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Attention Assignment

(1) Given that arguably the function of attention is to improve discrimination at the attended location, would it be in the observer's best interest to broaden or to narrow spatial frequency and/or orientation bandwidths at the attended location? Justify your choice with reference to a model of a particular task that would predict improved performance with the hypothesized change in bandwidth.

Under medium-to-high noise conditions during a fine orientation discrimination task, it would be in the observer's best interest to narrow bandwidths at the attended location. For example, this would be true in a discrimination task where the observer has to classify the orientation of a grating relative to some reference line. This reference line would be either presented at the same time as the grating (in the neutral condition) or slightly before the grating (in the cued condition). Here, under high contrast, stray noise may be confused for the true grating. Having narrower tuning curves will allow the observer to pick out only the continuous grating pattern within the noise which will allow the observer to perform better at discriminating a left from a right oriented stimulus.
However, there are many cases where broadening the bandwidth might be optimal. For example, when having two discriminate between two low resolution images, having narrow bandwidth spatial frequency filters might obscure differences between the two images.

(2) Design a psychophysical experiment to test this hypothesis:
(a) Describe the experimental design including what kind of attention (spatial or feature, endogenous or exogenous) you are manipulating and how you are doing so, the particular stimuli, task, and procedure.

In the task described above, we would be manipulating endogenous feature attention (to orientation). The stimuli used would be a grating presented at the fovea surrounded by random noise (tv static). In cued trials, a reference line would be presented 600 ms before the trial begins (in order to allow feature based attention to come online). In uncued trials, the reference line will occur with the stimulus. The observer will have to classify the grating as tilted to the left or right of the reference line. This is essentially an equivalent-noise paradigm (Pelli 1999).

(b) Explain how you will analyze the data.

In order to distinguish the type of attention in use, we will use the threshold versus noise (TvN) functions. We will compare the values of the TvN function both with and without the pretrial cue using, for example, a t-test or a non-parametric regression (like a Gaussian process). We can also fit a model of V1 responses using a model like equation (1) from Ling, Liu and Carrasco (2009) where neurons are tuned to orientation rather than direction. We could then see if the data are better fit by a model where the bandwidth of the tuning curves for neurons near the reference line (σ in the model) decreases for pre-cued trials. In order to match the predictions to data, we would have to assume a readout model which could be just maximum likelihood.

(c) Describe the potential outcomes and how they will either prove or disprove the hypothesis.

One prediction of narrowing bandwidths is that at high noise levels, the threshold should decrease. The noise here is in terms of the contrast of the background white noise. If the effect of attention is really the bandwidth, narrowing, there should be a significant difference between the threshold with the neutral cues and the threshold with the attention cues. If there is only the bandwidth tuning, there should be minimal effects at lower external noise levels. However, feature based attention has been shown to involve both a gain increase and a bandwidth decrease, we would likely find effects at all noise levels. They hypothesis would be disproven if we were to only find effects at lower noise levels (suggesting a gain change) or not find any effects at all. There would be further evidence for or against the hypothesis if we did model comparison between models with and with out changes in the bandpass width. If we were not to find any effects, we might worry that our attentional manipulation didn't work properly.

(d) Include description of relevant control experiments that indicate you can measure a bandwidth and you have changed performance with your attentional manipulation.

`As a control, we could include invalid cue trials where the reference line switches at the time the stimulus comes on so the subjects allocate their attention to the wrong orientation. On these trials, we should see no effect of the cue indicating that the attentional manipulation was only directed to the orientations we intended. In addition, a comparison to the neutral cue trials would show whether the attentional manipulation increased performance. To check our bandwidth measurements, we can perform the task at various eccentricities and check whether our measured bandwidth increases as we move away from the fovea.