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Cue Combination for Texture-Defined Edge Localization

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Introduction

The *Modified Weak Fusion*[1] model has successfully accounted for many results in depth cue combination. Among other things, it suggests that depth signals d_i are:

- combined linearly:
  $d = w_1 d_1 + w_2 d_2 + w_3 d_3 + \ldots$
- with weights w_i proportional to cue reliability (inverse variance).

Here, we examine whether this model can apply to a different cue combination problem: localization of texture-defined edges.[2,3] Two edge cues were used — spatial frequency (*f*) and orientation (*o*) — and two reliability levels used for each, set using texture blur σ_f and σ_o.

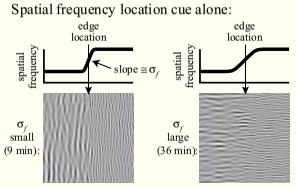
Questions:

- Are multiple edge-location cues combined linearly?
- Do observers use the predicted, optimal weights?

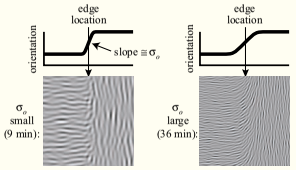
Stimuli

Single-cue

Spatial frequency location cue alone:

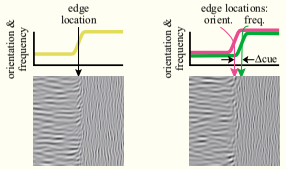


Orientation location cue alone:



Two-cue

Consistent location cues: Inconsistent cues:



Task: Vernier Discrimination

Which edge is rightmost?

Conditions:

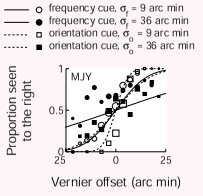
Single-cue: frequency or orientation (both patches of the same type)

Two-cue: one patch a consistent-cues and one an inconsistent-cues stimulus (7 values of Δcue)

Offset controlled by staircase. Two values of *f*, *o*, σ_f & σ_O.

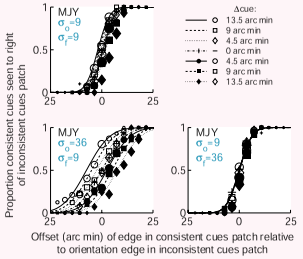
Upper patch: Consistent cues. Lower: Inconsistent.

Single-Cue Results



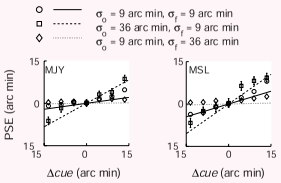
Increased texture blur (σ_f or $\sigma_O = 36$) decreased reliability (i.e., decreased slope; made it harder to localize the edge) as intended.

Two-Cue Results



The perturbed cue (spatial frequency) had the greatest effect (caused the largest shift of the psychometric functions) when its relative reliability was highest (e.g., $\sigma_f = 9$ & $\sigma_o = 36$).

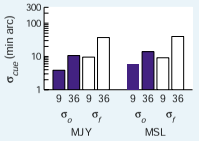
We next plot the points of subjective equality (*PSEs*, the 50% points above) as a function of the amount of cue perturbation Δcue. Slopes are estimates of the perturbed spatial frequency cue weight wf.



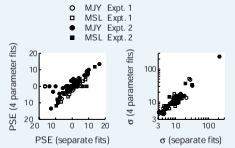
Linear? Yes! Weights based on reliability? Yes!

Modeling

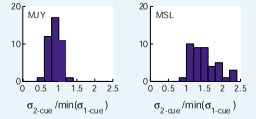
The ideal, linear, cue combination model was fit to the entire dataset (25 single- and two-cue conditions), assuming Gaussian noise. All solid curves in the previous figures are from this model fit. The model has only four parameters (the localization noise for each cue, for each degree of texture blur). The fit parameters increase with texture blur, as expected:



The predicted PSEs and slopes are well-correlated with the actual PSEs and slopes (except for single-cue PSEs, which are biased):



CAVEAT: The model predicts higher reliability in two-cue than in single-cue conditions. For one subject (MSL) this was *not* the case:



Note: This work is currently in press: Landy, M. S. & Kojima, H. (2001). Ideal cue combination for localizing texture-defined edges. *JOSA A*.

References

1. Landy et al. (1995). *Vision Research, 35*, 389-412.
2. Rivest & Cavanagh (1996). *Vision Research, 36*, 53-66.
3. McGraw et al. (2000). *IOVS, 41 Supp.*, S804.

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