

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

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Cindy Ho¹, Yousef M. Shahin², Henry Reis¹, Stefanie Grenier¹, Deborah Giaschi²
¹Integra Eyecare Centre, Burnaby, BC, Canada; ²Department of Ophthalmology & Visual Sciences, University of British Columbia



Background

- Growing evidence suggests that amblyopia is not a monocular problem, but rather is a condition of impaired binocularity.¹⁻³
- While clinical studies confirm the benefits of occlusion therapy and penalization for improving visual acuity in the amblyopic eye (AE)⁴, deficits in stereopsis⁵ and motion perception⁶ often persist.
- Researchers are developing binocular therapies for amblyopia treatment,^{7,8} 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.^{9,10}
- 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

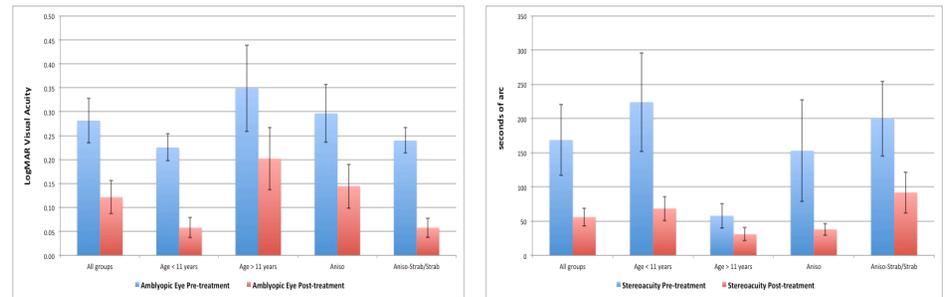
Performed with Oculus Rift VR headset, hand controls, and the Vivid Vision clinical system.

BREAKER	RING RUNNER	HOOPIE	BUBBLES
			
Dichoptic stimuli: AE Ball Both eyes: Bricks FE Paddles	Dichoptic stimuli: AE Rings marked R, B or G FE Spaceship	Dichoptic stimuli: AE Balls marked X or O FE Hoop	Stereoscopic stimuli: Presented to AE and FE with relative disparity
Task: hit the ball to break the bricks Level difficulty change: more bricks, faster brick speed, # of hits to break Clinician modifiable: ball speed, ball size Skills: anti-suppression, fusion, hand-eye coordination	Task: move the spaceship through B and G marked rings, avoid the R marked rings and asteroids Level difficulty change: increase speed Clinician modifiable: marker size, number of distractors, start speed Skills: anti-suppression, fusion, attention, hand-eye coordination	Task: catch the Os but not the Xs using the hoop Level difficulty change: increase ball speed, angle of trajectory Clinician modifiable: ball speed, X and O marker size, hoop size, flash duration (if tachistoscope mode enabled) Skills: anti-suppression, visual-motor coordination, visual memory (with tachistoscope mode)	Task: pop the floating bubbles in order from closest to farthest away Level difficulty change: more bubbles, less relative disparity between bubbles Clinician modifiable: bubbles size, arm length Skills: stereoacuity, hand-eye coordination

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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correspondence: drcindyho@integraeyecare.com