The spatial limits of recovered stereopsis in strabismic/amblyopic adults

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Introduction

We recently developed a perceptual learning procedure which enabled individuals who were stereoblind or stereo-anomalous to recover their stereo perception (Ding & Levi, 2010). However, what is the nature of the recovered stereopsis? Here, we used bandpass noise (BN) to study the spatial limits of the recovered stereopsis.

Stimuli

(A) Binocular-fusion-assisting frames: dichoptic nonius cross with binocular fusors in the surrounding.

Strabismic/amblyopic observers were able to achieve binocular fusion and alignment.

(B) Bandpass noise was produced by filtering a two-dimensional binary random noise with a 2D-isotropic bandpass filter.

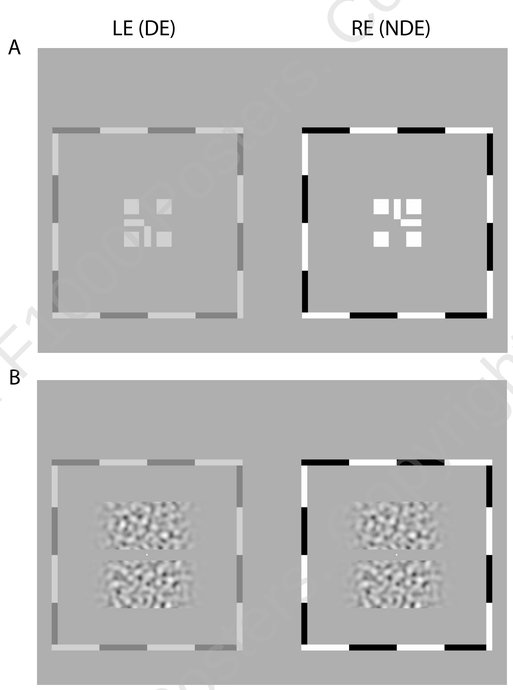
Central spatial frequency: 0.34, 0.68, 1.36, 2.72, 5.44, 10.88, or 21.76 cpd

Bandwidth: 1.26 octaves

Observation distance: 0.68 or 1.36 cm

Size: 9° x 3° or 4.5° x 1.5°

Task: indicate the relative depth of the target (top patch with non-zero disparities) related to the reference (bottom patch with zero disparity). No feedback.

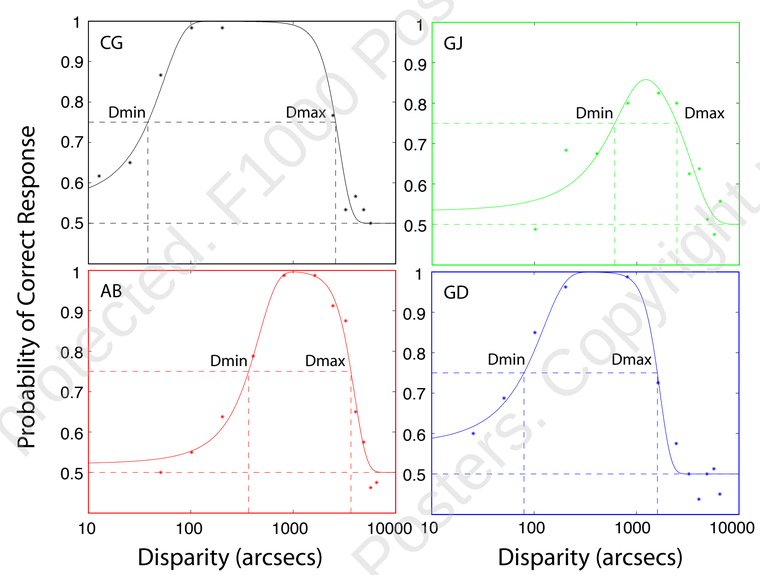


Observers

CG: normal observer (black)
AB: strabismus (Alter esotropia 9Δ; R hypertropia 8Δ) with normal monocular vision (R 20/20; L 20/20) (red)
GJ: strabismus (R esotropia 5Δ) with amblyopia (R 20/40; L 20/16) (green)
GD: anisometropia (R 20/12.5; L 20/50) (blue)

Results

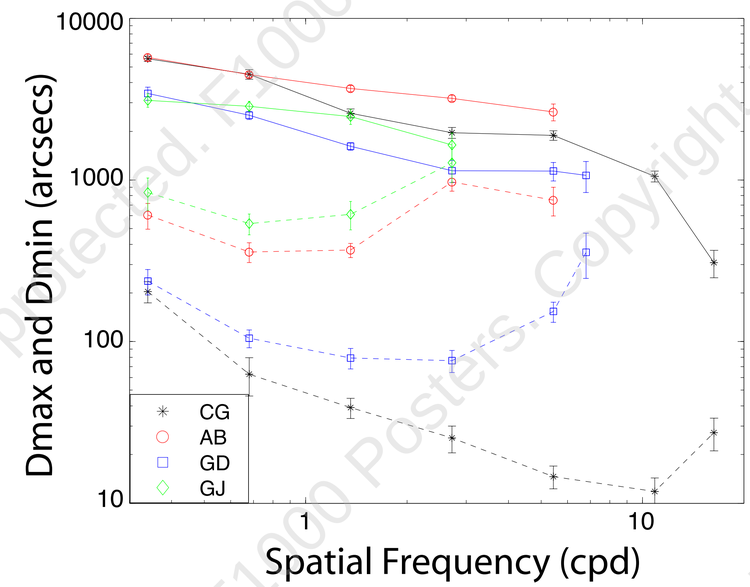
Psychometric functions. Probability of correct response as a function of binocular disparity (10 -- 10,000 arc seconds) was fitted by the summation of two psychometric functions, one for Dmin and one for Dmax, as shown in this following figure when spatial frequency was 1.36 cpd.



Dmin and Dmax: measured at 75% correct response

Elevated stereo threshold (Dmin) was observered in recovered stereopsis. However, Dmax looks similar in normal and recovered systems.

Spatial frequency reponse. Dmax (solid curves) and Dmin (dashed curves) as functions of spatial frequency



Dmin: bandpass frequency response for both normal and recovered stereopsis with narrower frequency band for recovered stereopsis.

Dmax: low-pass frequency response for both normal and recovered stereopsis with possible similar cutoff frequency; the failure at a high spatial frequency in recovered stereopsis might be due to the elevated stereo threshold (Dmin).

Conclusion

We conclude that the stereopsis recovered following perceptual learning is more limited than in the normal visual system in the spatial frequency band and the perceived disparity range. The limits might be mainly due to a higher stereo threshold, especially at a higher spatial frequency, in recovered stereopsis.

References

(1) Ding, J., & Levi, D. (2010). Recovery of stereopsis in human adults with strabismus through perceptual learning. J Vis August 2, 10(7): 1124;

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