Using noise to study letter identification

Evidence for four types of spatial interaction

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Introduction

We study object recognition using behavioral methods to reveal the computation underlying how a physical stimulus gives rise to a perceptual experience.

Masking refers to the impairment of target recognition by other stimuli that directly stimulate the same feature detectors. The mask can be either **on** or **off** the target letter. Off-letter masking is sometimes called contour interaction.

Crowding occurs when objects cannot be identified due to the proximity of other objects or stimuli.

Grouping is the perception of several features as one object, such as a smiley face.

Research goals

Characterize the effect of noise in four locations:

1. Superimposed
2. Near
3. Far
4. Farther

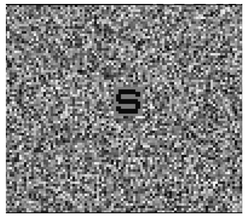
Methods

Noise locations:

1. Superimposed

2. Near

3. Far



4. Farther (reduced)

We measure threshold contrast for letter identification. When possible we compute efficiency, the fraction of the human threshold energy that is required by a mathematically ideal algorithm to achieve equal performance.

The four regions are defined by where the noise is placed. Each noise occupies a square annulus with inner radius *r* and outer radius *R*. Acuity *A* depends on eccentricity.

Superimposed: $r = 0°$, $R = 1°$
Near: $r = 1°$, $R = 1° + A/2$
Far: $r = 1° + A/2$, $R = 3° + A/2$
Farther: $r = 3° + A/2$, $R = \infty$

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Results

Letter identification in noise

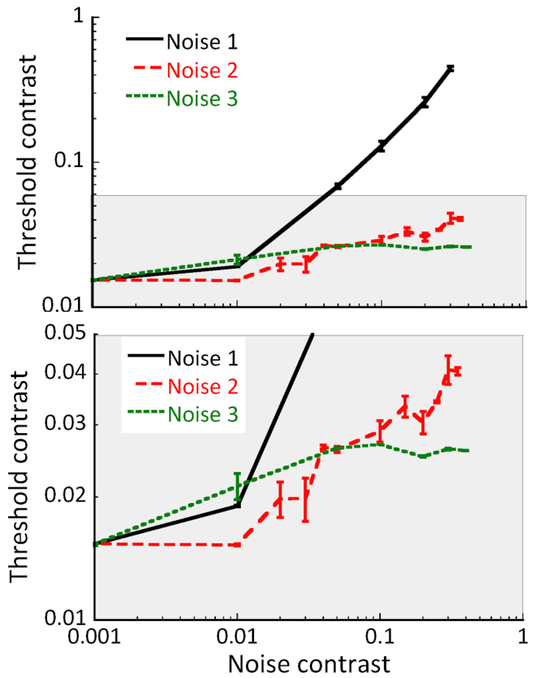

Figure 1a. Threshold contrast vs. noise contrast. The log-log slope is 1 for noise 1 (superimposed) and much lower for noises 2 & 3 (near & far).

Figure 1b. Blow up of Fig. 1a. For near noise, the threshold contrast is a low-exponent (0.2) power function of noise contrast. For far noise, the curve rises with a slower slope (0.1) and quickly saturates.

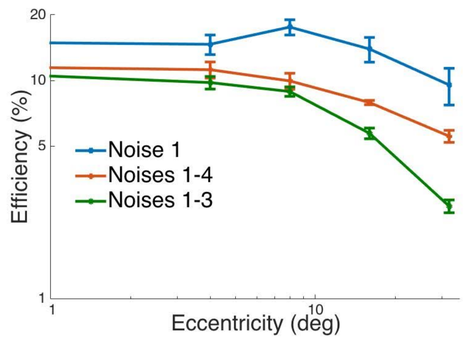

Figure 2. Efficiency vs. eccentricity. The vertical scale is efficiency for identifying a letter in superimposed noise. Superimposed noise (blue) establishes a baseline. Adding near and far noise (green) reduces efficiency. Adding further noise *improves* efficiency (red).

Conclusions

1) Threshold contrast is proportional to contrast of *superimposed* noise, the hallmark of masking through signal-like variance. 2) Threshold contrast is a low-exponent power function of *near* noise contrast, which may represent the weaker masking effects of contour interactions. 3) The effect of *far* noise quickly saturates as a function of noise contrast, as in crowding. 4) *Farther* noise relieves crowding, much like the long distance effects of extra flankers. We continue to investigate the mechanisms underlying noise interactions in different locations.