Influence of Spatial versus Orientation Probability on Perceptual Estimations

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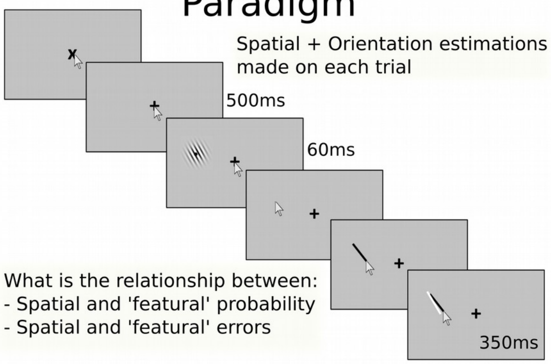
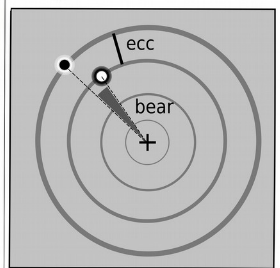
Paradigm

Spatial + Orientation estimations made on each trial

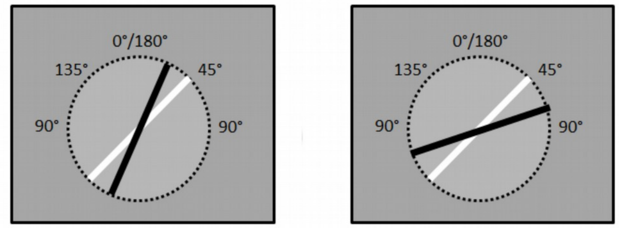


What is the relationship between:
- Spatial and 'featural' probability
- Spatial and 'featural' errors

Spatial Error



Orientation Error



Stimulus orientation = 45°
Response orientation = 22°
Bias = -23° (towards the vertical)

Stimulus orientation = 45°
Response orientation = 68°
Bias = 23° (towards the horizontal)

What does this suggest?

Orientation probability affects orientation errors, but not spatial errors

Spatial probability has no effect on spatial or orientation errors.
-- Previous exogenous spatial cueing shows effects on orientation errors

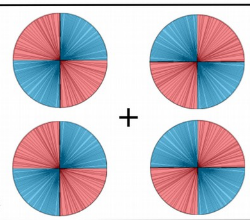
Orientation and Spatial Errors are not strongly correlated
-- Are features and space processed separately?

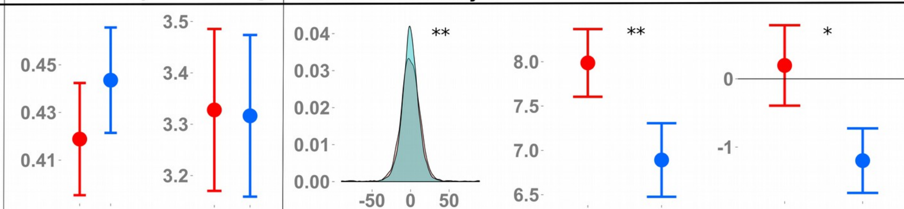
Eccectricity | Bearing | Error Variability | Median Abs Error^ | Bias | Space vs. Orientation Correlations[a]

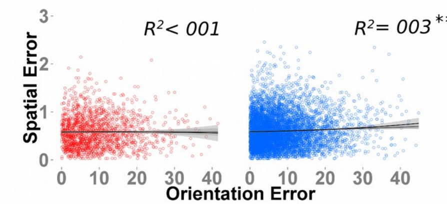
Expt 1 (Orientation Prob)

High Prob : 80%
Low Prob : 20%

From previous experiments:
Affects orientation error
Can be conditional on fix cross



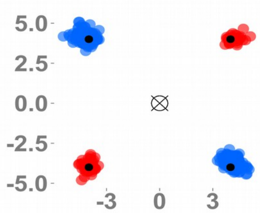


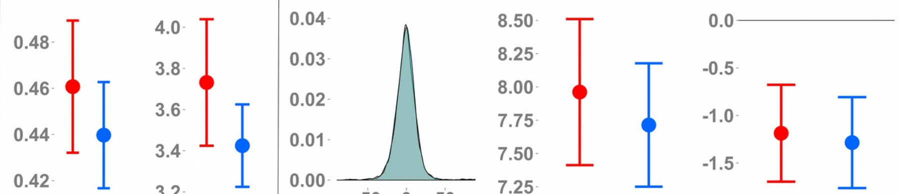


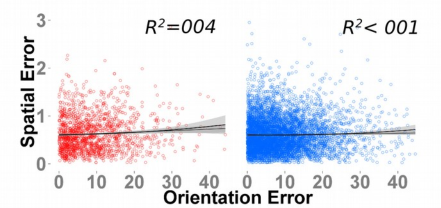
Expt 2a (Simple Spatial Prob)

Only 4 possible locations

High Prob : 80%
Low Prob : 20%



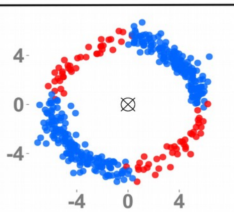


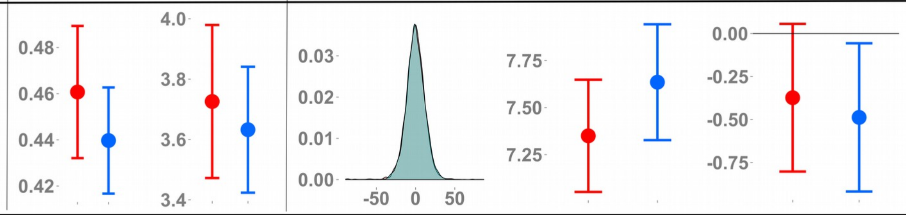


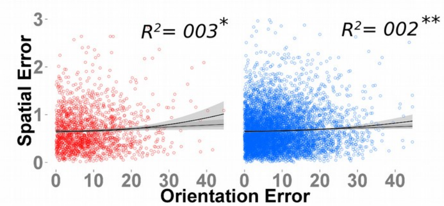
Expt 2b (Complex Spatial Prob)

Constant eccentricity
Psudo-random bearing

High Prob : 80%
Low Prob : 20%







***** p <.05, ** p <.01**
^Median of the absolute value of signed angular errors. Mean absolute errors show the same trends.
 # all orientations biases are significantly vertical except for low-probability orientations.
[a] Adjusted R^2 for a linear model. No improvement for a quadratic model.

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Everything in the poster in RED corresponds to low probability, and BLUE corresponds to high probability.
Notes available on the other side

The question we have been interested in is: ***How does probability affect perception?*** We have done some previous work with orientation probability using an orientation estimation task: High probability orientations are estimated more precisely, and this is true even when probability differences is fine, or contingent on another object, such as the colour of the fixation cross. We also know that exogenous spatial cues have similar effects on perceptual precision as orientation probability. But what about spatial probability? Here we try to examine how spatial probability affects perceptual precision, and whether that might be different from the effect orientation probability has.

Instead of using forced-choice paradigms, we use direct reports of perception. Each trial, we show participants a Gabor at some location with some orientation, it disappears, and using a mouse, participants try to click on the presented location, and then draw a line matching the orientation they think they saw. This task allows us to get measures of both spatial and orientation precision. In none of our experiments were participants told about which orientations or positions are likely, or that we even manipulate probability. They were just told to be as precise as possible.

Spatial precision here can be divided into 2 polar components: Eccentricity errors (how far off participants are radially), and bearing errors (what the difference in spatial angle between estimate and the target is).

Orientation precision is measured as angular error: The difference in angle between the drawn line and the actual orientation. We also have a “bias” measure, which calculates whether the angular error is more vertical or horizontal than it should be. Our previous research suggests that people tend to be vertically-biased, and especially so for orientations that are likely.

First off, using this paradigm, we tried to replicate our previous experiment on orientation probability, which would also tell us whether orientation probability affects spatial error or not. Gabors appear in one of the four corners. With equal frequency. 2 Gabors had orientations that were more likely left-tilting. The other two were more likely right-titling. Positions were counterbalanced across participants. The probability ratio was 80% to 20%.

What we find is that orientation probability does not affect spatial error, in either of its' components. As the density plot of angular errors shows, people show significantly less variability in angular error for high-probability tilts. Mean absolute errors collaborate this. And we replicate the vertical bias we saw in out previous task where participants were just using keyboard responses, suggesting this is a perceptual rather than a task-based effect. And particularly, people are more vertically biased (coded as negative) for high-probability orientations.

We ran correlations between spatial and orientation error, Because each Gabor presentation gives both spatial and orientation information, if there is poor encoding for that trial, both spatial and orientation estimates should be affected: If “object-based attention” is correct, we expect a strong correlation here. But we find neither a strong linear or quadratic trend: It is almost as if people are encoding the two features independently

We then manipulate spatial probability. We retained the 4 possible locations, but now 2 diagonally opposing corners occurred more frequently, with the same 80/20 ratio. This was again counterbalanced. Orientation probability was uniform in all locations. What we find, is that spatial probability does not affect spatial estimates. This is pretty interesting considering participants can actually tell us, in our post experiment questionnaire that 2 of the corners are more likely; They don't report such distribution awareness in the orientation probability case. Spatial probability also does not track orientation estimation, which is surprising given that spatial exogenous cues do. But we still see that orientation estimations are vertically-based. We again, also see no strong correlations between spatial and orientation errors.

Maybe participants couldn't show differences because the spatial locations were too simple to figure. In the last experiment, Gabors appeared at any bearing from fixation. 2 quadrants were more likely. But we still find the same (null) effects!

Orientation probability affects orientation precision *only*, and spatial precision does *not* affect orientation precision. Orientation and spatial errors are also weakly correlated, if at all. Is feature-processing and the corresponding probability effects separate?