t(24) = 5.6$, $p < 0.0001$]. The authors concluded there are significant differences at baseline between individuals with normal BV and those with symptomatic CI. Treatment with OBVAT significantly improves the rate and magnitude at near compared to OBPT for both base-in and base-out phoria adaptation.

In an RCT, Scheiman et al. (2011) assessed the effectiveness of various types of VT for improving accommodative amplitude or accommodative facility in 221 children with deficiencies in these measures at baseline. All types of VT (i.e., office-based VT, HBCVAT+, and HBPP) were superior to office-based placebo vision treatment for improving mean accommodative amplitude. Regarding accommodative facility, only the office-based VT group exhibited a significantly greater improvement than the placebo group. This study did not report the results of symptoms or other clinical signs. One year after completion of therapy, reoccurrence of decreased accommodative amplitude was present in only 12.5% and accommodative facility in only 11%. The authors concluded that VT/orthoptics is effective in improving accommodative amplitude and accommodative facility in school-aged children with symptomatic CI and accommodative dysfunction (Included in the 2023 Hayes Technology Assessment).

Shin et al. (2011) conducted a prospective controlled trial comparing office-based VT with no VT treatment. The study included 57 children aged 9-13 years who were diagnosed with symptomatic CI (n = 27) or combined symptomatic CI and accommodation insufficiency (AI) (n = 30). They were independently divided into a treatment and a control group, matched by age and gender. Office-based VT significantly improved symptoms and clinical signs including NPC, PFV, mean accommodative amplitude, and mean accommodative facility relative to no treatment in children with CI and AI. Of the people with concurrent CI and AI who received VT, 77% were considered improved and 61% were considered cured. Of the 11 participants who completed the 1-year follow-up, symptom scores had deteriorated to abnormal levels in two children and one child also showed regression of the NPC. The authors concluded that this study supports the use of VT as a successful method of treating CI and CI combined with AI.

Vision Therapy (VT) for Convergence Excess or Nystagmus

No well-designed clinical trials evaluating the use of vision therapy for convergence excess or nystagmus were identified.

Vision Therapy (VT) for Divergence Excess or Insufficiency

No well-designed clinical trials evaluating the use of vision therapy for divergence excess or divergence insufficiency were identified.

Orthoptic or Vision Therapy (VT) for Exotropia or Esotropia

Only limited quality clinical evidence was found to support the use of orthoptic or VT for exotropia. Existing publications are limited by post hoc analyses, lack of long-term follow-up, and inconclusive findings.

Through an RCT, Ma et al. (2024) evaluated the short-term effects of office-based vergence and anti-suppression therapy (OBVAT) on the office control score when compared to observation alone in children with small-to-moderate angle intermittent exotropia (IXT). The results of the trial showed that at the primary outcome visit, the OBVAT group (n = 20) had a significantly better distance Office Control Score (adjusted mean difference: -0.9; 95% CI: -0.2 to -1.5; $p = 0.008$; partial eta squared: 0.19) than the observation group (n = 16). Participants from the OBVAT group were likelier than those from the observation group to have ≥ 1 point of improvement at the 17-week visit (OBVAT group: 75%; Observation group: 25%; $p = 0.006$). The authors concluded that the OBVAT group had a significantly better distance Office Control Score than the observation group at the 17-week visit. This study provides the first data from an RCT demonstrating the effectiveness of OBVAT in improving the control of IXT. The findings are limited by the lack of long-term follow-up.

In An RCT by Liang et al. (2023), the authors assessed the effectiveness of binocular vision training (BVT) and Fresnel press-on prism (FPP) for children with esotropia combined with amblyopia. Registered for the trial were children aged 3-9 years with esotropia and amblyopia (n = 101). Two random groups were formed, the combined group (n = 48) and the prism group (n = 53). The children in the prism group received FPP treatment, while those in the combined group received a combination of therapy, BVT, and FPP. The primary outcomes measured were the VA, binocular function, and strabismic therapeutic effects. The results demonstrated a sizable improvement in both groups for VA versus before treatment ($p = 0.0079$). The binocular-monocular function, plus synoptophore visual function and the Titmus stereopsis, in both groups, was significantly better compared with those before treatment ($p < 0.05$), and it was more substantial in the combined group versus the prism group ($p < 0.05$). The cure rate of strabismus was 87.50% (42/48) and 30.19% (16/53)

in the combined group and the prism group, respectively, and there was a significant difference between groups (p = 0.0036). The cure time decreased with the lower degree of esotropia. The study is limited by the small sample size. Larger, multi-center, and multi-disciplinary, high-quality research should be performed for further investigation. The authors concluded that BVT combined with FPP can efficiently promote the healing of BVin children with esotropia combined with amblyopia, and some children can attain a complete cure for strabismus.

Through an RCT, Zhang et al. 2023 investigated the effect of VR technology on children after surgery for concomitant strabismus. Included in the trial were 200 children with concomitant exotropia or concomitant esotropia who were randomly divided into two groups: the training group (n = 100) and the control group (n = 100). In the training group, participants received VR intervention training within a week after surgery. Those in the control group did not receive training. The results of the trial demonstrated that six months after the surgery, the orthophoria (the far or near strabismus degree was ≤ 8Δ) rate was meaningfully higher in the training group than in the control group (p = 0.001). In contrast, the eye position regression rate (versus the strabismus degree within one-week post-surgery, the amount of regression > 10Δ) was notably lower in the training group versus the control group (p = 0.001). Six months post-surgery, the number of children with simultaneous vision and remote stereovision was substantially higher in the training group compared to the control group (p = 0.017 and 0.002, respectively). The differences in the quantity of children with peripheral stereopsis, macular stereopsis, and stereopsis in macular fovea centralis at one, three-, and six-months post-surgery among the training and the control groups were not statistically significant (p = 0.916, 0.274, and 0.302, respectively). The authors concluded that the intervention of VR technology after strabismus correction efficiently enhanced children's visual function and cure rate post-surgery and sustained their eye position.

In a 2023 meta-analysis of RCT, Song and associates sought to compare the efficiency of PTO and the observation of intermittent exotropia (IXT) therapy. The exploration uncovered four articles with 617 individuals that could be included in the meta-analysis. The pooled outcomes exhibited PTO with higher effects versus observation, with more substantial reduction in exotropia control at distance and near (MD = 0.38, 95% CI: -0.57 to -0.20, p < 0.001; MD = -0.36, 95%CI, -0.54 to -0.18, p < 0.001), those subjected to PTO therapy had a more noteworthy reduction in distance deviations (MD = -1.95, 95% CI: -3.13 to -0.76, p = 0.001). And there was a more substantial increase in near stereoacuity among the PTO group versus the observation group (p < 0.001). The limitations of the study include a limited number of participants included leading to possible selection bias, limited data from included studies, and different classes of deviation control scale contributing to clinical heterogeneity. The authors concluded that PTO improved control and near stereopsis and reduced distance exodeviation angle of children with IXT compared with observation. PTO therapy is superior to observation for improving stereopsis at near. Studies are necessary to investigate if the advantage of PTO treatment is stable after the completion of therapy, the relationship between compliance and treatment results, and the effect of increasing occlusion duration on results.

In a 2023 RCT, Hatt et al. evaluated the effect of part-time patching versus observation on distance exodeviation control in a post hoc analysis of 3- to < 11-year-olds with IXT formerly reported in an RCT. This trial analyzes 306 participants who, at a distance fixation, naturally manifested either a constant or IXT or had continued recovery after monocular occlusion at baseline. The authors measured the change in control at distance and near fixation, from baseline to three months and baseline to six months. The results showed a more significant improvement in the distance control score with patching than with observation at three months (MD, 0.4 points; 95% CI, 0.1-0.7) and six months (MD, 0.3 points; 95% CI, 0.02-0.6). The limitations of this trial consist of the analyses being conducted post hoc with 75% of the cohort for which treatment group differences in distance exodeviation control did not achieve statistical significance. Additionally, multiple comparisons were made, which can cause a greater likelihood that some are significant by chance. The authors concluded that part-time patching may result in improved distance control and reduced exodeviation in this subgroup of children. Due to the post hoc nature of the analysis, added studies are required to confirm the above results and decide the sustainability of the results.

In a Cochrane Database Systematic Review, Pang et al. (2021) analyzed the effects of various surgical and non-surgical treatments located in RCTs consisting of individuals with IXT. Additional aims of the review were to report intervention criteria and determine whether the treatment effect varies by age and subtype of IXT. The exploration uncovered six RCTs with a total of 890 individuals with basic or distance IXT. A meta-analysis of two RCTs comparing patching (n = 249) with active observation (n = 252) was completed. Further meta-analysis could not be undertaken due to clinical and methodological heterogeneity in the remaining trials. The evidence shows patching was clinically more effective than active observation for improving motor alignment at near and distance fixation. The results were measured by a prism and alternate cover test (PACT) at six months; results for patching: MD−2.23, 95% CI −4.02 to −0.44, and for active observation, MD −2.00, 95% CI −3.40 to −0.61. The results showed little to no difference in stereoacuity at near fixation (MD 0.00, 95% CI −0.07 to 0.07). The authors concluded from the evidence that patching offers a clinical benefit in children 12 months to 10 years of age who have basic-or distance-type IXT compared with active observation. From the literature, there is not enough evidence to determine if interventions such as bilateral lateral rectus recession (BLR) vs.

unilateral rectus recession with medical rectus resection; PAT before eye muscle surgery versus eye muscle surgery alone; and lateral rectus recession and medial rectus plication versus lateral rectus recession and medial rectus resection offer any benefit.

Feng et al. (2021) conducted an RCT in 60 participants with IXT to determine the efficacy of using over minus lenses combined with prisms to improve control of IXT. Group one (n = 30) was the observation group, and they wore lenses if refractive error met any of the following criteria: spherical equivalent (SE) anisometropia ≥ 1.00 D; astigmatism ≥ 1.00 D in either eye; or SE hyperopia ≥ + 1.00 D. Group two (n = 30) was treatment group, and they were prescribed over minus lenses of -2.50 D combined with the two prism diopters (PD) base-in prism on each side. Any participant who did not need refractive correction was prescribed Plano lens to be worn at each follow-up visit, but not to be worn in during the trial. Ocular alignment, status of BV, and refraction were measured at one, three, six and 12 months for both groups. After 12 months, the mean refractive error was 1.42 ±1.25 D, and 1.43 ±1.12 D for the observation and the treatment group, with a (95% CI: − 0.61 to 0.62)); the mean exotropia control score was 5.72 ±1.28 and 1.75 ±1.18 in the observation and the treatment group, with a (95% CI: − 4.63 to – 3.33); the mean near stereoacuity was 2.16 ±0.42 log arcsec and 1.91 ±0.26 log arcsec in the observation and the treatment group, respectively (95%CI: − 0.44 to – 0.06). The authors concluded that over minus lenses combined with prisms significantly improved the control of IXT and stereopsis. It reduced the angle of strabismus in children with IXT. Limitations of the study includes small population size and no long-term monitoring after treatment to see control of IXT remains.

Shin et al. (2017) conducted a retrospective review to determine the effect of preoperative part time occlusion (PTO) therapy on long-term surgical success in early-onset exotropia in 51 consecutive participants. The mean duration of preoperative occlusion therapy was 10.2 ±5.4 months (range, 6 to 28 months). The mean follow-up duration after surgery for exotropia was 78.0 ±28.1 months (range, 36 to 135 months). Overall, the final success rate of surgery for early-onset exotropia was 66.7%. Five participants (9.8%) showed persisting consecutive esotropia and eventually underwent surgical correction for these consecutive esotropia at a mean age of 18.8 months (range, 8 to 40 months) after the primary surgery for exotropia. A higher long-term success and lower recurrence rate was found in those who were deemed as compliant (≥ 0%) than in the group of people who were deemed to be non-compliant (< 0%). These findings are limited by the observational design of the study.

Joyce et al. (2015) conducted a systematic review of RCTs, quasi-experimental and cohort studies with a comparison group examining interventions for divergence excess, simulated divergence excess or basic type exotropia in children, up to and including 18 years of age, followed for at least 6 months. Eleven studies satisfied the eligibility criteria. Seven examined the comparative effectiveness of two surgical procedures: four compared surgeries with other interventions, including botulinum toxin A therapy, orthoptic exercises, occlusion, BV training and watchful waiting. The evidence retrieved was of limited extent and quality with differences across studies in terms of outcome assessment and the most appropriate time-point for measuring long-term outcomes. There were mixed outcomes when comparing unilateral recession/resection (R&R) with BLR on improving angle of deviation, which makes it difficult to recommend either surgical option with confidence. While non-surgical interventions appear 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 required to address the question of the most effective management for treatment of childhood exotropia. Importantly, consensus is required on what constitutes a successful outcome as well as agreement on how this should be measured.

An RCT was designed to compare part-time patching with observation for previously untreated IXT in children 12-35 months old (n = 201). Participants were randomly assigned to either observation (no treatment for 6 months) or patching prescribed for 3 hours daily for 5 months, followed by 1 month of no patching. The authors reported deterioration (defined as constant exotropia measuring at least 10△ at distance and near) or receipt of non-protocol treatment for IXT over 6 months was uncommon, with or without patching treatment. There was insufficient evidence for the authors to recommend part-time patching for the treatment of IXT in children in this age group (Mohney et al., 2015).

Buck et al. (2012) investigated the current patterns of management and outcomes of intermittent distance exotropia in an observational cohort study which recruited 460 children aged < 12 years of age with previously untreated distance exotropia. The data collected included angle, near stereoacuity, VA, control of distance exotropia measured with the NCS, and treatment. The main outcome measures were change in clinical outcomes in treated and untreated distance exotropia, 2 years from enrolment (or, where applicable, 6 months after surgery). At follow-up, data were available for 371 children (81% of the original cohort). Of these, 53% (195) had no treatment; 17% (63) had treatment for reduced VA only (pure refractive error and amblyopia); 13% (50) had no- surgical treatment for control (spectacle lenses, occlusion, prisms, exercises) and 17% (63) had surgery. Only 0.5% (2/371) of children developed constant exotropia. The surgically treated group was the only group with clinically significant improvements in angle or NCS, but rates of overcorrection were high.

Non-surgical treatment of intermittent distance exotropia had less significant impact on angle of deviation or scores on the NCS.

Orthoptic or Vision Therapy (VT) for Stroke and Traumatic Brain Injury

Only limited quality clinical evidence was found to support the use of orthoptic or VT for stroke and traumatic brain injury. Limitations of the literature included conflicting findings and a lack of high-quality study design.

Namgung et al. 2025 conducted a multicenter RCT on personalized visual perceptual learning digital therapy for visual field defects following a stroke to evaluate the efficacy and safety of a personalized digital therapeutic based on visual perceptual learning for treating post stroke visual field defects (VFDs). The trial included poststroke outpatients 19 years or older with persistent VFDs (> 3 months after stroke) and neuroimaging-confirmed stroke lesions in the visual pathway. The training group underwent personalized visual discrimination tasks (orientation and rotation) using a mobile virtual reality headset 5 days a week for 12 weeks, with 360 trials per day. The control group received no intervention. The primary outcome measured was improved visual areas [defined as sensitivity increased by ≥ 6 decibels (dB) for 12 weeks] assessed using Humphrey visual field tests at baseline and 12 weeks. The results showed that as primary measures, the training group, with a high adherence rate, showed significantly greater improvement (sensitivity increased by ≥ 6 dB) in the whole field [median difference, 72 (95% CI, 36-108) degrees squared; p = .003; mean (SD), 194.1 (197.3) vs 82.5 (95.0) degrees squared] and defective hemifield [median difference, 72 (95% CI, 36-108) degrees squared; p = .002; mean (SD), 158.9 (159.0) vs 72.0 (91.4) degrees squared] compared with the control group. As secondary measures, mean (SD) Humphrey visual field test scores improved after 12 weeks in the training group but not in the control group. The authors concluded that in this RCT of a digital therapeutic for chronic poststroke VFDs, the visual perceptual learning-based training showed significant improvements in the whole field and defective hemifield. The study is limited by primary analyses focused on adherent participants and short follow-up.

Namgung et al. 2024 conducted a double-blind, multicenter, RCT to investigate the efficacy and safety of virtual reality-based visual perceptual learning for visual field defects in stroke. To conduct the trial, outpatients with stroke and VFDs (> 6 months after stroke onset) were randomized into NV (defective field training) or Nunap Vision-Control (NV-C, central field training) groups. Both interventions provided visual perceptual training, consisting of orientation, rotation, and depth discrimination, through a VR head-mounted display device five days a week for 12 weeks. The two groups received VFD assessments using Humphrey visual field (HVF) tests at baseline and 12-week follow-up. The final analysis included those who completed the study (NV, n = 40; NV-C, n = 35). Efficacy measures included improved visual area (sensitivity ≥ 6 dB) and changes in the HVF scores during the 12 weeks. The results of the trial demonstrated that with a high compliance rate, NV and NV-C training improved the visual areas in the defective hemifield (> 72 degrees^2) and the whole field (> 108 degrees^2), which are clinically meaningful improvements despite no significant between-group differences. According to within-group analyses, mean total deviation scores in the defective hemifield improved after NV training (p = .03) but not after NV-C training (p = .12). There are limitations to this trial, and future larger studies that provide eye tracking objective measures of training and compliance, visual measures other than luminance detection, and sham training as the control are warranted to support the study findings. The authors concluded that the current trial suggests that VPL-based digital therapeutics may induce clinically meaningful visual improvements in those with poststroke VFDs. Yet, between-group differences in therapeutic efficacy were not found as NV-C training exhibited unexpected improvement comparable to NV training, possibly due to learning transfer effects.

In a 2022 RCT, Batool et al. examined the effects of visual scanning exercises and a task-specific approach on balance and ADL for individuals' post-stroke with eye movement disorders. Recruitment of 64 individuals took place, where the participants were randomized into either an experimental (n = 32) or a control group (n = 32). The EG was treated with visual scanning exercises and a task-specific approach, and the control group was treated with a task-specific approach alone. The outcomes measured were pre- and post-balance and ADL assessed on the Berg balance scale and Barthel index scale at baseline and the fourth week. The trial results demonstrated an Intra-group analysis of BERG BALANCE SCALE in the EG and showed statistically significant results ($p < 0.05$) in all items except items four, 13, and 14, respectively. Intra-group analysis of BERG BALANCE SCALE in the control group showed statistically significant results ($p < 0.05$) in items three, five, eight, and 12, respectively, while all remaining items showed statistically insignificant results. Intra-group analysis of BARTHEL INDEX SCALE in the EG showed statistically significant results in all items ($p < 0.05$) except in items nine and 10, respectively. Intra-group analysis of BARTHEL INDEX in the control group showed statistically significant results ($p < 0.05$) in items one, three, four, and eight, respectively, while all outstanding items showed statistically insignificant results. Inter-group analysis displayed statistically significant findings in total scores of BERG BALANCE SCALE ($p = 0.000$) and BARTHEL INEX SCALE ($p = 0.033$). The limitations of the study include small sample size and the lack of assessment of both therapies at follow-up. The authors concluded that visual scanning exercises and task-specific approach were more effective than a task-specific approach alone. Visual scanning exercises and a task-specific approach can be used to train balance and ADLs for individuals with stroke and eye movement disorders.

Qiu et al. (2021) performed a meta-analysis of seven RCTs including (n = 211) participants reviewing the efficacy of PA treatment in unilateral neglect post-stroke. Of the seven studies included, one study investigated the effects of PA in acute post-stroke neglect, and another study examined the chronic stage of stroke rehabilitation. Four studies reviewed terminal PA, two studies reviewed concurrent PA, and another singular study reviewed both treatments combined. Only one trial used no goggles as the control treatment, but neutral goggles (sham adaptation) were used in control groups of other studies. Visual deviation toward the right varied from six to twelve degrees. One trial adopted prism goggles with 11.4-degree rightward shift of visual field, and other trials used the goggles with 10-degree rightward deviation. The duration of PA treatment ranged from four days to four weeks, and most of the studies conducted two weeks of treatment. The results of the present meta-analysis show that PA did not have significant short-term or long-term beneficial effects which showed significant improvement in neglect symptoms of people with unilateral stroke. These outcomes were measured by using the Behavioral Inattention Test (BIT) or Catherine Bergego Scale (CBS) and compared with neutral goggles (sham adaptation) and standard care alone (no adaptation). The results were highly consistent and evaluated by the I^2 statistic ($I^2 \leq 15.9\%$) between studies regardless of the variability in treatment duration, type of PA, parameter of visual shift, and follow-up duration. The authors concluded that the application of PA, compared to using a placebo or no treatment, lacked significant data which demonstrated much improvement in neglect symptoms of participants diagnosed with unilateral post-stroke. The meta-analysis and systematic review findings do not support routine use of PA therapy for unilateral post-stroke participants.

Cavanaugh et al. (2020) published the results of an RCT evaluating the efficacy of motion discrimination training as a potential therapy for stroke-induced hemianopia visual field defects. Forty-eight subjects with stroke-induced homonymous hemianopia were randomized into two training arms, an intervention, and a control. The subjects were between 21-75 years of age and presented with no ocular issues. Subjects were randomized with equal allocation to receive training in either their sighted or deficit visual fields. Training was performed at home for six months, consisting of repeated visual discriminations at a single location for 20-30 minutes per day. Pre- and post-training testing was identical, consisting of Humphrey visual fields, macular integrity assessment perimetry, ocular coherence tomography, motion discrimination performance, and visual quality of life questionnaires. Primary outcome measures were changes in perimetric mean deviation (PMD) on Humphrey Visual Field Analyzer in both eyes. The results showed mean PMDs improved over 6 months in Deficit-trained subjects, and no improvement was observed in Sighted-trained subjects. However, there were no significant differences between alternative training modalities. It was concluded that while there is no widely accepted therapy available to treat homonymous hemianopia, this study evaluated the efficacy of visual perceptive training as a potential therapy.

In a 2019 Cochrane systematic review, Pollock et al. sought to determine the effects of various interventions for people with visual field defects following a stroke. Randomized trials in adults after a stroke were selected if the intervention was specifically targeted at improving the visual field or improving the ability of the participant to cope with vision loss. The primary outcome was functional ability in ADL and secondary outcomes included functional ability in other ADL, including reading ability, visual field measures, balance, falls, depression and anxiety, discharge destination or residence after stroke, quality of life and social isolation, visual scanning, AEs, and death. There were 20 studies that evaluated the effect of treatments for visual field defects, however only 10 of them compared the effect of a particular treatment with no treatment. Of these, four studies investigated a type of eye movement training designed to improve the lost visual field (a 'restitutive' intervention), four studies investigated the effect of scanning training, which involves training people to 'scan' across the space in front of them and into the 'lost' visual field, in order to better cope with their lost vision (a 'compensatory' intervention), and three studies investigated the effect of wearing a special prism on a pair of glasses, which increases the amount a person can see on their affected side (a 'substitutive' intervention). One of the studies investigated the effect of specialized assessment by an orthoptist (a hospital-based vision specialist), compared to standard care. Only two studies presented data relating to how treatment can improve stroke survivors' abilities in ADLs, and there was a lack of consistency across studies that limited our ability to draw clear conclusions. There was insufficient evidence to draw any conclusions about the effectiveness of restitutive interventions as compared to control. There was low or very low-quality evidence that scanning training may help improve quality of life but may have no effect on other outcomes (including AEs). There was low or very-low quality evidence that prisms may have an effect on the ability to scan (look) for objects but may cause a range of minor AEs (particularly headache) and may have no effect on other outcomes. Limitations with the evidence meant that we could not draw any conclusions about the benefits of assessment interventions.

Hunt et al. (2016) conducted a systematic review of evidence regarding the use of oculomotor-based vision assessment to identify and monitor recovery from mild traumatic brain injury (mTBI). Their objectives were to (1) identify changes in oculomotor-based vision following mTBI; (2) distinguish methods of assessment; (3) appraise the level and quality of evidence; and, if warranted, (4) determine clinical recommendations for assessment. Articles were included if study populations were clearly identified as having mTBI and used as an assessment of oculomotor-based vision. Twenty articles met their inclusion criteria. Exploratory findings suggest that measurements of saccades, smooth pursuit, and

vergence are useful in detecting changes associated with mTBI. The authors noted that the strength of this evidence is not yet sufficient to warrant clinical recommendations. Research using rigorous methods is required to develop reliable, valid, and clinically useful assessment protocols.

In a systematic review of interdisciplinary literature, Klinke et al. (2015) identified rehabilitation interventions that can be integrated into ward-based nursing for individuals with hemi-spatial neglect following stroke in the right brain hemisphere. Using 41 original studies, 11 interventions were identified. The selected studies were graded according to the strength of their evidence (Levels 1-5); the proposed interventions were given recommendation grades (Grades A-D). The interventions included right half-field eye patching (Grade D), smooth pursuit of eye-movement training (Grade B) and visual scanning training (Grade D). The authors noted that there was generally low level of evidence and the diversity of interventions which made it difficult to endorse specific priorities and combinations for implementation and interventions should be applied after careful evaluation of each individual's unique capacities and problems. The authors also emphasized the need to integrate evidence-based interventions to stimulate rehabilitation outcomes and further research.

Van Wyk et al. (2014) evaluated the effect of saccadic eye movement training with visual scanning exercises (VSEs) integrated with task-specific activities on USN post stroke. A matched-pair RCT was conducted. Subjects were matched according to their functional activity level and allocated to either a control (n = 12) or an EG (n = 12). All participants received task-specific activities for a 4-week intervention period. The EG received saccadic eye movement training with VSE integrated with task specific activities as an "add on" intervention. Assessments were conducted weekly over the intervention period. Statistically significant differences were noted on the King-Devick Test (p = .021), Star Cancellation Test (p = .016), and Barthel Index (p = .004). The authors concluded that intensive saccadic eye movement training with VSE integrated with task-specific activities has a significant effect on USN in individuals post stroke. Long-term follow-up and further studies with larger populations are needed to verify these results.

Orthoptic or Vision Therapy (VT) for Dyslexia and Other Learning Disabilities (LD)

Only limited quality clinical evidence was found to support the use of orthoptic or VT for dyslexia and other LDs. Findings are limited by single-arm design and inconclusive findings.

In 2018, Hussaindeen et al. carried out a study at a center for LD to report the frequency of BV anomalies in children with specific learning disorders (SLD) and to assess the efficacy of VT in children with a non-strabismic BV anomaly (NSBVA). The study consisted of 94 children with a diagnosis of SLD. Children with BCVA of ≥ 6/9 --- N6, who are cooperative for examination and free from any ocular pathology, were assessed for BV. Participants diagnosed with NSBVA (n = 46) 24 of 46 were randomized to VT, with no intervention for 22 participants placed in the experimental control. Each group received ten sessions of VT, with a BV assessment performed for both the intervention and non-intervention groups. The results showed BV anomalies in 59 children (62.8%); of the 59 children, 13 (22%) had strabismic binocular vision anomalies (SBVA) and 46 participants (78%) had NSBVA. Most seen in individuals with NSBVA was accommodative infacility (AIF), found in 67%, followed by CI in 25%. The intervention group showed significant improvement post-VT and met all the BV parameters (Wilcoxon signed rank test, $p < 0.05$) apart from negative fusional vergence.

Hall et al. (2013) conducted a randomized, double-blind trial with 73 delayed readers to compare changes in reading and spelling as well as irregular and non-word reading skills after 3 months of wearing either the Harris or the Dyslexia Research Trust (DRT) filters. Reading improved significantly after wearing either type of filter, with 40% of the children improving their reading age by 6 months or more during the 3-month trial. However, spelling ability and non-word reading improved significantly more with the DRT than with the Harris filters. The authors concluded that education and rehabilitation professionals should consider colored filters as an effective intervention for delayed readers experiencing visual stress. According to the authors, this research will help to support the use of colored filters for visual reading capacity, but further rigorous research is needed. The study is limited by lack of comparison group undergoing a non-filter intervention or no intervention.

In a double-masked, placebo RCT, Ritchie et al. (2011) tested the efficacy of Irlen colored overlays for alleviating reading difficulties thought to have been caused by Irlen syndrome, a proposed perceptual disorder with controversial diagnostic status. Sixty-one school children (aged 7-12 years) with reading difficulties were included in the study. Based on the study results, the authors concluded that Irlen colored overlays do not have any demonstrable immediate effect on reading in children with reading difficulties.

Visual Information Processing Evaluation

Limited clinical evidence was found to support the use of visual information processing evaluations for diagnosing learning-related or other types of visual deficits. While research suggests correlations with important outcomes, the clinical

utility of visual information processing evaluation has not been addressed in the research designed of the identified studies.

Hopkins et al. (2019) conducted a study to evaluate the association between performance on visual information processing tests and academic performance in 222 second grade school children, with a mean age of 8-8.5 years. The Progressive Achievement Tests in Reading (PAT-R) and Mathematics (PAT-M) were used as assessment tools. Both tests are timed, paper based, standardized tests, referenced against the Australian national curriculum used in schools across Australia to monitor student progress, typically across testing sessions 9–12 months apart. The results showed that visual information processing assessed using the Visual- Motor Integration (VMI) and Developmental Eye Movement (DEM) measures were significantly associated with academic performance. However, given that the VMI task involves visual spatial, visual analysis and visual motor skills, it may be more relevant than the DEM test in capturing the diverse range of activities (e.g., reading, writing and mathematics) carried out by children in a classroom. In a clinical setting, a child's academic performance can play an important role in the optometric management of conditions such as hyperopia, thus tests, such as the VMI, can provide clinicians with insight into a child's potential overall academic performance and support clinicians regarding their management decisions. Limitations of this study include the potential for normal developmental differences in children of the same age or year in school, as the authors did not include assessment of refractive error, accommodation, or general IQ tests. It is important that future research includes these parameters to assess if the provision of optometric interventions can improve academic performance in longitudinal studies.

Goldstand et al. (2005) compared visual and visual-information processing skills between children with and without mild reading and academic problems and examine 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, visual-motor 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 visual screening performed significantly better in visual perception than those who failed. According to the investigators, visual function significantly distinguishes between children with and without mild academic problems, as well as on visual-perception scores. The investigators concluded that the high occurrence of visual deficits among participants warrants consideration of vision deficits among school children with academic performance difficulties. These findings require confirmation in a larger study.

Visual Perceptual Therapy

Only limited quality clinical evidence was found to support the use of visual perceptual therapy. Findings are limited by conflicting findings, weak study designs, lack of follow-up beyond treatment completion, lack of statistical comparisons with standard care.

In a 2024 Hayes evolving evidence review on RevitalVision perceptual learning vision training program (Talshir Medical Technologies LTD) for treating amblyopia minimal support was found from clinical studies, no/unclear support of systematic reviews, and no/unclear support from practice guidelines. The review's insights suggest RevitalVision as a treatment option for individuals with amblyopia who have not achieved optimal vision with conventional measures. This software-based training program may interest adults with significant amblyopia, as conventional treatments are usually not effective. The literature reveals no safety concerns. Although findings show consistent improvement in technical measures of vision measures, they do not evaluate impact on social or academic function or quality of life. The available studies are few and are limited by weak study designs, lack of follow-up beyond treatment completion, lack of statistical comparisons with standard care, and/or unknown generalizability to typical amblyopia populations. At this point, additional evidence from ongoing trials is not forthcoming. This Hayes evidence review was updated in 2025. The review of full-text clinical studies suggested minimal support for the technology. No/unclear support was uncovered through systematic reviews and clinical practice guidelines, and position statements.

In 2024, Park and associates conducted a systematic review and meta-analysis aimed at evaluating the effectiveness of perceptual learning (PL) for individuals with low vision. The results of the exploration found that most studies had minimal risk of bias. Meta-analysis showed significant improvement in visual search for individuals with cortical blindness (Hedges' G = 0.71; 95% confidence interval, 0.48 to 0.93; p = 0.002); all other analyses did not show significant improvements—reading in central vision loss and cortical blindness, and visual field in peripheral vision loss and cortical blindness. However, the narrative synthesis provided evidence showing effectiveness, particularly in individuals with central vision loss and cortical blindness, proving positive effects on reading, contrast sensitivity, visual field, and motion perception. The review's limitations included variations of study design, PL protocols, and heterogeneity. The authors concluded that the efficacy of PL in vision rehabilitation remains uncertain. Although meta-analysis results were mostly inconclusive, the narrative synthesis indicated improved visual functions following PL, consistent with individual study findings.

In 2022, Zhong et al. conducted an RCT to evaluate the therapeutic efficacy of perceptual learning (PL) in improving CS function (CSF) and VA. Children with limbal dermoid (LD) (n = 25) and children without LD were compared regarding CSF and VA. The LD group was randomized to two arms: PL combined with patching (n = 9) and patching only (n = 8). The outcomes measured were the area under log CSF (AULCSF) and best corrected VA (BCVA). The results showed a reduction in the LD group compared to controls. After six months of training, the difference in the changes in the AULCSF between the PL and patching groups was 0.59 (95% CI: 0.32, 0.86, $p < 0.001$), and the between-group difference in VA at six months was -0.30 (95% CI: -0.46, -0.14, $p < 0.001$). The limitations of the study were the small sample size and short-term following up. The authors concluded that those suffering from LD with amblyopia simultaneously showed CSF deficits and VA loss. According to the results, PL could improve CSF and VA in the amblyopic eye better than patching (Included in the 2024 Hayes evolving evidence review).

Choi (2022) developed a pilot study to investigate the effects of task-oriented training on upper-limb functioning, visual perception, and activities of daily living (ADL) for individuals following acute stroke. The study enrolled 20 participants, randomly assigned to either a control group or an experimental group in a 1:1 ratio. For six weeks, task-oriented training and table-top activity training were employed. The Manual Function Test (MFT) was applied to evaluate changes in upper limb functioning. The Motor-Free Visual Perception Test-Vertical (MVPT-V) was employed to assess visual perceptual skills, and the Korean Modified Barthel Index (K-MBI) was used to gauge ADL performance. The results of the study showed that the group effect was not significant ($p > 0.05$); however, there was a significant interaction in the MFT and MBI score between group and time ($p < 0.05$). After the intervention, both groups demonstrated a substantial increase in MFT and MBI scores ($p < 0.001$), although the effect size was more significant in the task-oriented training group versus the table-top activity training group. The MVPT-V score demonstrated no significant interaction between the group and time ($p > 0.05$); additionally, the results showed no significant group difference ($p > 0.05$). After the intervention, both groups demonstrated significant improvement in MVPT-V scores ($p < 0.001$). The authors concluded from the pilot study that both trainings effectively recover upper-limb function, visual perception, and ADLs for individuals following acute stroke.

Vision Restoration Therapy (VRT)

Only limited quality clinical evidence was found to support the use of vision restoration therapy. Findings are conflicting and study designs have significant limitations.

In 2023, Navarro et al. conducted a systematic review and meta-analysis to determine the effectiveness and safety of non-invasive electrical stimulation (NES) for vision restoration. The primary outcomes reviewed were visual acuity, detection accuracy, foveal threshold, mean sensitivity as the parameter for the visual field, reading performance, contrast sensitivity, electroencephalogram, quality of life (QoL), and safety. The results showed that from thirteen RCTs involving 441 individuals with vision impairment indicate that NES may improve VA in the immediate post-intervention period (low certainty) and probably increases QoL and detection accuracy (both moderate certainty). NES resulted in little or no difference. Compared with sham stimulation, NES increases the risk of minor adverse effects (moderate certainty). The effect of NES on CS, reading performance, and electroencephalogram was uncertain. The limitations of the study included all populations having not had the same etiology and severity of vision impairment. There was a lack of data that outlined outcomes that resulted in wide CIs. Publication bias could not be evaluated, and significant differences clinically in follow-up. The authors concluded that although NES may slightly improve VA, detection accuracy, and QoL, the clinical relevance of these findings remains uncertain. Future research should focus on improving the available evidence's precision and consistency. The authors stressed the need for conducting future RCTs to provide more robust evidence.

Alber et al. 2017 conducted an open-label pilot study in a rehabilitation center, which included seven individuals receiving transcranial direct current stimulation (tDCS)/VRT vs. a convenience sample of seven individuals in the control group. All participants suffered from homonymous visual field defects following a posterior cerebral artery stroke. The combined therapy of tDCS and VRT was employed for 50 days post-stroke in the form of 10 sessions for seven individuals with homonymous hemianopia. Following treatment, visual field recovery was compared with retrospective data from seven controls matching the defect sizes and age of lesions and matched to those in the experimental group who had received standard rehabilitation with compensatory eye movement and exploration training. Safety and acceptance from the participants were exceptional, although individuals reported occasional itchy skin under the electrodes. Both the treatment and control groups demonstrated improvements in visual fields confirmed by an increased mean sensitivity threshold in decibels shown in standard static perimetry. For the tDCS/VRT group, recovery was significantly greater (36.73% 37.0%) than the control group (10.74% 8.86%). From the study, the authors concluded that treating tDCS/VRT for individuals following an acute stroke is safe with excellent applicability and acceptance of the treatment. Data suggested tDCS/VRT is superior to standard vision training procedures. Larger sample, controlled, randomized and double-blinded trials are underway and necessary to determine real tDCS vs. sham tDCS supported visual field training in the early vision rehabilitation phase.

In a prospective, double-blind, placebo-controlled RCT, Sabel &Gudlin (2014) determined if behavioral activation of areas of residual vision using daily 1-hour VRT for glaucoma for 3 months improved detection accuracy compared with placebo. The study participants included a volunteer sample of individuals with glaucoma (mean age, 61.7 years) with stable visual fields and well-controlled intraocular pressure. Study interventions included computer based VRT for glaucoma (n = 15) or visual discrimination placebo training in the intact visual field (n = 15). After randomization, 4 participants withdrew from the trial because of mild headaches (n = 2) or lack of time to complete the schedule (n = 2). The primary end point was change in detection accuracy in high-resolution perimetry. VRT for glaucoma led to significant detection accuracy gains in high-resolution perimetry, which were not found with white-on-white or blue-on-yellow perimetry. Furthermore, the pre-post differences after VRT for glaucoma were greater compared with placebo in all perimetry tests, and these results were independent of eye movements. VRT for glaucoma (but not placebo) also led to faster reaction time. Vision-related quality of life (QOL) was unaffected, but the health-related quality-of-life mental health domain increased in both groups. The authors concluded that visual field defects caused by glaucoma can be improved by repetitively activating residual vision through training the visual field borders and areas of residual vision, thereby increasing their detection sensitivity. According to the authors, this trial revealed evidence that visual field loss is in part reversible by behavioral, computer-based, online controlled vision training, comprising a new rehabilitation treatment option in glaucoma. These findings require confirmation in a larger study with long-term follow-up (Included in the 2024 systematic review by Park et al.).

Jung et al. (2008) evaluated the effects of VRT on the visual function of 10 individuals with anterior ischemic optic neuropathy in a double-blind pilot RCT. All participants were evaluated before VRT and after 3 and 6 months of treatment by Early Treatment Diabetic Retinopathy Study (ETDRS) VA, CS, reading speed, 24-2 SITA-standard Humphrey visual field (HVF), High Resolution Perimetry (HRP) (perimetry obtained during VRT), and vision-based QOL questionnaire. Participants were randomized between two VRT strategies (5 in each group): I) VRT in which stimulation was performed in the seeing VF of the affected eye ("seeing field-VRT"); 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 person and between the two groups at each evaluation. VA qualitatively improved in the ARV-VRT group; however, the change was not statistically significant. Binocular reading speed significantly improved in the ARV-VRT group. HVF foveal sensitivity increased mildly in both groups. HRP analysis showed a similar increase in stimulus accuracy in both groups (mean improvement of about 15%). All participants reported functional improvement after VRT. A small study population limits the conclusions that can be reached from this study.

Mueller et al. (2007) performed a case series including observational analysis of visual fields of 302 patients before and after being treated with computer-based VRT for a period of 6 months. The visual field defects were due to ischemia, hemorrhage, head trauma, tumor removal or anterior ischemic optic neuropathy. Primary outcome measure was a visual field assessment with super-threshold perimetry. VRT 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 older than 65 years benefited most. Conventional perimetry validated visual field enlargements and patient testimonials confirmed the improvement in every day visual functions. The lack of a control group limits the validity of the results of this study (Included in the 2024 systematic review by Park et al.).

Clinical Practice Guidelines

American Academy of Pediatrics (AAP) Section on Ophthalmology/Council on Children With Disabilities/American Academy of Ophthalmology (AAO)/American Association for Pediatric Ophthalmology and Strabismus (AAPOS)/American Association of Certified Orthoptists (AACO)

A 2011 joint technical report by the AAP, AAO, AAPOS, and AACO indicates that vision problems can interfere with the process of reading, but children with dyslexia or related learning disabilities (LD) have the same visual function and ocular health as children without such conditions. LD constitutes a diverse group of disorders in which children who generally possess at least average intelligence have problems processing information or generating output. Their etiologies are multifactorial and reflect genetic influences and dysfunction of brain systems. Currently, there is inadequate scientific evidence to support the view that subtle eye or visual problems cause or increase the severity of LD. According to the report, scientific evidence does not support the claims that visual training, muscle exercises, ocular pursuit-and-tracking exercises, behavioral/perceptual vision therapy (VT), "training" glasses, prisms, and colored lenses and filters are effective direct or indirect treatments for LD. There is no valid evidence that children who participate in VT are more responsive to educational instruction than children who do not participate (Handler & Fierson 2011).

According to a joint policy statement issued by the AAP, AAO, AAPOS, and AACO, diagnostic and treatment approaches for dyslexia that lack scientific evidence of efficacy such as behavioral VT, eye muscle exercises, or colored filters and lenses are not endorsed or recommended. The ophthalmologist should identify and treat any significant visual defect according to standard principles of treatment. Strabismus, amblyopia, and refractive errors may require glasses, eye patching, eye drops, or eye-muscle surgery. In addition, the ophthalmologist should discuss the lack of efficacy of VT and other "alternative treatments" with the parents (AAP, 2009).

American Academy of Ophthalmology (AAO)

In the 2022, updated in 2024 AAO preferred practice pattern for Amblyopia, the recommendations are as follows:

- Treatment of refractive error alone can improve VA in children with anisometropic, strabismic, or combined Amblyopia. VA of children with bilateral refractive Amblyopia also can substantially improve with refractive correction alone.
- Most children who have moderate amblyopia (20/40 to 20/80) respond to initial treatment consisting of 2 hours of daily patching or weekend atropine.
- Following treatment of Amblyopia caused by strabismus, anisometropia, or both, continued monitoring is necessary, and additional treatment, if needed, is associated with the long-term durability of the VA improvement.
- Suitable treatment options for Amblyopia include optical correction, patching, pharmacological treatment, optical treatment, Bangerter (translucent) filters, digital therapeutics, and managing the underlying cause of Amblyopia.
- Amblyopia treatment may be effective in older children and adolescents, particularly if they have not previously been treated (Cruz et al., 2023).

The AAO's 2021; updated 2023 Preferred Practice Pattern guidelines for pediatric ophthalmology/strabismus summary benchmarks for treating:
Amblyopia:

- All children with amblyopia should be offered treatment regardless of age, including older children and teenagers, especially if not treated previously.
- Prognosis for attaining normal vision depends upon age of onset, cause, severity, and duration of amblyopia, history of and response to previous treatment, adherence to treatment, and concomitant conditions.
- The first goal is to correct any cause of visual deprivation; the second goal is to correct refractive errors likely to cause blur; third is to promote use of the amblyopic eye, ultimately to achieve equal VA between the two eyes.
- Choose treatment based on age; VA; adherence and response to previous treatment; and physical, social, and psychological status.
- Once maximal VA has been obtained, treatment intensity can be tapered to maintenance therapy.
- If VA in amblyopic eye is maintained as therapy is tapered, treatment may be stopped but with follow up planned because approximately one-fourth of children experience a recurrence within the first year off treatment.

Exotropia:

- All forms of exotropia should be monitored, and some will require treatment.
- Young children with intermittent exotropia (IXT) and good fusional control can be followed without surgery.
- Deviations that are present most or all the time require treatment.
- Prescribe corrective lenses for any clinically significant refractive error causing reduced vision in one or both eyes.
- Optimal therapy for exotropia, the long-term benefit of early surgical correction, and the relative merits of bilateral versus unilateral surgery are not well established.
- Amblyopia is uncommon in those with intermittent exotropia, but, if present, should be treated.

Esotropia:

- Consider all forms of esotropia for treatment and re-establish binocular alignment as soon as possible.
- Significant refractive errors should be corrected.
- If eyeglasses and amblyopia management are ineffective in aligning the eyes, then surgical correction is indicated.
- Amblyopia treatment is usually started before surgery because it may alter the angle of strabismus and/or increase the likelihood of good postoperative binocularity.

The AAO esotropia and exotropia preferred practice pattern (Wallace et al. 2018) states the potential benefits of treatment for esotropia include promoting BV and normal visual function in each eye. If binocularity is achieved, the number of surgical procedures over a lifetime may be reduced. Treatment should be considered for all forms of esotropia, and binocular alignment should be established as soon as possible, especially in young children, to maximize binocular potential to prevent or facilitate treatment of amblyopia and to restore normal appearance.

The following are included in the list of current treatment practices for esotropia:

- Correction of refractive errors.
- Bifocal eyeglasses.
- Prism therapy.
- Amblyopia treatment.
- Extraocular muscle surgery:
  - Botulinum toxin injection.
  - Other pharmacologic agents.

The AAO includes the following in its list of current treatment practices for exotropia:

- Correction of refractive errors.
- Stimulating accommodative convergence (overcorrection of myopia or under-correction of hyperopia).
- Patching (anti-suppression) therapy.
- Amblyopia treatment.
- Prism therapy.
- Convergence exercises for CI insufficiency exotropia.
- Extraocular muscle surgery.
- Botulinum toxin injection.

The AAO's amblyopia preferred practice pattern (Repka et al. 2017) states that timely treatment of amblyopia usually improves VA and binocularity, and it decreases the likelihood of severe visual handicap if there is loss of vision in the fellow eye later in life. The prognosis for attaining normal vision in an amblyopic eye depends on many factors, including the age of onset; the cause, severity, and duration of amblyopia; the history of and response to previous treatment; adherence to treatment recommendations; and concomitant conditions. Several strategies are used in the treatment of amblyopia:

- Treatment of refractive error alone is the initial step in care of children 0 to 17 years of age with amblyopia (moderate quality, strong recommendation).
- Patching is an appropriate choice for treatment for children who do not improve with eyeglasses alone or who experience incomplete improvement (moderate quality, strong recommendation).
- Patching as initial therapy after refractive correction should be considered for children with moderate amblyopia (20/40 to 20/80) (moderate quality for treatment of amblyopia, strong recommendation) with a prescribed dose of 2 hours of daily patching or weekend atropine (moderate quality for amount of time treatment, discretionary recommendation).
- Patching should be considered for older children and teenagers, particularly if they have not previously been treated. (moderate quality, discretionary recommendation).
- Pharmacological treatment that produces cycloplegia of the non-amblyopic eye is an appropriate choice for treatment for children who do not improve with eyeglasses alone. (moderate quality, strong recommendation).
- There is insufficient evidence to recommend VT techniques.

In 2022 the American Academy of Ophthalmology Preferred Practice Pattern Pediatric Ophthalmology/Strabismus Panel highlighted findings and recommendations for care for esotropia and exotropia.
The recommendations are as follows:

- Strabismus in children under 4 months of age sometimes resolves without treatment, particularly if the deviation is intermittent, variable, or measures less than 40 prism diopters.
- Repeat cycloplegic refraction is indicated when esotropia does not respond to an initial prescription for hyperopia or when esotropia recurs after surgery.
- Acquired esotropia should be evaluated and treated promptly.
- Young children with intermittent exotropia and good fusional control can be followed without surgery because there is a low rate of deterioration to constant exotropia or reduced stereopsis.
- Indications for surgery in intermittent exotropia include a progression to constant or nearly constant deviation, reduced stereopsis, and/or a negative effect on social interactions.
- Unilateral recess-resect and bilateral lateral rectus recessions are both effective initial surgical procedures for the treatment of intermittent exotropia.
- Convergence insufficiency occurs in children and adults, and symptoms with near viewing can often be improved using vergence exercises.
- Simultaneous prism and cover testing measures the manifest angle of strabismus, and prism and alternate cover testing measures the total angle of misalignment. Both inform the ophthalmologist's decisions regarding management and surgical indications.

American Academy of Optometry

In 2016 the American Academy of Optometry developed a policy statement for childhood vision screening. In summary the policy statement advises that in order to facilitate early detection of children's vision problems and meet the vision needs of all children, the American Academy of Optometry recognizes the value of a continuum of eye care that includes both evidence-based vision screenings and access to comprehensive eye examinations by optometrists or ophthalmologists.

American Association for Pediatric Ophthalmology and Strabismus (AAPOS)

In a 2017 policy statement, the AAPOS stated that "Vision screening of young children is an effective means of detecting eye disorders such as refractive error, amblyopia (poor vision), strabismus (eye misalignment) and other medical conditions of the eye. Early detection of these abnormalities through vision screening leads to earlier treatment and life-long benefits to these children. Some eye diseases, if not detected and treated in childhood, can lead to irreversible, life-long vision loss. A comprehensive ophthalmologic examination is medically necessary in children whose vision screening has indicated a possible abnormality of eye health and/ or vision. This medical necessity exists regardless of the ultimate presence or absence of ocular pathology. Thus, in children who have failed a vision screening and who are not found to have amblyopia, strabismus, or other medical condition on examination, the examination following a failed vision screening is still considered medically necessary and not considered routine eye care."

American Association for Pediatric Ophthalmology and Strabismus (AAPOS)/ American Academy of Ophthalmology (AAO)

In 2022, the AAPOS and AAO created a joint statement on vision screening for infants and children. The recommendations for community and school screening programs state that in community and school-based screening programs, screeners should have specific training in vision screening techniques and protocols as recommended by the Academy and AAPOS. Children who do not pass these screenings should be referred to for an additional ocular assessment performed by the primary care provider or an eye care provider with training and experience in treating children.

In the primary care setting, the Academy and AAPOS recommend that an ocular assessment be performed whenever questions arise about the health of the visual system of a child of any age. In addition, even without specific signs or symptoms, they recommend that infants and children be routinely screened for vision problems and that any child who does not pass one or more of these screening tests have an ophthalmological examination.

- A pediatrician, family physician, or other appropriately trained health care provider should examine a newborn's eyes for general eye health and perform a red reflex test in the nursery. Any baby with an abnormal red reflex requires urgent consultation. An ophthalmologist should be asked to examine all high-risk infants (i.e., those at risk of developing retinopathy of prematurity (ROP); those with a family history of retinoblastoma, glaucoma, or cataracts in childhood; those with a family history of retinal dystrophy/degeneration; those with systemic diseases or neurodevelopmental delays associated with eye problems; those with any opacity of the ocular media; or those with nystagmus).
- From 1 month to 4 years of age, infants and toddlers should have their ocular health assessed at each routine well-child visit, including an external inspection, pupillary examination, corneal light reflection, and fixation, and following behavior assessment. This assessment should address any concerns raised by the family or noted by the primary care provider.
- Emphasis should be placed on checking VA when a child is cooperative enough to complete the assessment. Generally, this occurs between the ages of 3 ½ and four years. This assessment can be performed by a pediatrician, family practitioner, ophthalmologist, optometrist, orthoptist, nurse, or other appropriately trained individuals. Screeners should not have a vested interest in the screening outcome. A child referred from a vision screening or uncooperative at a second attempt at vision testing should be referred for a comprehensive eye evaluation. It is essential that formal testing of VA be performed by the age of 5 years.
- Photo screening and handheld autorefraction may be electively performed in children 12 months to 3 years of age, allowing earlier detection of conditions that may lead to amblyopia. Photo screening and handheld automated refraction are recommended as an alternative to VA screening with vision charts (typically used for children 3 through 5 years of age) and in children who are unable or unwilling to cooperate with routine acuity screening with vision charts (but are not superior to vision chart testing for children able to participate). Using vision charts to assess amblyopia in children 3 to 5 years of age remains a viable practice.
- Additional screening on each child should be done at routine school checks or well-child visits every 1-2 years after age five. Regular comprehensive professional eye examinations performed on normal asymptomatic children have no proven medical benefit.

- Children with possible or diagnosed learning disabilities, such as dyslexia, should undergo a comprehensive eye examination to identify and treat any undiagnosed vision impairment. Such children should be referred for appropriate medical, psychological, and educational evaluations and treatment of any learning disability. There is inadequate scientific evidence to suggest that "defective eye teaming" and "accommodative disorders" are common causes of educational impairment. Hence, routine screening for these conditions is not recommended.

Many serious ocular conditions are treatable if identified through screening during the preschool and early school-aged years. Many of these conditions are associated with a positive family history. Therefore, additional emphasis should be directed to screening high-risk infants and children, and when necessary, screeners should readily refer such children to an ophthalmologist for a comprehensive eye evaluation (2022).

In a joint policy statement, the AAPOS and the AAO state that amblyopia is a medical condition and requires treatment. Amblyopia is typically a preventable and treatable form of vision loss caused by developmental abnormalities of the brain's vision centers. Unless amblyopia is treated promptly during childhood, permanent structural changes occur in the brain, resulting in decreased visual function; recovery of vision in this instance is rarely achieved.

Current methods of preschool vision screening can identify risk factors (primarily high levels of refractive error and anisometropia) that, if untreated, increase the likelihood of amblyopia developing. Therefore, these amblyopia risk factors should also be considered medical conditions.

Optical correction such as eyeglasses and contacts may be medically indicated as a part of amblyopia treatment in addition to other modalities, such as patching and/or pharmacologic treatment (AAPOS, AAO; 2002, revised and reaffirmed 2017).

American Optometric Association (AOA)

According to the AOA's revised guideline on the care of the patient with strabismus: esotropia and exotropia, VT is successful in the treatment of many forms of strabismus. The AOA states that VT or orthoptics involves active training procedures to improve the patient's fixation ability and oculomotor control, to help eliminate amblyopia, to improve sensory and motor fusion, and to increase facility and the range of accommodation and vergence responses. They note that the prognosis is most favorable for patients with intermittent strabismus, especially IXT, who have sensorimotor fusion at some point in space and those with recently developed strabismus (Rutstein et al., 2010b).

In their guideline on care of the patient with accommodative and vergence dysfunction, the AOA states that improvement in both accommodative and vergence adaptation systems is the basis of the success of VT. According to the guideline, data is lacking for the efficacy of home-based VT by itself. Home-based VT may be less effective than office-based therapy, as there is no therapist available to provide motivation or correct inappropriate procedures. Therefore, preferred clinical management involves office-based VT in combination with home therapy. They note that therapy combining diplopia awareness with operant-conditioning techniques to reinforce alignment in the absence of visual cues has been advocated for divergence excess, and that VT is usually successful in patients with divergence insufficiency (Cooper et al., 2010).

The AOA (2009) issued a clinical care publication on the definition of optometric VT. The document states that research has demonstrated VT can be an effective treatment option for:

- Ocular motility dysfunctions (eye movement disorders).
- Non-strabismic binocular disorders (inefficient eye teaming).
- Strabismus (misalignment of the eyes).
- Amblyopia (poorly developed vision).
- Accommodative disorders (focusing problems).
- Visual information processing disorders, including visual-motor integration and integration with other sensory modalities.
- Visual sequelae of acquired brain injury.

The AOA clinical practice guideline on care of the patient with learning related vision problems describes these as deficits in two broads' visual system components: visual efficiency and visual information processing.

- Visual efficiency comprises the basic visual physiological processes of VA (and refractive error), accommodation, vergence, and ocular motility.
- Visual information processing involves higher brain functions including the non-motor aspects of visual perception and cognition, and their integration with motor, auditory, language, and attention systems. Learning related vision problems are the manifestation of deficits in visual efficiency and visual information processing.

- Visual efficiency problems include uncorrected refractive error, dysfunction of accommodation and vergence control systems and the interaction of these systems, and ocular motility. Accommodative and vergence dysfunctions can be primary deficits or can occur secondary to uncorrected refractive error. Isolated visual efficiency deficits are relatively uncommon; most patients presented with multiple deficits.

This guideline also notes that correction of refractive error and treatment of visual efficiency dysfunctions can result in improved visual information processing. The treatment of vision information processing deficits usually requires VT, which can begin during the later stages of visual efficiency therapy. This is dependent on associated conditions such as accommodative and vergence dysfunction (Garzia et al., 2008).

In their clinical guideline on the care of the patient with amblyopia, the AOA states that the rationale for using occlusion is that occluding the better eye stimulates the amblyopic eye, decreasing inhibition by the better eye. Occlusion enables the amblyopic eye to enhance neural input to the visual cortex. It is also important in eliminating eccentric fixation. However, noncompliance with occlusion represents a significant factor in occlusion failures, especially in patients over eight years of age in whom up to 50 percent noncompliance is common. They also note that active VT for amblyopia is designed to remediate deficiencies in four specific areas: eye movements and fixation, spatial perception, accommodative efficiency, and binocular function. The goal of VT is remediation of these deficiencies, with subsequent equalization of monocular skills and, finally, integration of the amblyopic eye into binocular functioning. Untreated individuals with amblyopia are at a greater risk for loss of vision in the better eye (Rouse et al., 1994; revised 2004).

National Institute for Health and Care Excellence (NICE)

In the 2023 NICE guidelines on stroke rehabilitation in adults the recommendations on vision are as follows:

- Offer people who are in hospital after stroke a specialist orthoptist assessment as soon as possible. If this cannot be done before discharge, offer the person an urgent outpatient appointment.
- Offer eye movement therapy to people who have persisting hemianopia (blindness in one half of the visual field of one or both eyes) after stroke.

Department of Veterans Affairs and Department of Defense (VA/DoD)

In 2022, the Department of Veterans Affairs and the Department of Defense Clinical Practice Guideline for the Management and Rehabilitation of Post-acute Mild TBI states that “There is insufficient evidence to suggest for or against the use of any particular modality for the treatment of visual symptoms attributed to mild traumatic brain injury such as diplopia, accommodation or convergence deficits, visual tracking deficits and/or photophobia” (Eapen et al., 2022).

United States Preventative Services Task Force (USPSTF)

The USPSTF (2017) recommends the primary treatment for amblyopia as the correction of any underlying refractive error with the use of corrective lenses, occlusion therapy (eye patching, atropine eye drops, or Bangerter occlusion foils), or a combination of treatments.

U.S. Food and Drug Administration (FDA)

This section is to be used for informational purposes only. FDA approval alone is not a basis for coverage.

Vision therapy is a procedure and, as such, is not subject to FDA regulation. Devices used in vision training programs may be classified under several different product codes. Some of these devices may be exempt from the 510(k)-clearance process. For information on a specific device or manufacturer refer to the following website: http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm. (Accessed May 23, 2025)

NovaSight announced that the FDA has cleared CureSight, a digital therapy device for amblyopia (lazy eye). CureSight is an eye-tracking-based system that improves visual and stereo acuity by training the visual system to use both eyes simultaneously. The ground-breaking clearance was based on visual outcomes data from a multicenter, RCT in which 103 participants aged 4 to < 9 were randomized to CureSight or eye patching—the current gold standard-of-care treatment. Decision date 2022 Sep 29. For more information, refer to the following website: https://www.accessdata.fda.gov/cdrh_docs/pdf22/K221375.pdf. (Accessed May 23, 2025)

NovaVision™, an attention task performance recorder, consists of two software programs, one for healthcare professionals for precise diagnosing of visual deficiencies, develop specific therapies and analyze results of therapy. The other software is intended for individuals in their homes to train and improve impaired visual functions. It is intended for the diagnosis and improvement of visual functions for those with impaired vision that may result from trauma, stroke, inflammation, surgical

removal of brain tumors or brain surgery, and may also be used to improve visual function for those with amblyopia. Additional information is available at: http://www.accessdata.fda.gov/cdrh_docs/pdf2/K023623.pdf. (Accessed May 23, 2025)

Luminopia One, Luminopia Inc. was granted De Novo classification (DEN210005) on February 26, 2021. According to the FDA website, Luminopia is a software-only digital therapeutic designed to be used with commercially available Head-Mounted Displays (HMDs), which are compatible with the software application. Luminopia One is indicated for improvement in VA for individuals with amblyopia, aged 4-7, associated with anisometropia and/or mild strabismus, having received treatment instructions (frequency and duration) as prescribed by a trained eye-care professional. Luminopia One is intended for both previously treated and untreated people. Luminopia One is intended to be used as an adjunct to full-time refractive correction, such as glasses, which should also be worn under the HMD during Luminopia One therapy. Luminopia One is intended for prescription use only in an at-home environment. Additional information is available at: https://www.accessdata.fda.gov/cdrh_docs/pdf21/DEN210005.pdf. (Accessed May 23, 2025).

The RevitalVision technology 510K: K012530 was originally FDA cleared in 2001 (originally branded as the NeuroVision AA-1 system) for treating amblyopia in patients aged ≥ 9 years. Additional information is available at: https://www.accessdata.fda.gov/cdrh_docs/pdf/K012530.pdf. (Accessed May 23, 2025)

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Policy History/Revision Information

Date	Summary of Changes
01/01/2026	**Template Update** • Created shared policy version to support application to Oxford plan membership **Supporting Information** • Archived previous policy version 2025T0072EE and VISION 011.31

Instructions for Use

This Medical Policy provides assistance in interpreting UnitedHealthcare standard benefit plans. When deciding coverage, the member specific benefit plan document must be referenced as the terms of the member specific benefit plan may differ from the standard plan. In the event of a conflict, the member specific benefit plan document governs. Before using this policy, check the member specific benefit plan document and any applicable federal or state mandates. UnitedHealthcare reserves the right to modify its Policies and Guidelines as necessary. This Medical Policy is provided for informational purposes. It does not constitute medical advice.

This Medical Policy may also be applied to Medicare Advantage plans in certain instances. In the absence of a Medicare National Coverage Determination (NCD), Local Coverage Determination (LCD), or other Medicare coverage guidance, CMS allows a Medicare Advantage Organization (MAO) to create its own coverage determinations, using objective evidence-based rationale relying on authoritative evidence (Medicare IOM Pub. No. 100-16, Ch. 4, §90.5).

UnitedHealthcare may also use tools developed by third parties, such as the InterQual® criteria, to assist us in administering health benefits. UnitedHealthcare Medical Policies are intended to be used in connection with the independent professional medical judgment of a qualified health care provider and do not constitute the practice of medicine or medical advice.