Bayesian Analysis of Motion Priors and Speed Discrimination in the Periphery

[1]Amy Nguyen (nguyenaa@iu.edu), [2]Michael S. Landy, [2,3]Eero P. Simoncelli, [1]Kathryn Bonnen (kbonnen@iu.edu)

[1]School of Optometry, Indiana University, [2]New York University, [3]Flatiron Institute

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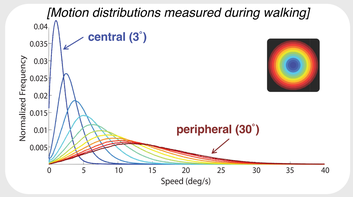
Initial Motivation

What is the relationship between the **ecological distribution** and **perception of retinal speed**, in **central vs. peripheral visual fields?**

Retinal motion distributions at central and peripheral vision are different.

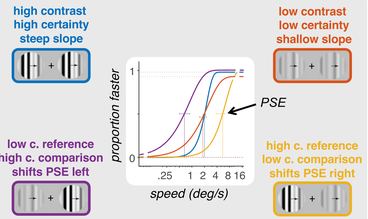


Why? Humans fixate, stabilizing the retinal image in central vision
→ less motion at central vision
→ increased speeds in the visual periphery.

Hypothesis: Perceptual biases due to a "slow speed prior" should be diminished in the periphery, where retinal motion distributions are faster.

[**NOTE:** We are not yet able to test this hypothesis. This poster will address issues surrounding the use of contrast as a proxy for uncertainty.]

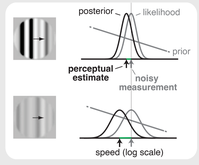
The natural statistics of motion impacts speed perception



A Bayesian estimator with a **slow speed prior** can explain these perceptual biases (*Weiss et.al. 2002; Stocker & Simoncelli 2006).*

How? The prior has a greater influence on uncertain stimuli.

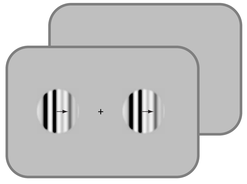
low certainty stimulus will be perceived as slower



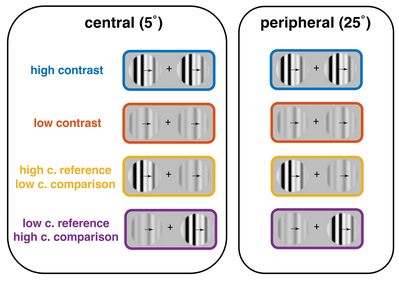
Methods

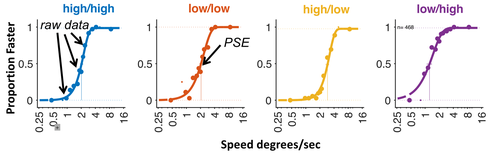
Speed Discrimination:
Two alternative forced choice task

Is the right faster or slower than the left?



stimuli -- 1 s

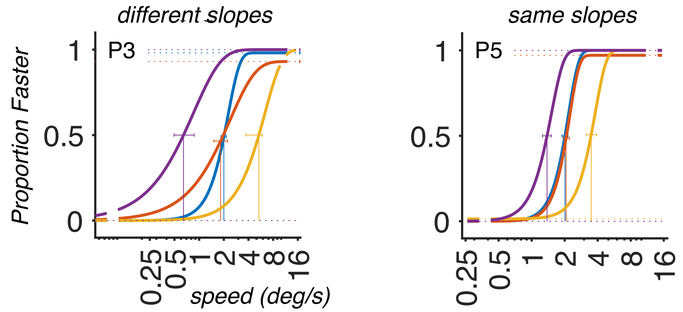




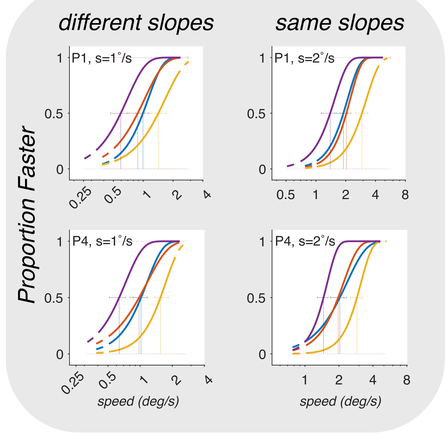
All psychometric fits with psignifit [4,5]

Challenges for contrast as a proxy for uncertainty

Central vision: **half of participants** exhibit little difference in slope between the low contrast and the high contrast conditions but retain biases in the high/low and low/high conditions.



Possible explanation: When the speed discrimination comparison is difficult, participants choose the higher-contrast stimulus.



Reanalysis of Stocker & Simoncelli (2006) reveals the same issue

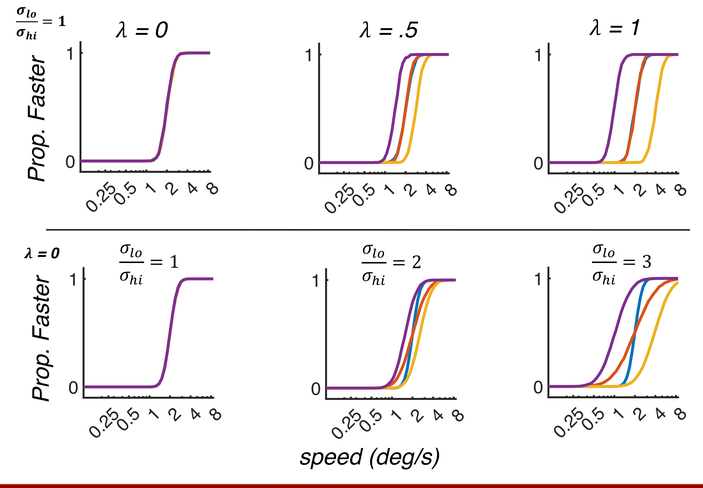
The data collection was designed to maximize the number of reference speeds and contrast comparisons with few matched contrast conditions making this easy to miss.

Girshick, Landy & Simoncelli (2011) reported a similar problem.

- Measured biases for orientation discrimination using direct manipulation of stimulus variability
- Adjusting participant instructions helped
  Which stimulus is more clockwise? left or right? →
  Is the right stimulus more clockwise than the left?

Preliminary Model Simulations

We extended the model in Stocker & Simoncelli (2006) to include an additional parameter (λ). When the difference between speed estimates is small (i.e., $< \lambda$), the model chooses the higher contrast stimulus.



Alternatives to contrast

Using contrast as a proxy for uncertainty has proven difficult.

Manipulate speed explicitly:

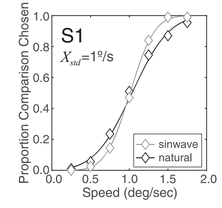
- spectral spread
- dots drawn from a distribution of speeds

However, it unclear how participants will perform the task (average speed vs. max speed)

Chin & Burge (2020):

- 1D motion stimuli generated from drifting natural images
- Larger stimulus variability for natural motion stimuli
  → decreased sensitivity relative to drifting gabor stimuli
  (equivalent RMS contrast)

Fig. 10a, Chin & Burge 2020



References

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Acknowledgements

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