Effects of Stereoscopic Vision Training on the Vergence System of Binocularly Normal Subjects
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Introduction: The vergence system is responsible for the ability to track an object changing in 3-dimensional (3D) space. Multiple brain regions are involved in these eye movements including the cerebellum, midbrain, and frontal eye fields.1 The preprogrammed vergence system is responsible for fusing stimuli presented to both eyes into a single image while the feedback vergence system allows a subject to adapt and fuse stimuli throughout near and far space.2 While randomized clinical trials studying Convergence Insufficiency (CI) patients report significant improvement in vergence function after vision therapy,3 it is unknown whether the therapy induces changes to the visual system of those with normal binocular vision. Stereoscopic vision training is analogous to modern 3D entertainment in that vergence is stimulated by presenting images separately to each eye. The goal of this study is to ascertain if 3D gaming will have a significant impact on the human vergence system by utilizing stereoscopic vision therapy on binocularly normal subjects.

Materials and Methods: Experiments were approved by the Institutional Review Board at New Jersey Institute of Technology (F128-12) and then carried out in a haploscope (Figure 1a). Visual stimuli were reflected off of half-silvered mirrors and presented separately to each eye in order to stimulate vergence eye movements in the midsagittal plane. Infrared cameras were used to track the horizontal position of the pupil. VisualEyes, a custom LabVIEW program, was used for data collection, and custom MATLAB programs were written to calculate eye rotation and related parameters. In order to perform high throughput analysis, automated software was developed.

Vision therapy consisted of vergence steps, in which the stimulus position changed discretely, and vergence ramps, in which the stimulus moved towards and away from a subject’s nose at a constant rate. Vergence step experiments alternated between near space (8° to 10° inward monocular rotation) and far space (0.5° to 2.5° inward monocular rotation). Ramp stimuli traversed the defined extremes of near and far space at speeds of 0.5°/s, 1°/s, 2°/s, and 4°/s. Five subjects completed twelve one-hour sessions.

Results and Discussion: Throughout vision training, 4 of 5 subjects reported an improvement in fusing stimuli in far space. This qualitative data indicated an increase in these subjects’ vergence range for on the mid-sagittal plane. However, when quantitative analysis was performed, only one subject showed statistically significant changes in disconjugate (opposite) eye rotation. As seen in Figure 1b, Subject 1 exhibited an increase in total vergence for all convergence ramps (p < 0.05). Ramp data were additionally analyzed for variance in velocity and calculated eye position error, but no significant trends emerged as vision training progressed. Furthermore, binocularly normal subjects exhibited no improvement in the preprogrammed vergence system, quantified by peak velocity in response to step stimuli.

Conclusion: The feedback vergence system improved for one subject, but no significant trends were seen in improved ability to track targets in near or far space for the remaining four subjects. Preliminary data support that vision training did not substantially change the vergence system of binocularly normal controls as compared to the changes observed in CI patients.3 Results can be extended to hypothesize that 3D entertainment may not have a significant impact on the preprogrammed vergence system. However, qualitative reports along with the results for Subject 1 indicate potential effect of 3D entertainment on the feedback controlled vergence system.

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