H99
V-VSS 2021

The orientation-difference cue in figure-ground separation: border ownership and timing

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Motivation

Figure-ground separation, a crucial component of visual processing, can be driven by differences in contrast, orientation, and other local cues. We previously showed (VSS 2020) that the orientation cue has distinctive characteristics: figure-ground separation depends not only on the magnitude of the orientation difference, but also on whether the oriented component is present in the figure vs. the ground. Here we show that this dependence is invariant with respect to convexity vs. concavity and determine how it evolves over time.

Conclusions

When figure-ground identification is driven by texture, image statistics in figure and ground play different roles. For oriented image statistics (the "opposite-sign" condition), thresholds are lower when they are present in the figure, than when they are present in the ground.

- This asymmetry is driven by border ownership, but not by border shape.
- It is already present at 125 ms, and amounts to a twofold difference in threshold.

Related Work:

Victor, J.D., Thengone, D.J., Rizvi, S.M., and Conte, M.M. (2015) A perceptual space of local image statistics. Vision Research 117, 117-135. http://www-users.med.cornell.edu/~jdvicto/vitpr15.html

Victor, J.D., and Conte, M.M. (2019) The role of local image statistics in separating figure from ground. (Abstract) Vision Sciences Society Annual Meeting 2019. http://www-users.med.cornell.edu/~jdvicto/vps/vss19_vico.pdf

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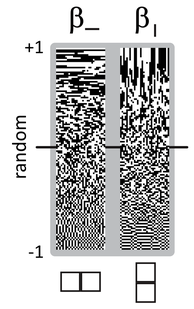
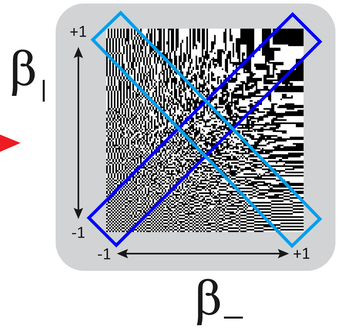
Support: NIH EY7977

Stimulus domains



Each strip shows the textures generated by varying a second-order image statistic over its range, from +1 to -1. These statistics determine correlations between pairs of checks that are adjacent horizontally (β_-), or vertically ($\beta_|$). In both cases, a random texture corresponds to a correlation of 0.

Pairwise combinations



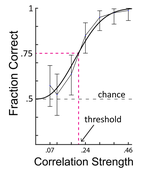
The square domain shows the texture space generated by varying both second-order statistics. Within the darker blue rectangle, β_- and $\beta_|$ have the same sign; within the lighter blue rectangle, β_- and $\beta_|$ have opposite signs. When the image statistics have opposite sign, the texture is strongly oriented. The random texture is at the origin (both statistics equal to zero).

Methods

Sample Trials and Task

Before each block, subjects were shown samples of the targets with cartoons illustrating size and location of circles. These are examples from the same-sign plane. **Left:** circles are defined by negative correlations; background by positive correlations. **Right:** circles are defined by positive correlations; background by negative correlations.

Threshold Determination

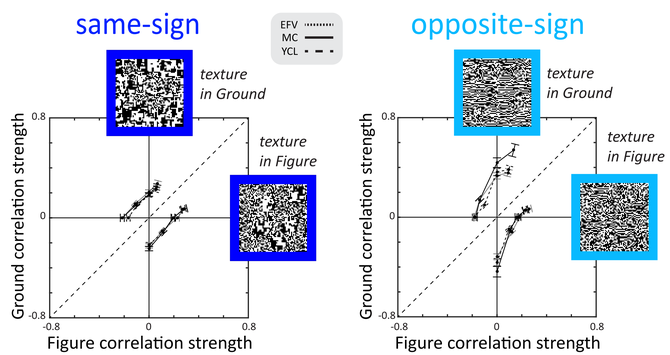


Threshold was taken to be the texture contrast at which fraction correct was 0.75, as determined by maximum-likelihood fits to Weibull functions.

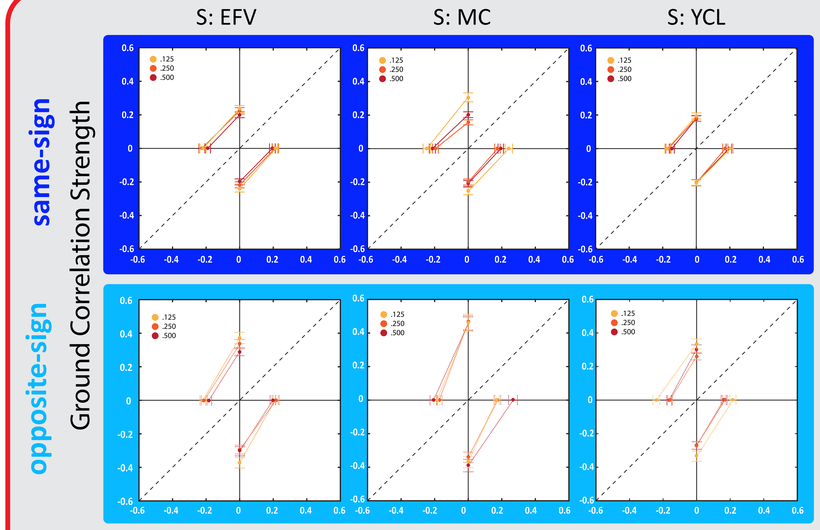
Testing Details

Subjects: 3F; VA = 20/20 **Conditions**: 2-AFC design with 140 trials/block, 16-32 blocks/condition (**94,080** total trials), Practice: 1 hr/subj, feedback only with practice. Binocular viewing at 1 m. **Stimuli:** Contrast: 1.0, Check size: 9.8 min; Display size: 10.5 deg, Luminance: 81 cd/m², Standard trial: two 500 ms presentations followed by a 500 ms mask. For shorter presentations, a blank interval separated the stimuli so that the total trial duration was unchanged. Target structure: 5 circles randomly-placed = 25% of stimulus area.

Results - previous work



We previously found that for opposite-sign image statistics, thresholds for figure-ground identification were higher when correlations were present in the ground, than in the figure. However, this experiment does not indicate whether border shape plays a role.



Dynamics

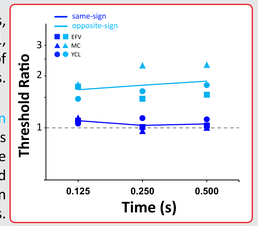
Here we probe the time course of the figure-ground asymmetry, by varying the presentation time of the two alternative stimuli.

For the same-sign condition, no asymmetry was present at any duration. For the opposite-sign condition, the asymmetry increased slightly for stimulus durations of 250 and 500 ms.

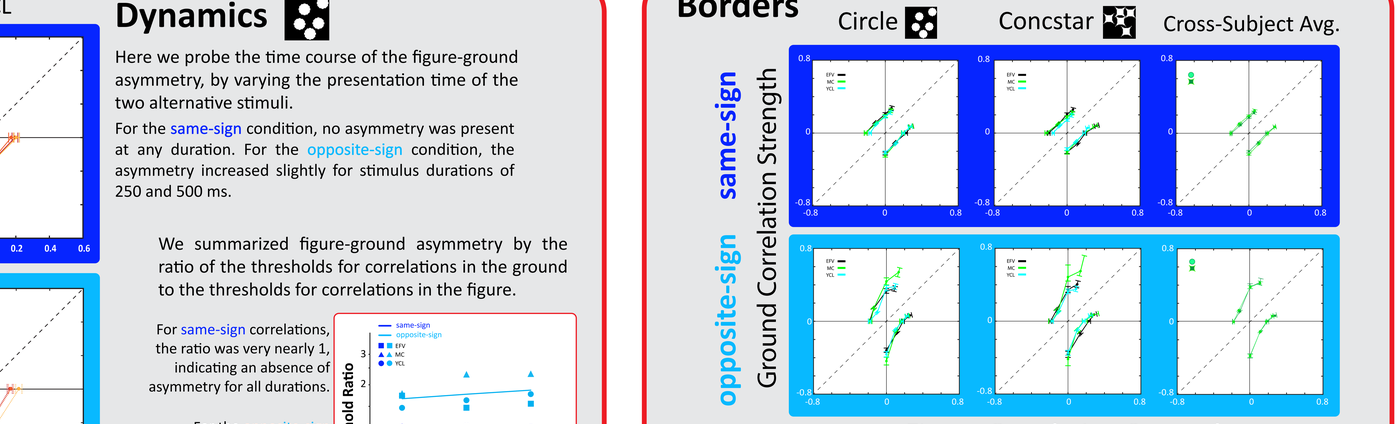
We summarized figure-ground asymmetry by the ratio of the thresholds for correlations in the ground to the thresholds for correlations in the figure.

For same-sign correlations, the ratio was very nearly 1, indicating an absence of asymmetry for all durations.

For the opposite-sign correlations, the ratio was nearly a twofold difference in threshold, and increased somewhat from a duration of 125 ms to 500 ms.



Borders



Here we ask whether the figure-ground asymmetry seen above is dependent on border convexity. We compared thresholds for circular figures (left column) with thresholds for figures of equal area but concave boundaries ("concstar", middle column). Thresholds were virtually identical (right column), indicating that border ownership, and not border convexity, drove the asymmetry.