The texture centroid paradigm: A new method for isolating preattentive visual mechanisms

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General rationale

What are the basic image attributes sensed by human vision? This question has proved difficult to answer experimentally. The **texture centroid paradigm** may help answer this question in the context of visual texture perception.

The task

On each trial, the participant sees a brief display comprising a set of randomly positioned texture disks. Different disks vary in quality along the continuum between a distractor texture D and a target texture T. The task is to mouse-click the centroid of the disks, weighting the location of each disk by its relative similarity to T vs D.

Model assumptions

Suppose that the participant produces responses by

(1) computing a set of neural images corresponding to preattentive mechanisms, M_k,
(2) combining these images into a weighted average image S with nonnegative weights w_k,
(3) extracting the centroid of the resulting image.

Implications

(1) An ideal observer, that aims to produce the "best" estimate of the centroid (minimum Euclidean distance) concentrates all weight on a single mechanism for which $M_k(T)/M_k(D)$ is largest.
(2) If a subject produces near-ideal performance, we conclude that performance is based on a single mechanism.
(3) We can characterize this mechanism by examining the influence of different distractors in the task.

An application of the texture centroid paradigm

What mechanisms in human vision confer sensitivity to spatially random mixtures of different grayscales?

Conditions

Textures were randomly scrambled mixtures of 9 grayscales with Weber contrasts -1.0, -0.75,…, 1.0.

There were five separately blocked conditions, each targeting a different Weber contrast:

1. -1.0 (Targeting black)
2. -0.75 (Targeting near-black)
3. -0.5 (Targeting dark-gray)
4. 0.75 (Targeting near-white)
5. 1.0 (Targeting white)

The subject strove to find the centroid of the disks in each stimulus, weighting each disk by the proportion of pixels in the disk with the targeted Weber contrast.

Stimulus construction

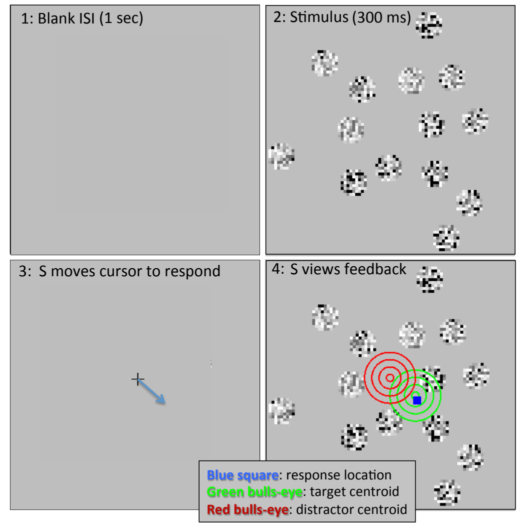
Disk histograms: On each trial, there were 14 disks, two each in which the proportion of pixels with the targeted Weber contrast was equal to 0.0, 0.04, 0.08, 0.12, 0.16, 0.20 and 0.24. The other contrasts in a given disk were randomly drawn from the remaining (non-targeted) contrasts.

Disks were randomly positioned:
(1) Drawn from a circular, bivariate Gaussian distribution.
(2) Translated so that the sample centroid (unweighted) of all disks was at the screen center.
(3) Expanded/contracted so that the mean distance of the disks from the screen center was 2.25°.

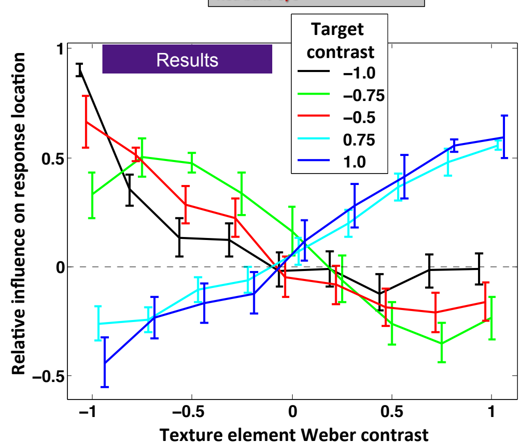
Training

The participant completed at least 15 100-trial blocks in each condition. The 3 blocks yielding the poorest performance were discarded in each case.

An example trial from the condition targeting black



Results



Results cont.

1. All three of the sensitivity functions achieved with target Weber contrasts -1.0, -0.75 and -0.5 differ significantly in form from each other.
2. The sensitivity functions achieved with target Weber contrasts 0.75 and 1.0 do not differ significantly in form from each other.
3. The sensitivity function achieved in the condition targeting black resembles the "blackshot" sensitivity function (Chubb, Landy, Econopouly, 2004).

Conclusions

If the model assumptions hold, then each of the black, red, green and blue (light blue = dark blue) functions in the results figure reflects the sensitivity of a different preattentive mechanism.

BUT

1. Do the model assumptions actually hold?
2. What experiments might answer this question?

Reference: Chubb C., Landy M. S., Econopouly, J. (2004) A visual mechanism tuned to black. *Vision Research* 44 (2004) 3223–3232.

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