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VSS 2014

Stereoscopic depth from absolute and relative disparities
or
The phenomenon of absolute depth "blindness"

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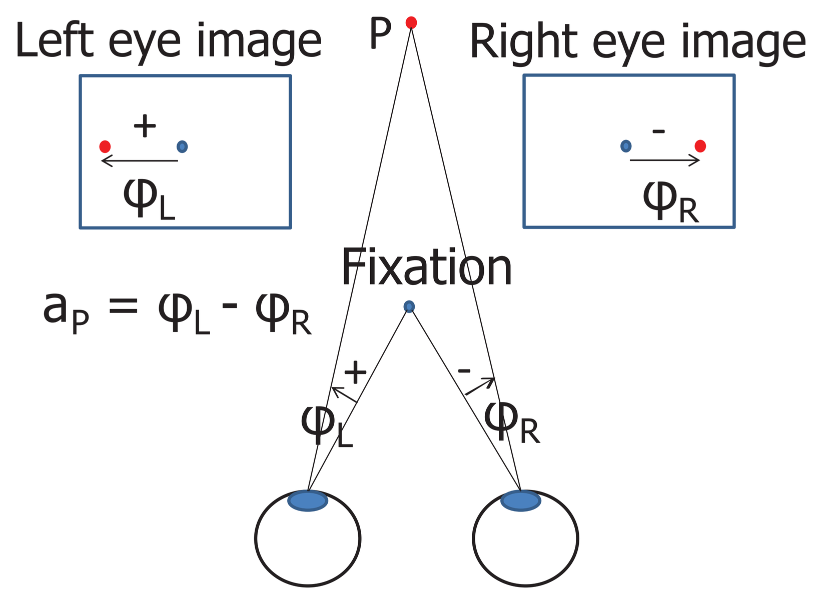
What are absolute and relative disparities?

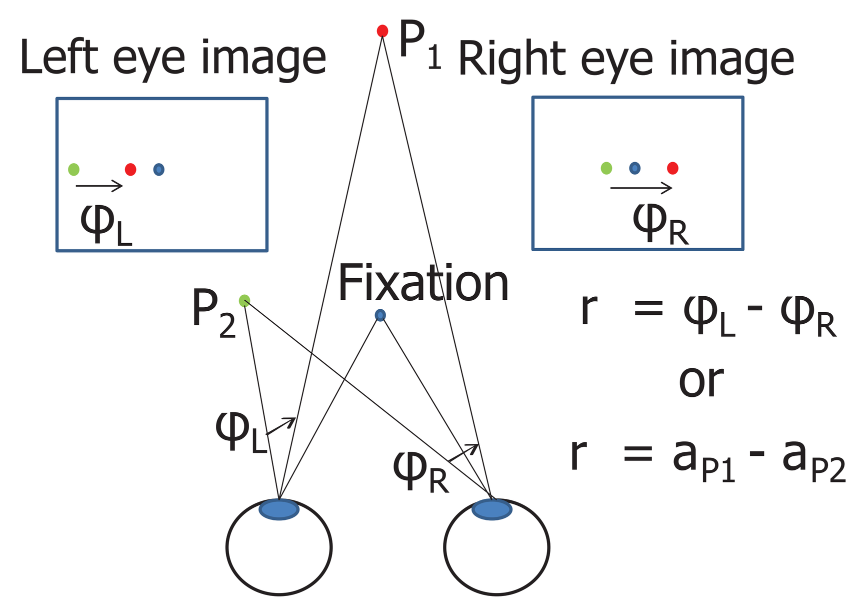
Absolute disparity a

An object's absolute disparity is calculated relative to the fixated point in each eye (fovea).



Relative disparity r

The relative disparity between two visual objects is their difference in absolute disparity, which may be computed directly from the binocular difference in their horizontal displacement in each eye.



Are absolute and relative depth systems independent?

It is an unresolved question: are relative disparities independently acquired or are they computed as a difference of absolute disparities[1]?

Some believe that the two systems are independent because relative depth performance is better than absolute depth performance. However several concerns need to be addressed.

Concern 1: The absolute depth condition always presents a visible reference (fixation or screen border), creating relative disparities[2].

Solution: We measured performance without any visible references. In a dark room, the fixation point was extinguished upon stimulus presentation and the screen's border was in binocular rivalry by the mean of a diamond-shaped occluder.

Concern 2: Absolute depth performance is typically measured with 2IFC and relative depth with 2AFC giving the advantage to relative depths (because of memory decay)[3].

Solution: We used a single stimulus method, introducing the same memory burden in the two conditions.

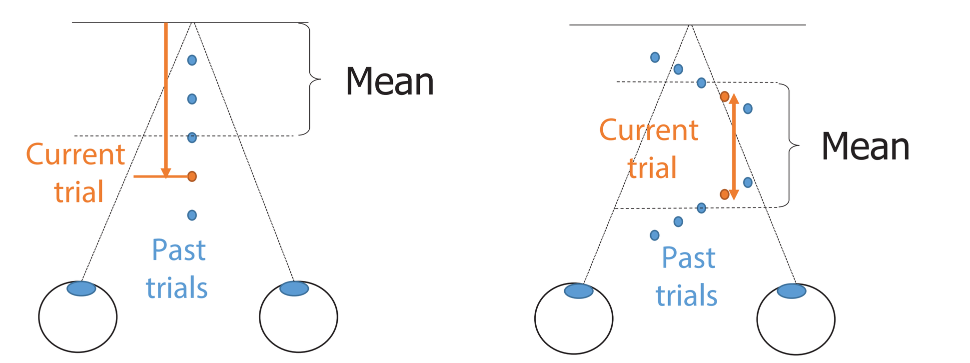
Configuration:
-Always 2 lines in depth, either the same depth (absolute) or different depths (relative).
-Always one above and one below fixation point.

Stimulus duration: 200 ms

Participants: 21 controls and 13 dressmakers

Absolute Depth
Is the line closer than the mean of all past trials?

Relative Depth
Is the inter-depth between the two lines smaller than the mean of all past inter-depths?



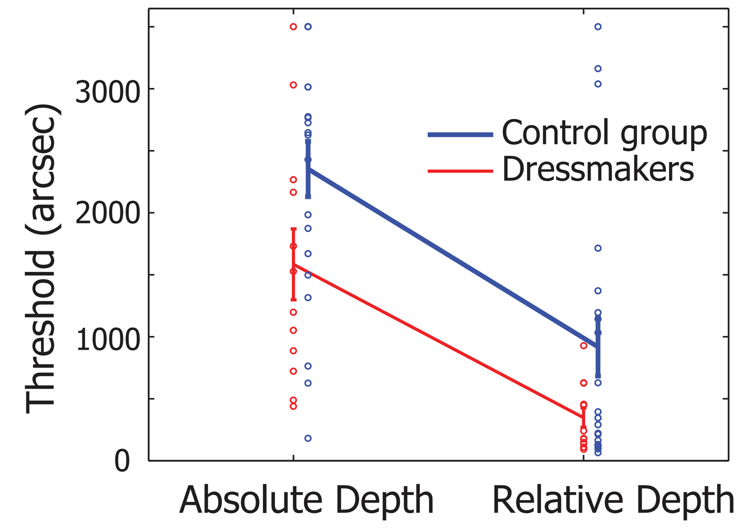
References

1. Parker AJ. Binocular depth perception and the cerebral cortex. Nat Rev Neurosci. 2007;8(5):379–391.
2. McKee SP, Welch L, Taylor DG, Bowne SF. Finding the common bond: Stereoacuity and the other hyperacuities. Vision Res. 1990;30(6):879–891.
3. Westheimer G. Cooperative neural processes involved in stereoscopic acuity. Exp Brain Res. 1979;36(3):585–597.

RESULTS

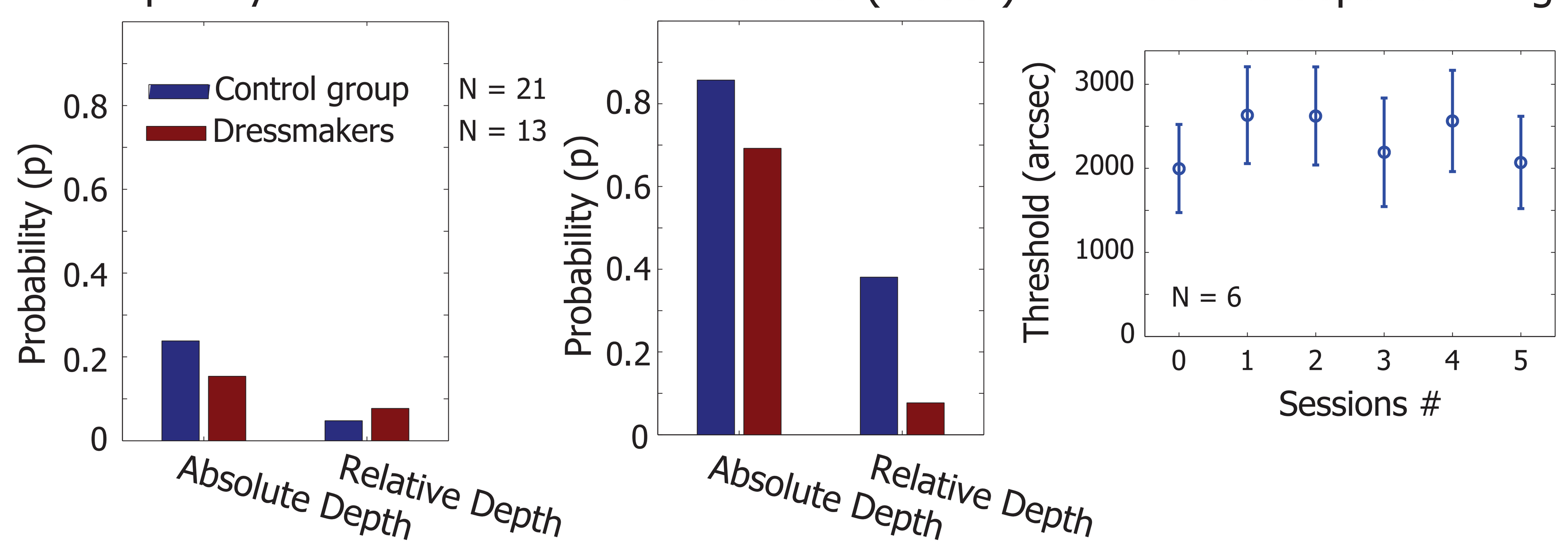
Stereopsis: absolute vs. relative depth

Relative depth performance is significantly better than absolute performance (ANOVA; $p<0.0001$). No correlation between absolute and relative thresholds.



Absolute depth "blindness"

Stereoblindness and absence of fine stereopsis are more likely for absolute depths than for relative depths. 86% of the control participants lack fine stereopsis for absolute depths. Absolute depth training did not yield benefits after 5 sessions.



Dressmakers

Concern 3: Only "psychophysics experts" have been measured.

Solution: Participants were naive: either students or professional dressmakers, who may particularly benefit from a good stereopsis in their activity.

Result: Dressmakers are more precise than the control group ($p<0.001$ - one outlier). However, difference is not significant when considering only relative depth and when excluding stereoblind participants. The probability of lacking fine stereopsis for relative depth is lower for dressmakers than for controls but only marginally (chi2, $p<0.10$).

Vergence

Concern 4: Vergence noise could explain the difference between the two conditions.

Solution: We measured vergence noise for each participant with a nonius line task.

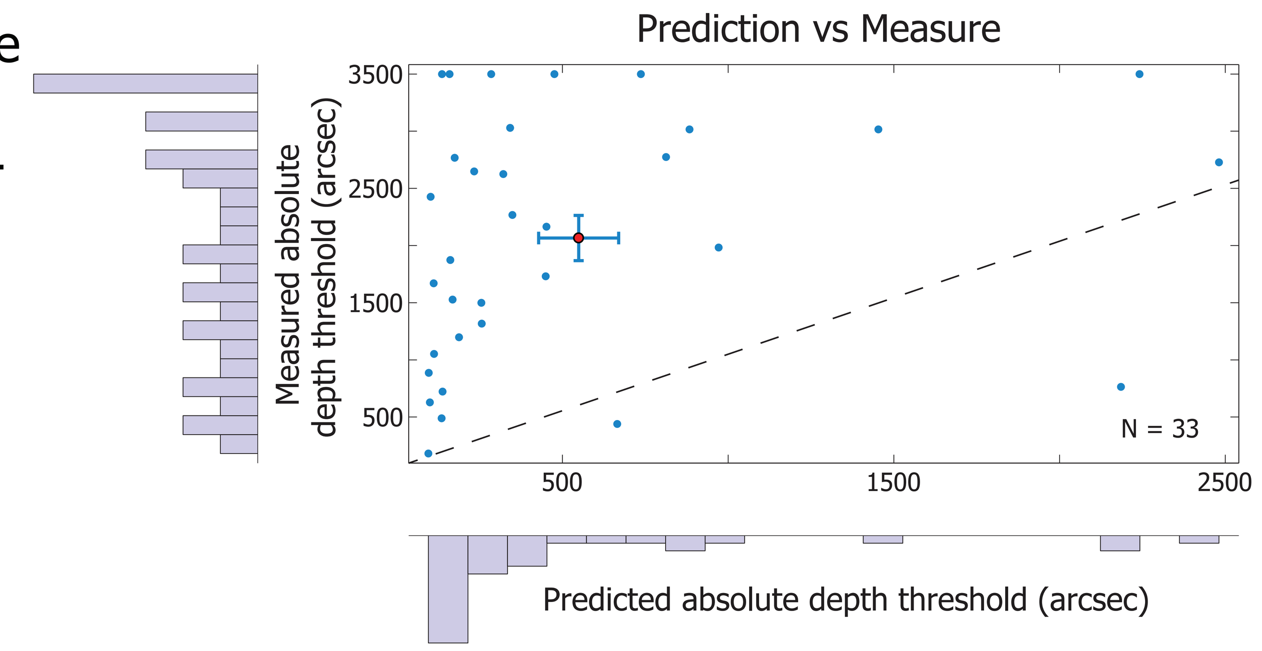
Result: Vergence thresholds average to 140 arcsec, much lower than absolute disparity thresholds, thus ruling out an explanation of absolute depth blindness from vergence noise. It is not different between control and dressmakers.

Predictions

Under the assumption that a relative disparity is a difference of absolute disparities, an expected absolute depth performance can be calculated from the relative depth performance and the vergence noise:

$$\widehat{\sigma_{abs}} = \sqrt{\left(\frac{\sigma_{rel}}{\sqrt{2}}\right)^2 + \sigma_{verg}^2}$$

Real performance is a lot worse than the prediction ($p<0.0001$).



CONCLUSIONS

1) Observers are almost blind to absolute disparities (under our conditions of sparse stimuli and brief exposure), therefore:
   a) either there is no direct read-out of absolute depth (absolute depth blindness)
   b) or absolute and relative depth are two independent systems.

2) Training absolute depth performance does not produce benefits.

3) The difference between absolute and relative depth thresholds cannot be explained by memory, vergence noise, or the presence of references.

4) Dressmakers have better performances, probably because they were less likely to lack fine stereopsis.

ACKNOWLEDGEMENTS

This work was supported by the NEI and the Swiss National Foundation.