

Sensitivity to local image statistics is (almost) scale-invariant Mary M. Conte, Syed M. Rizvi, Daniel J. Thengone, Jonathan D. Victor

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Motivation

Segmenting visual images into objects and identifying their surface properties require the analysis of multipoint correlations, as these define lines, edges, and texture. Here we ask how visual analysis of these local image statistics and their interactions depends on spatial scale.

To analyze how the visual system processes statistics individually and in image local combination, we developed a space of artificial images in which these correlations can vary independently. This is a 10-parameter domain (see below) which captures the types of correlations that are informative in natural images (Tkacik et al., PNAS 2010). Recently, focusing on a single spatial scale (14 min check size), we showed that visual sensitivity within this domain was concisely described by a Euclidean metric (VSS 2013). Here, we extend the analysis to cover a 10-fold range of check sizes.





Sensitivities to local image statistics as a function of spatial scale Over most of the range (2.8 to 14 min), sensitivities to all image statistics are approximately constant. At the smallest check size (1.4 min), sensitivity to pairwise and higher-order correlations decreases substantially relative to sensitivity to the first-order statistic, γ . This preservation of sensitivity to γ even for the smallest checks is to be expected, since determining the mean luminance does not require resolution of individual checks. Positive and negative variations of α are plotted separately; for the other image statistics, sensitivity to positive and negative variations are similar and therefore pooled. Error bars are 95% confidence limits.

Stimuli and Methods

SUBJECTS

6 subjects VA: 20/20, with correction if neede CONDITIONS

peats of 20 on-axis poin 16 repeats of 8 off-axis poin 288 trials per block, random orde 8 blocks per check size 9,216 trials per plane 322,560 total trials

STIMULI

Display size: 14.8 deg² Contrast: 1.0

TASK: Find the location of the target stripe (4-AFC, top, right, bottom, left)

In this example, the target stripe defined by (\mathbf{A}_{\perp}) is on a random background.









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14.8 deg



Isodiscrimination contours for pairs of local image statistics as a function of spatial scale

The findings for individual image statistics extend to their pairwise interactions. Specifically, over the range of check sizes from 2.8 to 14 min, isodiscrimination contours remain approximately constant. At the smallest check size (1.4 min), the contours enlarge in every axis except that of the first-order statistic, γ . In these plots, the axes all span the range from -1 to 1, and the random texture is at the origin. The icon above each column indicates the coordinate plane of the pair of image statistics. Error bars are 95% confidence limits.

check size (min) 1.4 2.8 **1**4

Isodiscrimination Contours

Conclusions

Visual sensitivity to local statistics is approximately scale-invariant over the range of check sizes from 2.8 to 14 min.

> For check sizes that approach the acuity limit (1.4 min), sensitivity to multipoint correlations is degraded but, as expected, sensitivity to first-order statistics is maintained.

References

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