# Texture difference cues in figure-ground separation


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## Motivation

Parsing an image into figure and ground, a critical element of visual processing, can be driven by many textural cues, including the distribution of luminance, orientation, and higher-order image statistics.

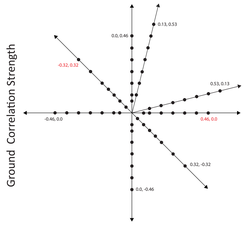
Recently (2023), we showed that for differences in orientation, thresholds depended on whether the oriented component was present in the figure or the ground. Since, for the stimuli used in that study, the figure-ground distinction was only possible after orientation is analyzed, this asymmetry implies functional recursion.

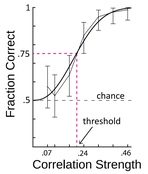
Here, we ask whether this asymmetry extends to higher-order image statistics, which are known (2015) to be primarily processed in V2.

## Methods

### Sampling the Texture Planes

For each figure-ground plane, we explored rays extending in multiple directions from the origin (random). Along the cardinal axes, either the figure or the ground was structured but not both (e.g., $c_{fig}$, $c_{gnd}$ = 0.46, 0.0). In the oblique directions, both figure and ground were structured (e.g., $c_{fig}$, $c_{gnd}$ = - 0.32, 0.32). We determined the range of contrasts (●) along each ray for which performance varied from near-chance to near-perfect.



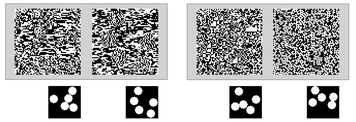




Thresholds were determined by fitting Weibull functions to the obtained fraction correct along each ray. Error bars are 95% confidence limits. Threshold is taken as the texture contrast at which fraction correct is 0.75.

### Sample Stimuli

Previous Work: Single Image Statistics

Current Study: Combinations of Image Statistics



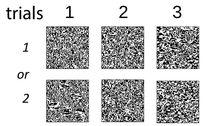
Before each experimental block, subjects were shown samples of the targets with cartoons illustrating size and location of circles.

Examples are drawn from the β_ texture plane. **Left:** circles are defined by positive horizontal correlation; background is random. **Right:** circles are defined by negative horizontal correlation; background by positive horizontal correlation.

These examples are from the (α θ) in-phase condition. **Left:** circles are defined by positive values of both statistics; background is random (both statistics equal to zero). **Right:** circles are defined by the random texture; background is defined by negative values of both statistics.

### Task

*Which interval has the target?*




### Details

**Subjects**
N = 2
VA: 20/20

**Conditions**
2-AFC design
140 trials/block
32 blocks/combination
16 texture combinations
143,360 total trials

**Stimuli**
Contrast: 1.0
Check size: 9.8 min
Display size: 10.5 deg$^2$
Luminance: 81 cd/m$^2$
Binocular viewing at 1 m
Duration: 500 ms intervals followed by 500 ms mask
Target structure: 5 circles randomly-positioned; 25% of stimulus area


***Support:*** *NIH EY07977*



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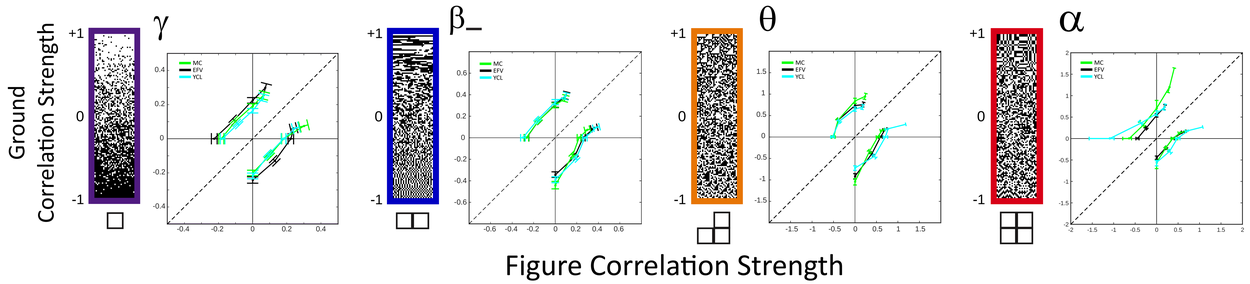
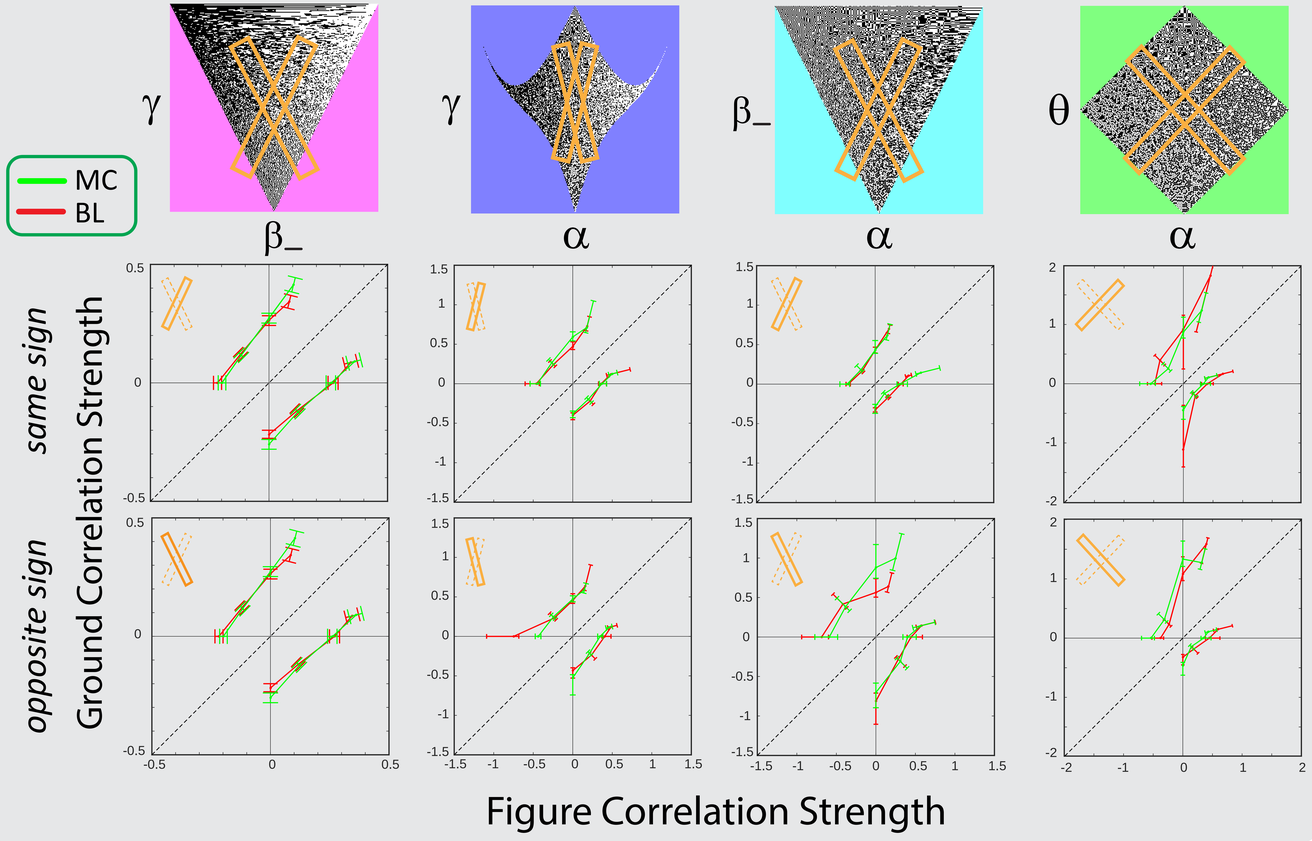
## Previous Results - Single Image Statistics

Plots show thresholds for identifying figure-ground organization, with figure and ground each defined by a *single* image statistic (shown next to each plot). Each strip shows the effect of varying a statistic over its range, from -1 to +1. First-order statistic: fraction of white vs. black checks. Second-order statistic: correlations between pairs of adjacent checks (here, horizontal). Third- and fourth-order statistics: parity of checks in regions containing 3 and 4 checks, respectively. In all cases, a correlation of 0 corresponds to a random texture.




## Results - Combinations of Image Statistics




## Results and Conclusions

Plots show threshold for figure-ground organization, with figure and ground each defined by a combination of image statistics (domain shown above the plots). Each domain shows the effect of the two statistics independently. The center of each domain corresponds to a random texture.

In the upper row of plots, the image statistics are combined with the same sign; in the lower row, they are combined with the opposite sign. In each case, the abscissa indicates the texture contrast in the figure; the ordinate indicates texture contrast in the ground. Symmetry across the diagonal, if present, indicates that threshold does not depend on whether the texture contrast is in the figure or the ground.

When alpha is combined with the other statistics (γ, β , or θ), the thresholds show a pronounced figure-ground asymmetry.

Because figure and ground are only defined by their image statistics, this asymmetry implies that figure-ground separation utilizes functional recursion from visual areas that process higher-order image statistics, such as V2, to V1.

### References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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.

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Yu, Y., Schmid, A.M., and Victor, J.D. (2015) Visual processing of informative multipoint correlations arises primarily in V2. eLife. 10.7554/eLife.06604.