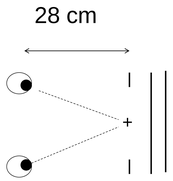
Are blur and disparity complementary cues to depth ?

Michael Langer Ryan Siciliano

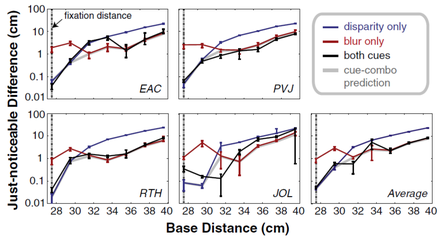
School of Computer Science, McGill University, Montreal,Canada

Introduction



Optical blur and binocular disparity both increase with the distance from the fixation plane. Perceived depth from disparity is accurate near the fixation plane, but it is *in*accurate away from this plane when diplopia occurs. Mather and Smith [1] hypothesized that at large distances from fixation, depth perception is based more on blur than disparity [1]. Held, Cooper & Banks found evidence to support this hypothesis as shown by the data below [2]:

Cross fusible stereo pair (shown here or illustration purposes only)

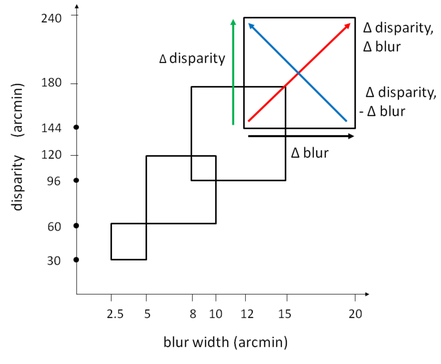


One prediction of this theory is that, at large disparities, varying the blur lead to variations in perceived depth. Our experiment tested this prediction by examining four classes of cue combinations of Δ blur and Δ disparity (see illustration below).

Method

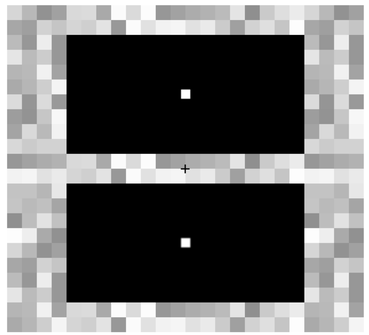
Apparatus: Dell laptop with NVIDIA 3D shutter glasses. Software was PsychoPy[6]

Design: 48 conditions = 3 types of images (see above right)
x 4 reference values of disparity or blur
x 4 combinations Δdisparity, Δblur
(10 trials per condition)

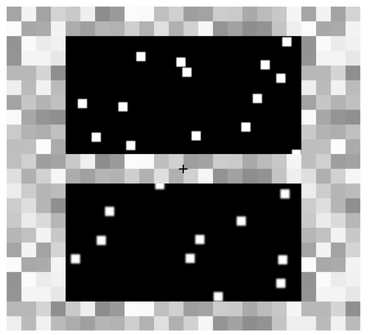


Procedure: Presentation time: 200 ms.

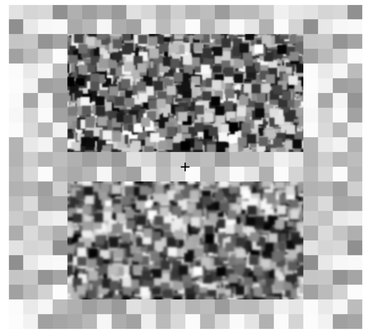
Subjects: 14 naïve (+ 11 that didn't meet given criterion)



blurs = 5,10 disparities = 60, 120 (arc min)

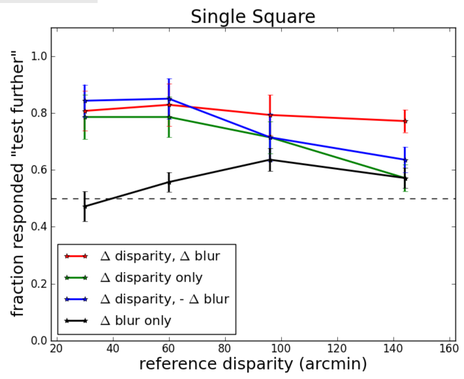


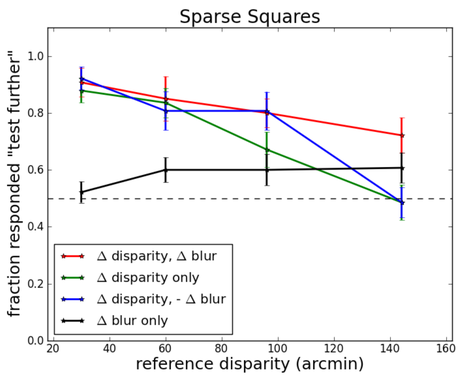
blurs = 8,15 disparities = 96, 180 (arc min)

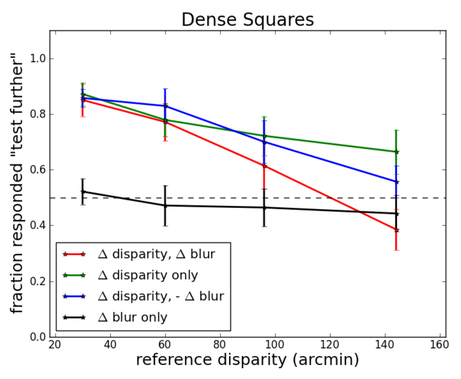


blurs = 12, 20 disparities = 144, 240 (arc min)

Results







- In all three Δ disparity conditions, performance fell as disparity and density increased → No surprise, since related effects occur for random dot stereograms [4] .
- For the single and sparse square images, performance was better in the cue consistent conditions than in the cue inconsistent conditions, and performance for the Δ blur (only) condition was slightly above chance. → Blur seems to be used.
- For the dense square images, performance was worse in cue consistent conditions, and was at chance in the Δ blur (only) condition → Unclear how / if blur was used.

References

[1] Mather and Smith, *VisRes* 2000.
[2] Held, Cooper, Banks,*Cur Bio* 2012
[3] Richards and Kaye, *VisRes*1974
[4] Blakemore , *J. Phys*1970
[5] Wilcox and Hess, *Vis Res* 1995
[6] Glennerster, *Vis Res* 1998
[7] Peirce, *J. Neur. Meth.* 2007

Conclusion

There is a fundamental problem with the theory that blur and disparity are complementary cues to depth [1, 2]. Depth from blur has a sign ambiguity, and the visual system depends on disparity to disambiguate this sign. But the sign information is less reliable for large disparities i.e. near or beyond Dmax for stereo [3-6]. We conclude that *if* blur and disparity are indeed complementary cues to depth - as has been hypothesized - then the way that these cues are used may depend on the type of image present.