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Correlation Between Stereopsis and Reverse Stereopsis

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Stereopsis requires binocularity and depends on the lateral separation of the globes and the horizontal displacement of retinal images. Stereopsis is the result of higher order visual processing and is frequently used to determine fusional ability. Stereoacuity can also be used to predict a range of visual acuities in patients suspected of having nonorganic vision loss¹. The effect of visual field defects on stereopsis in humans has been rarely studied^{2–5} with only one study detailing the effects of non-glaucomatous visual field defects on stereopsis⁴.

Hirai et al.⁴ suggested that patients with a bitemporal hemianopia should not be able to see a stereoscopic image projected further away from the patient. In their study, 13 patients with compressive lesions of the optic chiasm had stereoacuity testing. Stereoacuity was tested with the stereoacuity book held upright and with the stereoacuity book inverted, presumably rotated 180 degrees. Ten patients had bitemporal hemianopias on visual field testing and 8 of the patients with bitemporal hemianopias correctly identified 2 or less circles out of 9 circles on stereoacuity testing. The other 2 patients with bitemporal hemianopias correctly identified 6 of 9 circles on stereoacuity testing. Three patients with a lesion involving the optic chiasm on MRI had normal visual fields and normal stereoacuity⁴. The authors hypothesized that patients with bitemporal hemianopias have a loss of overlapping visual fields at and beyond fixation resulting in monocular viewing centrally and a subsequent loss of stereopsis at fixation and at points beyond fixation (Figure 1). However, Hirai et al.⁴ did

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not specify which orientation of the stereoacuity book was used to test each patient or which stereoacuity score (upright or inverted) was reported. Therefore, following our previously published study in this journal¹, we wanted to determine if there is a difference between traditional stereoacuity (TS) and reverse stereoacuity (RS) in patients without visual field defects prior to studying the effects of visual field defects (homonymous hemianopias and bitemporal hemianopias) on TS and RS.

We performed TS and RS testing, as well as a systematic, detailed neuro-ophthalmologic examination, including visual field testing, on consecutive patients with normal visual fields presenting to our neuro-ophthalmology service over a 6 month period. TS was defined as stereoacuity testing with the Titmus vectographic stereoacuity book held upright and RS was defined as stereoacuity testing with the Titmus vectographic stereoacuity book rotated 180 degrees. In TS testing, the virtual image appears closer to the patient and stimulates the temporal retina of each eye, corresponding to the nasal visual field of each eye (Figure 1A). Conversely, in RS testing, the virtual image appears further from the patient and stimulates the nasal retina of each eye, corresponding to the temporal visual field of each eye (Figure 1B). Stereoacuity was determined using the Wirt dot portion of the Titmus vectographic stereoacuity book (Figure 1). Each patient was first tested with the book held upright (TS) and then with the book rotated 180 degrees (RS). The stereoacuity score was determined, as in our previous study¹, as the highest numbered circle correct without previously missing two consecutive circles.

A total of 495 patients were screened, with 98 patients initially included in the study. The majority of patients (339) were excluded due to the presence of visual field defects. Patients were also excluded if stereoacuity or visual acuity data was not recorded (23 patients), if there was a heterotropia or history of strabismus or amblyopia (30 patients), if cognitive issues prevented accurate testing (0 patients), if non-organic vision loss was present (1 patient), or if the patient was unable to correctly identify any of the circles on TS testing (4 patients). The average age was 45 years old (range: 13 to 79); 83 patients (84.7%) were women. The median Snellen visual acuity (VA) was 20/20 (range from 20/20 to 20/125). The median stereoacuity score was 9/9 circles correct for both TS and RS with a range from 1 to 9 circles correct for both TS and RS (interquartile range of 1). The average stereoacuity score was 7.8 circles correct for TS and 7.5 circles correct for RS ($p = 0.07$, paired two-tailed t-test, 95% CI -0.64 to 0.03). Fifty-six patients (57.1%) scored the same on TS and RS testing, 18 patients (18.4%) had a one circle difference between TS and RS (10 scored better on TS and 8 scored better on RS), 18 patients (18.4%) had a 2 or 3 circle difference (11 scored better on TS and 7 scored better on RS), and 6 patients (6.1%) had a >3 circle difference (5 scored better on TS and 1 scored better on RS).

Since performance on stereoacuity testing is correlated with visual acuity¹, a subgroup analysis was performed on the 80 patients with good VA (20/30 or better). Average age was 44 years old (range from 13 to 79 years old); 70 patients (87.5%) were women. The median stereoacuity score was 9/9 circles correct for both TS and RS (range from 1 to 9 circles correct for both traditional and reverse stereoacuity). The average stereoacuity score was 8.1 circles correct for TS and 7.9 circles correct for RS ($p = 0.23$, paired two-tailed t-test, 95% CI -0.56 to 0.13). Fifty-one patients (63.8%) had no difference between TS and RS, 13

patients (16.25%) had a one circle difference (6 scored better on TS and 7 scored better on RS), 13 patients (16.25%) had a 2–3 circle difference (9 scored better on TS and 4 scored better on RS) and 3 patients (3.75%) had a >3 circle difference (2 scored better on TS and 1 scored better on RS).

Our data suggest that there is no significant difference between traditional stereoacuity and reverse stereoacuity in neuro-ophthalmology patients with good visual acuity (20/30 or better) and without strabismus or visual field defects. Therefore, any difference found in patients with good visual acuity with homonymous or bitemporal visual field defects likely can be attributed to the visual field defects themselves. The results of this study provides background for an ongoing study detailing the effects of homonymous hemianopias and bitemporal hemianopias on traditional and reverse stereoacuity.

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Figure 1.

Schematic depicting retinal stimulation by virtual stereoisimages with traditional stereoacuity testing and reverse stereoacuity testing. The solid lines in both the traditional stereoacuity (A) and reverse stereoacuity (B) schematic depict the projection of light from a point located in the plane of the stereoacuity book (vertex of each pair of solid lines) onto the fovea of each retina. In traditional stereoacuity testing (A) the virtual image projects closer to the patient (represented by the vertex of the dashed lines). Light rays from this virtual image (dashed lines) project to the temporal retina corresponding to the nasal visual field. In reverse stereoacuity testing (B) the virtual image projects further from the patient

(represented by the vertex of the dashed lines). Light rays from this virtual image (dashed lines) project to the nasal retina corresponding to the temporal visual field.