



Neuroplasticity And Vision Therapy: A Comparative Review Of Revital And Bynocs Vision Therapy

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Abstract: Functional amblyopia is a developmental visual disorder characterized by diminished (BCVA) without ocular pathology, often accompanied by reduction in contrast sensitivity, binocular balancing, fixation, and perception of motion. Traditional treatments such as optical correction, patching, and pharmacologic penalization have been widely used. However, emerging vision therapy techniques leveraging neuroplasticity, including perceptual learning and dichoptic training, have demonstrated promising results.

Revital Vision (RV) and Bynocs are two novel therapeutic approaches that aim to improve visual function through distinct mechanisms. Revital Vision utilizes perceptual learning via Gabor patch-based stimulation to enhance neural efficiency and contrast sensitivity. This noninvasive, patient-specific therapy has shown efficacy in improving visual function in people with amblyopia, keratoconus, glaucoma, and after transplantation of cornea. Bynocs, on the other hand, employs dichoptic training with interactive exercises to reduce suppression of the amblyopic eye and enhance binocular integration. Studies indicate that Bynocs therapy benefits both pediatric and adult amblyopic patients, including those unresponsive to conventional occlusion therapy.

Comparative analysis suggests that dichoptic training is particularly effective in reducing suppression and improving stereoacuity, whereas Revital Vision excels in enhancing contrast sensitivity and BCVA. Both methods underscore the role of neuroplasticity in visual rehabilitation, offering viable alternatives to traditional therapies.

Index Terms - Perceptual Learning (PL), Dichoptic Training, Neuroplasticity, Bynocs Therapy, Revital Therapy.

I. INTRODUCTION

Functional amblyopia is a visual condition of developmental disorder characterized by decreased BCVA unilaterally or in rare cases, both eyes without any ocular pathology. In addition to deficiencies in contrast sensitivity, accommodation, binocular vision, fixation, saccades, colour, and form and motion perception, amblyopia is characterized by abnormalities in visual processing. In recent advancements, novel methods comprising visual computerized training employing various stimuli have been developed and tested as alternatives to the traditional therapies for amblyopia, which include spectacles, patches, bangerter filters and atropine penalization. According to neurophysiological research, video games improve attentional skills and have an impact on neuro-modulatory pathways, which supports these trainings. These new methods have enabled physicians to create new protocols based on dichoptic training, binocular therapy and perceptual learning (PL). Dichoptic training often relies on the use of polarized glasses while red-green glasses are necessary for binocular therapy, both approaches use

stimuli that have certain characteristics in common and some differences for each eye separately in order to undertake binocular fusion training.[1] Monocular occlusion is not utilized in dichoptic training. To promote binocular integration high and low contrast stimulus are supplied to suppressed eye and emetropic eye respectively (an alternative to avoid suppression in case of amblyopia in clinical practice). The hypothesis behind the approach is that individuals with amblyopia have a functionally monocular binocular visual system, result of an unbalanced inputs from two eyes (known as suppression in clinical settings).[2] Perceptual learning—more in particular the concept that practice makes perfect and that performing visual tasks may result in significant and permanent gains! The generally accepted belief that PL can result in long-lasting alterations in brain processing and performance at an early stage of visual coding is, in fact, one of the main reasons why the PL approach is so appealing for treating amblyopia.[3] The brain retains its neuroplasticity—the capacity to adjust neuronal networks and functions are processed in response to alterations in sensory input—after late adolescence. A substantial amount of research over the last few decades has demonstrated that the plasticity of neurons is present in the adult neural system for processing but could be enhanced through sophisticated training program PL, leading to faster processing of image and vision. [4] In individuals with amblyopia, including those above the age of eight, dichoptic therapy improves visual acuity, binocularity, and stereoacuity, particularly in cases of partial deprivation, ametropic, and anisometropic amblyopia.[5] Whereas in patients receiving RV sessions, we saw improvements in VA and contrast sensitivity. By increasing contrast sensitivity and, thus, quality of life, the RV training method may be a useful substitute to enhance the vision in individuals with keratoconus, amblyopia, glaucoma, post-transplantation of cornea, after Lasik, Axenfeld Rieger syndrome, and others.[6]

II. Understanding Neuroplasticity in Vision Therapy

The phenomenon known as neuroplasticity occurs in the brain where different stimuli cause the numerous brain cells to increase or decrease and synaptic remodeling. Without a doubt, neuroplasticity research depicts that human brain is a complex network of neurons with its ability to develop significantly in appropriate circumstances, rather than a static mass of cells.[7] "Hebbian" and "homeostatic" are the 2 main types of plasticities found in the central nervous system. Both influence the development of innovative treatments and contribute to the mechanisms underlying amblyopia. The synaptic foundation for associative learning is provided by Hebbian plasticity, in which correlated pre- and postsynaptic neuron activation reinforces the link between the two neurons (i.e., "what fires together, wires together"). The objective is to maintain a stable input-output relationship with neuronal activity rate as readout, whereas homeostatic plasticity stabilizes network firing rate in response to input activity.[8] The brain is not just a soft mass that is static; enclosed by a hard casing, and submerged in fluid. It continues to evolve once we reach a particular age. It is possible for the brain to grow. When the brain changes, end organs like the eye and its functioning can also change cortically, improve following insults and injuries, and be improved and remediated.[9]

III. Overview of Vision Therapy Solutions

To strengthen the sense of sight stimulus of the suppressed eye through patching, optical penalization or atropine in the emmetropic eye has been the backbone of amblyopia treatment. Refractive adaptation on oneself has been observed to significantly boost visual acuity. However, different studies have different durations for optical correction.[10]

IV. Optical Correction:

Around 1/3rd of children aged 3 to less than 7 whom with untreated anisometropic amblyopia get resolution of their amblyopia, and in many cases, VA is improved by refractive correction alone. An average improvement in VA of 3-lines brought on by spectacle treatment is likely to drop the difficulty of further amblyopia therapy for patients with higher levels of amblyopia, even though the majority of resolutions instances include mild (20/40-20/100) amblyopia.[11] Regardless of the age of the subjects or whether the aetiology was strabismic or refractive, effect sizes were consistently moderate to large. Therefore, in patients with refractive error, spectacles should be considered before alternative methods for treatment of amblyopia. Prior to starting additional therapy, improved acuity would likely reduce the inconvenience of occlusion or penalization and increase dedication to subsequent therapy. [12] Refractive correction alone significantly improved acuity in children with strabismic amblyopia as well as in patients with pure anisometropic amblyopia.[13]

V. Patching or Occlusion Therapy:

The first line of treatment for amblyopia is the inclusion of an adherent bandage over the emetropic eye. This encourages visual path establishment which forces stimulation of the normal eye. Children should expect consistency and significant results with full-time patching, but frequent followup is necessary for minimizing the possibility of developing occlusion amblyopia in the other eye.[14] Children with amblyopia caused by strabismus, anisometropia, or both who are 11 to 15 years old may benefit from compliant, full-time occlusion in terms of improved acuity. With or without maintenance patching, the majority of elderly patients get long-lasting improvement.[15]



Figure 1: Amblyopia Patches

VI. Penalization:

Pharmacologic penalization is a substitute to occlusion intervention in case of amblyopia; however, it is less frequently given. Using this technique, a prolonged-acting topical cycloplegic drug, The sound eye is infused with substances such as atropine sulfate. The better eye vision is blurred for reading distance due to the cycloplegia, which inhibits accommodation. When the cyclopleged sound eye is prescribed less than full plus spectacle correction, it can effectively blur its vision at both near and distance fixation, which could increase the penalization impact when the sound eye is hyperopic. Since the blurring impact on the sound eye may not be enough since the vision in lazy eye is lower than (20/100 or better), pharmacologic penalization has often only been recommended for mild to moderate amblyopia (20/100 or better). According to clinical experience, pharmacologic penalization is highly acceptable to parents and patients, which leads to high compliance rates.[16] Light sensitivity is one of the more common mild side effects of atropine penalization therapy, however in a therapeutic situation, this must be balanced against the possible advantages of twice-weekly eye drops as opposed to daily occlusion.[17]

VII. Transcranial Magnetic Stimulations (rTMS)

The amblyopic visual cortex's contrast sensitivity could be significantly upgraded by repetition of transcranial magnetic stimulation (rTMS). Research findings indicate that the visual system in amblyopia is plastic during adulthood and pave the path for a possible novel therapeutic approach to the management of amblyopia.[18] A non-invasive method for transforming the motor cortex's excitability requires passing a mild direct current via the scalp. Transcranial magnetic stimulation demonstrated excitability changes of up to 40%, which were achieved and persisted for a few minutes following the cessation of current treatment. Therefore, electrical transcranial stimulation with modest current could be a potential method for selectively and focally modifying brain hypersensitivity in a non-invasive, pain free, and alterable manner. [19]

VIII. Liquid Crystal Glasses (LCG)

4 hours of IO-Therapy with liquid crystal occlusion eyeglasses per day set at 50% occlusion would be beneficial for children with moderate, unilateral amblyopia around the ages of 3 to 8, time was not less effective than 2-hours of daily patching. This innovative tool offers youngsters and their often irritated families an alternative approach of treating amblyopia. These findings lend support to additional research using a multicenter, randomized clinical trial to validate and identify baseline variables, such as age, the severity of amblyopia, and subtype causes of amblyopia, that may affect the efficacy of IO-therapy glasses versus patching. [20]

IX. Revital Vision Therapy: Mechanism and Application

Revital Vision is a piece of software, interactive method that uses visual stimuli for perceptual acquisition customized to a subject and is noninvasive. It makes use of Gabor patches in a digitized visually oriented scheme (Figure 1), to promote cortical neural connections. To assess neural efficiency or deficiencies, the patient is first given a series of visual perception exercises. The target Gabor image is then shown along with flanking Gabor Patches that are oriented collinearly. If the patient fails to identify various gabor patch presentations, the task is repeated and a staircase protocol is implemented until the patient strikes their visual threshold value. A therapy plan customised to each patient is implemented based on this analysis. Studies have articulated a significant enhancement in visual acuity of 2.6 logarithms of the resolution of minimum angle (logMAR) lines. Gabor patches (vision restoration).[21] Gray-level gratings on a background with spatial frequencies ranging from 1.5 to 12.0 cycles per degree 1.5 and 12.0 cycles per degree with a brightness of 40 cdm⁻² made up the Gabor patches. The display screen was the only source of light, and the monitor screens were between 15 and 26 inches in size, and were placed at 1.5 meters distance from the viewer, and extending at an angle of 9° by 12°.[22] Depending on their medical condition, patients have undergone 20–40 sessions of RV (on average, 38). Patients responded to tasks using a mouse while seated in front of a computer screen in a dimly lit room during the sessions. The training was intended to be done at home because the program is web-based; nevertheless, in technician from the medical practice conducted the first two sessions were held to guarantee the outcome of learning in advance to sessions commenced in one's home. Over the course of 2-3 months, the patients received per week 3 training sessions, for 20-40 sessions in total. Patients perform two automated assessments using the system prior to the 20 training sessions in order to establish the base of their respective neuronal inefficiencies for the training program. In order to identify their own particular neurological deficiencies, patients went through 2 sessions of evaluation utilizing the fundamental RV system prior to beginning the 20 training sessions. The patient's response on each visually perceived challenges were recorded and uploaded to the RV servers online following each training session¹. The following are examples of variable binocular approaches: dichoptic treatment (dichoptic video games, virtual reality based on the principle of monocular fixation in the binocular field), perceptual learning (AmbPiNet), Revital vision (FDA approved for 9 years and older), and interactive binocular treatment (I-BiTTM). High-frequency transcranial random noise stimulation (hftRNS) and syntonics phototherapy with a red-orange filter are further alternatives.[23]

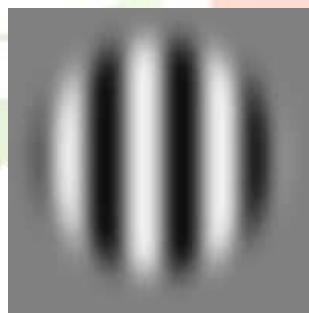


Figure 2: Gabor Patch (Revital Vision)

X. Bynocs Vision Therapy: Mechanism and Application

The Bynocs® Amblyopia treatment plan included five training sessions per week for six weeks, lasting thirty minutes each. The workouts comprised both fusional vergence exercises and dichoptic exercises. In dichoptic exercises, the dominant eye viewed most of the scenes (red-blue goggles were used for dissociation), while the non-dominant eye saw only one important stimulus for the game's performance. The size of these stimuli could be adjusted based on the patient's visual acuity. [24] The patient plays games on a personal computer using licensed software and puts on red-blue goggles for dissociation. Active graphic components within the software are filtered out for the other eye and only visible to the amblyopic eye. Details are perceived by both eyes in order to promote fusion. The games and stimuli's sizes are adjusted according to the patient's binocularity and visual acuity. Patients with amblyopia, including those who are older than the visual maturation age (> 8 years), as well as those who still have residual amblyopia after occlusion, particularly in ametropic and anisometropic amblyopia, benefit from dichoptic therapy training on the BynocsAmblyGo platform. After receiving dichoptic therapy, a significant proportion of patients those had not responded to conventional patching therapy proved

enhancements in their visual acuity and binocular vision parameters. Next to the discontinuance of Bynocs medication, the outcomes are sustained.[24]

XI. Comparative Analysis: Revital vs. Bynocs

Conventional therapy that involves occlusion of one eye does not work for adolescents in case of amblyopia, Binocular disruption during a prior crucial phase is the primary source of this common visual cortex issue. Here, we directly demonstrate that dichoptic stimulus presentation, which, in contrast to forced amblyopic eye usage alone, leads in higher levels of plasticity by reducing amblyopic eye suppression. This suggests that one of the main gating mechanisms, Suppression is what inhibits the amblyopic brain from learning to see.[25] Children with persistent amblyopia may benefit from home-based dichoptic training using the digital platform under evaluation to boost their amblyopic VA and stereoacuity. [26] Whereas In patients receiving RV sessions, observed enhancements in VA and contrast sensitivity. By increasing contrast sensitivity and, thus, quality of life, the RV training method may be a useful substitute to raise VA of individuals having keratoconus, amblyopia, glaucoma, post-corneal transplantation, post-Lasik, Axenfeld Rieger syndrome, and others.[27] In order to improve neuronal processing in the visual cortex, computer-based cortical vision training (RevitalVision, Lawrence, KS, USA) uses server-based software that uses Gabor patch stimuli. The assessment of how significantly the Revital Vision cortical vision training boosts amblyopic patients' Corrected Distance Visual Acuity (CDVA) and Functional Contrast Sensitivity (CSF).[28]

Table 1. Here is a table depicts the difference between the two therapies (Revital Vision Therapy and Bynocs Therapy) .

Type of Therapy	Perceptual learning, visual stimulation using Gabor patches	Dichoptic training using computer games
Target Population	Age 9+, adults and children with amblyopia, keratoconus, glaucoma, post-LASIK, etc.	Especially effective for amblyopia (including age > 8), ametropic, anisometropic, and residual amblyopia
Mechanism of Action	Cortical neural enhancement via repeated identification of Gabor patches (collinear flanking stimuli)	Dichoptic stimulation reduces suppression by presenting different stimuli to each eye via red-blue goggles
Session Frequency	3 sessions/week over 2–3 months (total 20–40 sessions; average 38)	For 6 weeks 5 sessions/week (30 sessions ~ In Total)
Session Duration	Unspecified per session, web-based software	~30 minutes per session
Training Medium	Computerized visual training using Gabor stimuli	Game-based therapy using licensed PC software
Initial Setup	First 2 sessions supervised by a technician	Fully home-based with red-blue goggles for dissociation
Evaluation Phase	Two baseline evaluations before training to assess neural inefficiencies	Visual acuity-based adjustments during game play
Patient Interaction	Mouse-controlled tasks in dim lighting	Game interaction via keyboard/mouse, wearing red-blue goggles
Outcome Metrics	Mean improvement of 2.6 logMAR lines, enhanced BCVA and contrast sensitivity	Improved VA and binocular vision, especially in cases unresponsive to occlusion therapy
Platform Access	Web-based, uploads data to server post-session	PC software, game-based with filtered graphic components
FDA Approval	Yes, for age 9+	Not specified in the excerpt
Customization	Therapy plan based on initial neural assessment	Stimuli/game adjusted for binocularity and acuity
Sustainability of Results	Improvements sustained after treatment	Improvements sustained post-therapy discontinuation
Additional Notes	Uses a staircase method to determine patient's threshold	Encourages fusion by showing key stimuli to amblyopic eye only

XII. Conclusion

Functional amblyopia is a complex visual disorder that can significantly impact quality of life. Traditional treatments such as optical correction, patching, and penalization have been the standard approach, but novel vision therapy solutions like Revital Vision and Bynocs have emerged as promising alternatives. These modern therapies leverage neuroplasticity to enhance visual processing, using perceptual learning and dichoptic training to improve visual acuity, contrast sensitivity, and binocular vision. Revital Vision employs Gabor patch-based perceptual learning, making it effective for a range of conditions beyond amblyopia, such as keratoconus and post-corneal transplantation. Bynocs focuses on interactive dichoptic training, benefiting patients even after traditional occlusion therapy. Both methods address suppression in amblyopia and promote neuronal adaptation, leading to long-lasting improvements. As research continues to validate these therapies, they offer hope for patients, including older individuals, who previously had limited treatment options. Future advancements in vision therapy may further enhance accessibility and treatment efficacy.

XIII. References

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