Interaction of first-order and isodipole statistics in a texture segregation task

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INTRODUCTION

Image statistics are often classified as first-order (e.g., luminance), second-order (e.g., contrast, autocorrelation, power spectrum) and high-order (e.g., fourth-order isodipole). Many studies of visual texture processing have considered texture discrimination based on one kind of image statistic, but few have examined how these statistics interact.

To examine the interaction of isodipole statistics and luminance statistics, we construct a novel two-dimensional space of binary textures. One axis in this space, γ, specifies the bias in luminance statistics (γ = 0 for bright, γ = 1 for dark). The second axis, α, specifies the bias in local fourth-order statistics (α = 1 for the “even” texture, 0 for the “odd” texture). Long-range statistics and statistics of other orders are determined by maximizing entropy. This uniquely defines the textures in terms of α and γ (within predetermined bins), and thus describes a two-parameter perceptual space.

METHODS

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

SUBJECTS: Na, VA corrected to 20/20
Practice: MC - 2 hrs, AO - 3 hrs, CC - 3 hrs
STIMULI: Size: 11.6 deg square, viewed binocularly at 57 cm Contrast: 0.8, Luminance 57 cd/m\textsuperscript{2}, Duration 200 ms Refresh: 75 Hz (Dell Trinitron Monitor)

CONDITIONS: 288 trials per block
8 repeats of coordinate axes points
16 repeats of designated contrast
Conditions randomized in every block
15 blocks per subject (4320 trials per subject)
Feedback on error in all practice and experimental blocks

STIMULI

ISO-DISCRIMINATION CONTOURS

To determine how the isodipole (α) and luminance (γ) cues combine, the psychophysical contours along all eight directions were fit to a set of Weibull functions via maximum likelihood. The scale parameter of the Weibull functions along the four oblique directions was determined by a Mikoszewski combination of the scale parameters α\textsubscript{a} and γ\textsubscript{a} along the adjacent coordinate axes. Thus, the fraction correct data F\textsubscript{MC}(6, 0) were fit to the following model:

\[ F_{MC}(6, 0) = \exp\left(\frac{-(\alpha + \gamma)^3}{2}\right) \]

A single Mikoszewski exponent γ\textsubscript{MC} and a single Weibull exponent γ\textsubscript{MC} was used for each subject. The Weibull scale parameters α\textsubscript{MC} and γ\textsubscript{MC} were allowed to depend on the sign of α or γ and, on whether the target was structured or random. Note that γ\textsubscript{MC} corresponds to probability summation of the two cues, and that α\textsubscript{MC} corresponds to ellipsoidal iso-discrimination contours.

RESULTS

For each of the three subjects, psychometric functions (fraction correct vs. target eccentricity along the coordinate axes (data points), along with the Weibull functions (curves)) were fit by maximum likelihood. Each graph shows the observed fraction correct for stimuli along adjacent oblique directions (isolated squares and triangles).

CONCLUSIONS

• Absolute sensitivity to differences in luminance statistics was approximately four times greater than sensitivity to isodipole differences.
• Salience of a texture patch was independent of the sign of the difference in first-order (luminance) statistics.
• Salience of a texture patch was strongly dependent on the sign of the difference in fourth-order (isodipole) statistics. A random patch on an even background was more readily detected than an even patch on a random background. The opposite was true for the odd textures.
• Luminance and isodipole statistics behave like cardinal axes, and the corresponding cues combined according to a Mikoszewski exponent of 2.
• This combination rule is consistent with probability summation.

REFERENCES


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