Access to sensory uncertainty in global motion perception depends on the stimulus

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Continuous versus discrete perception

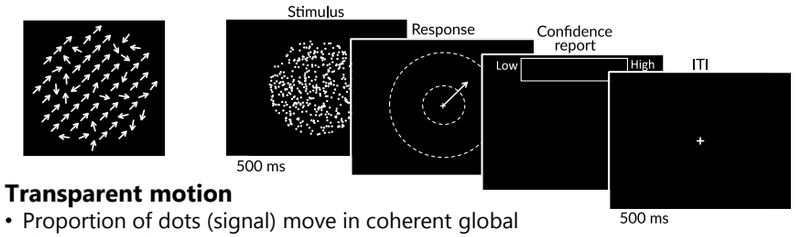
As the strength of a stimulus varies, perception can be:

- **Discrete** – perception is either highly precise, or it fails entirely, and the probability of failure depends on stimulus strength[1,2]
- **Continuous** – internal perceptual representation becomes more precise with greater stimulus strength[3]

We assess metacognitive access for continuous and discrete perception

- Discrete: Do we know if perception was successful, or if it failed entirely?
- Continuous: Do we know the precision of our internal representations?

Exp 1: Report global motion direction and confidence in decision

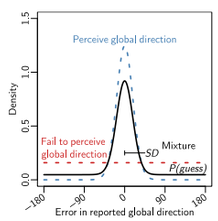


Transparent motion

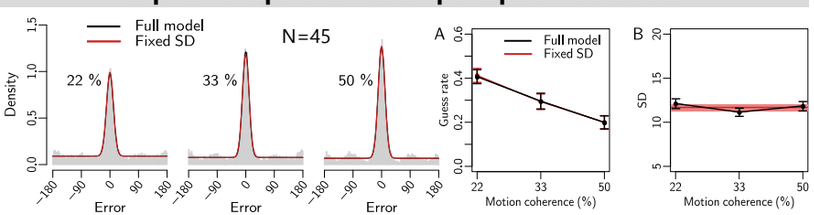
- Proportion of dots (signal) move in coherent global direction while remaining dots (noise) move randomly
- Stimulus strength determined by percent signal, termed coherence (22%, 33%, 50%)

Identifying discrete vs. continuous perception

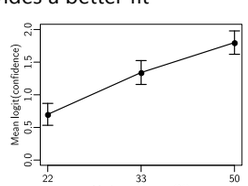
- When global motion perception is successful, errors are from von Mises with precision (SD) parameter.
- When global motion perception fails, observer enters a guess state and errors are from a uniform distribution
  - Mixture model analysis adapted from Zhang & Luck (2008) [4]



Exp 1: Transparent motion perception is discrete

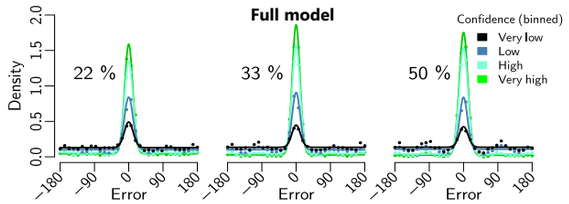


- **Increasing coherence increases only the probability of seeing global motion but has no effect on how accurately you do so.**
- Forcing SD to be constant across coherence provides a better fit than letting it vary.
  - $\overline{\Delta}BIC$ = 10.57 (44/45)
- **Confidence in perceptual decisions tracks motion coherence**
  - F(2,88)=82.26, p<.001, η_p^2=.65,BF=3.6e+16

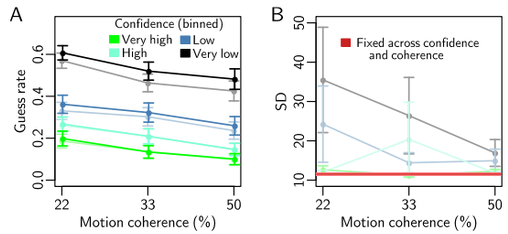


Exp 1: Metacognitive access to discrete states

Error data analyzed separately for very low, low, high, and very high confidence for each participant[5]



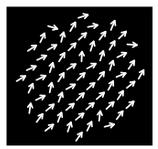
- Guess rates higher when confidence is lower
  - Full model fits better than one with restricted guess rate
    $\overline{\Delta}BIC$ = 37 (45/45)
  - Observers know they are in a guess state or perceive state
- SD is the same regardless of coherence or confidence
  - Forcing SD to be constant fits better than the full model
    $\overline{\Delta}BIC$ = 44 (45/45)



Guess rate varies with confidence but only somewhat with coherence when data are analyzed separately across confidence

- **Confidence accurately reflects the probability of being in a perceive state or guessing state**

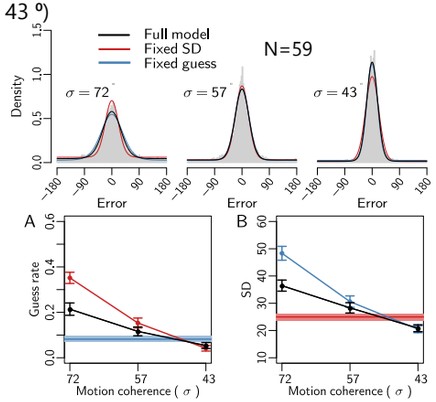
Exp 2: Gaussian motion perception is continuous

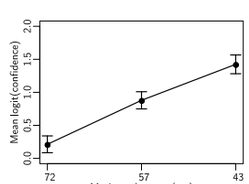


- Motion of each dot sampled from a Gaussian distribution
- Stimulus has average global motion direction, but there are not separable fields of signal and noise
- Stimulus strength determined by σ of the Gaussian, termed coherence (72º, 57 º, 43 º)

SD varies with coherence

- Full model fits better than forcing SD to be constant
  $\overline{\Delta}BIC$ = 10 (43/59)
- Forcing guess rate to be constant fits better than full model, $\overline{\Delta}BIC$ = 4 (44/59) but AIC is more ambiguous as the full model fits better than fixed guess, $\overline{\Delta}AIC$ = 4.5 (38/59).

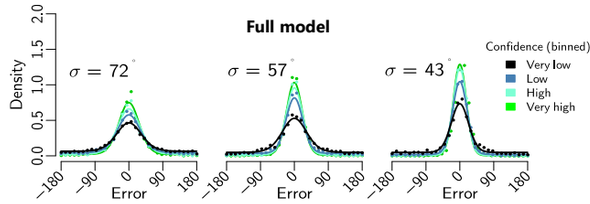




Confidence in perceptual decisions track motion coherence

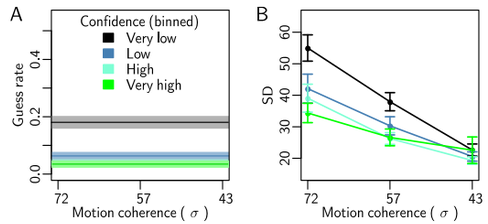
- F(2,116)=91.59, p<.001, η_p^2=.61, BF=1.7e+22

Exp 2: Metacognitive access to precision



Increasing coherence (smaller σ) decreases the SD of errors, and confidence tracks these effects

- Forcing guess to be fixed across coherence but letting SD vary across both coherence and confidence fits better than the full model
  $\overline{\Delta}BIC$ = 41 (59/59)



There is an interaction between coherence and confidence on SD

- Allowing SD to vary across both coherence and confidence does not fit any better than a model in which SD is fixed across confidence, $\overline{\Delta}BIC$ = 8 (30/59), $\overline{\Delta}AIC$ = 45 (39/59)
- 3 (Coherence) ×4 (Confidence) ANOVA on SD reveals interaction F(3,174)=32.56, p<.001, η_p^2=.11.
- Follow-up t-tests reveal that SD is significantly greater at 72º and 57º Coherence when Confidence is "very low", $ps \leq .01$.

SD varies with coherence but only somewhat with confidence when data are analyzed separately across confidence

- **Confidence tracks precision but cannot fully account for the effect of stimulus strength**

Conclusion

When perception is discrete:

- You know when perceiving a signal succeeds and when it fails
- Given that you are in a perceive or guess state, either precision (SD) does not vary, or if it does, you cannot access the trial-to-trial precision of discrete representations

When perception is continuous:

- You know when you are in a high or low stimulus strength condition, but within a trial you have little access to your precision
- Guess rate varies across confidence suggesting that knowledge of trial-to-trial perceptual failures is accurate for continuous perception

Access to sensory uncertainty depends on the stimulus, but the accuracy of metacognitive judgments vary across stimulus types

References

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5. Rademaker, R. L., Tredway, C. H. & Tong, F. (2012). Introspective judgments predict the precision and likelihood of successful maintenance of visual working memory. *Journal of Vision, 12(13),*21

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