Binocular treatment for amblyopia in adults and children with low-pass filtering when occlusion therapy fails

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Background

• Growing evidence suggests that amblyopia is a not a monocular problem, but rather is a condition of impaired binocularity.¹²
• While clinical studies confirm the benefits of occlusion therapy and penalization for improving visual acuity in the amblyopic eye (AE), deficits in stereopsis and motion perception often persist.
• Researchers are developing binocular therapies for amblyopia treatment,⁶,⁷ and some products are now available for use in clinical practice.
• Clinical trials have failed to establish the superiority of binocular treatment, with contrast-adjusted dichoptic stimuli, over occlusion therapy.⁵,¹⁰
• Vivid Vision is a virtual reality (VR) system allowing for dichoptic and stereoscopic training. Adults with anisometropic amblyopia showed improvement in visual acuity (VA) and stereoacuity with an early version of this system.¹¹

Purpose

To determine the clinical efficacy of Vivid Vision dichoptic training in the treatment of amblyopia using low-pass filtering (“blur”) and decreased luminance (“occlusion”) in the fellow eye (FE) image

Methods

Participants

• 34 patients with amblyopia; age 3 to 69 yrs; age groups: <11yrs (n=18), >11yrs (n=16)
• etiology groups: anisometropic (n=25), combined aniso-strabismic (n=5), strabismic (n=4)
• Vivid Vision was offered when occlusion therapy was unsuccessful due to poor compliance, plateau in improvement and/or regression.
• All (including participants who lacked fine stereopsis) were able to perceive the complete VR environment and perform all tasks.

Tasks

Performed with Oculus Rift VR headset, hand controls, and the Vivid Vision clinical system.

Procedure

• Weekly 30-minute sessions, with at least 3 tasks per session, for 8 consecutive weeks (4 wks for 3 participants).
• Equal amounts of “blur” and “occlusion” were applied to the FE image to allow 70-80% accuracy at the highest difficulty level throughout each session. Contrast was not modified.
• Adjustments for ocular misalignment were made to optimize fusion and eliminate diplopia in patients with strabismus.

Results

• Significant improvement in AE VA (measured with Snellen letters or Allen Figures) after treatment in full group, both age groups, and both etiology groups (p<0.0001).
• Change in FE VA approached significance (p=0.06).
• Randot (Circles) stereoacuity improved in participants who had measurable stereopsis (n=15) at the start of treatment (p=0.05); no measurable improvement in stereoacuity was observed in the remaining participants.

Conclusions

• Our independent assessment on the clinical efficacy of Vivid Vision confirms favourable outcomes, especially for visual acuity.
• Low-pass filtering with dichoptic training may bias binocular mechanisms involving larger, low spatial frequency-tuned receptors which may be more resistant to amblyogenic factors due to earlier development.
• This is supported by the sparing of binocular mechanisms tuned to a coarser scale in amblyopia such as those involved with maximum motion displacement (Dmax),¹² coarse stereopsis¹³ or global motion at fast speeds.¹⁴
• A preliminary analysis of pre- and post- treatment psychophysical thresholds for global motion and coarse stereopsis in a subset of patients was inconclusive.
• Performance of the tasks in the VR environment of the Vivid Vision clinical system requires integration of motion and form processing, attentional mechanisms, and visuomotor skills, among others. The relationship between these aspects of visual perception and the clinical outcomes reported warrants further study.

References


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