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Combining priors and noisy visual cues in a rapid pointing task

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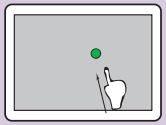
Introduction

Can subjects optimally integrate likelihood and prior information in a rapid pointing task?

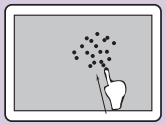
- Assumed, but not tested, by Körding & Wolpert.[1]
- Previously, we showed that subjects fully account for the likelihood of world states and consequent gains and losses.[2]
- Here, we directly test whether priors are optimally combined with likelihood in a pointing task

Methods

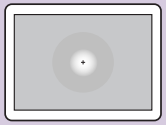
If you hit a target on the screen, I'll give you $.05. Be sure to make your reach in under 700 ms.



The problem is, I won't ever show you the target: you get randomly sampled dots drawn from a 2D Gaussian at the real target location:



However, I will tell you where the target tends to be on each trial (display of the prior distribution):

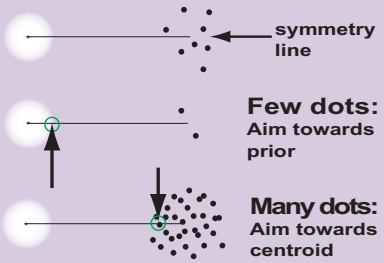


Screen sequence (per trial):

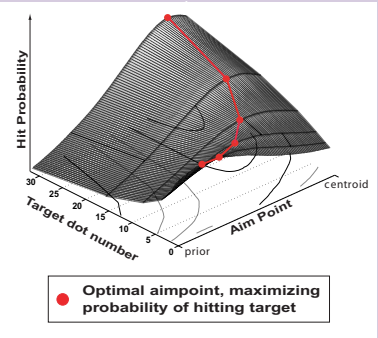
Prior display → Target dots → Hit/Miss feedback

Optimal Behavior

Optimally, one aims along the line from the center of the prior to the centroid of the target dots:



Numerical integration results agree: aim closer to the prior with fewer dots



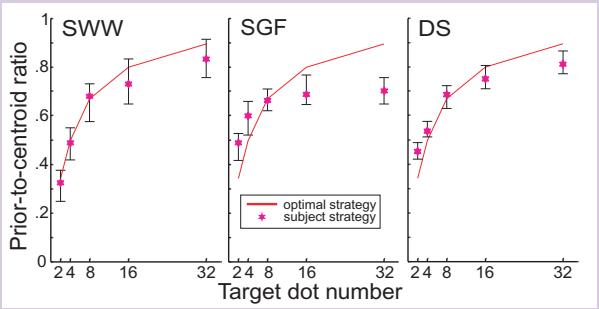
Ideal observers are hampered by error in:

- Target localization from dots

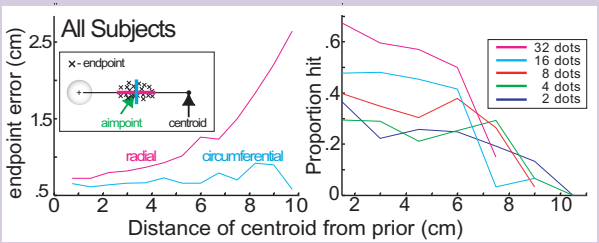
Humans are further hampered by errors in:

- Centroid calculation
- Aimpoint shift calculation
- Motor outcome

Results



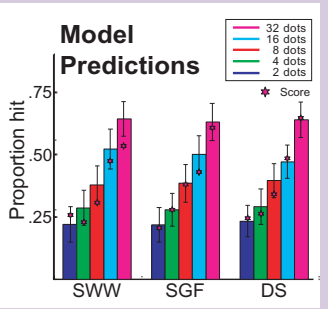
All subjects reliably shifted aim from prior location to centroid as informativeness of centroid increased (more dots).



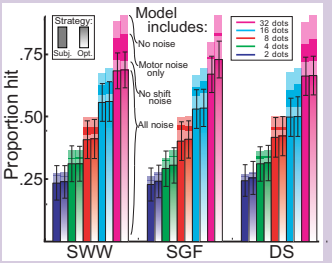
Aimpoint variability along line of symmetry grew with centroid distance (i.e. shift error).

Corresponding proportion of hits decreased as predicted with centroid distance.

Efficiency



Taking into account all sources of noise, the model predicts subjects' performance well.



The model can thus be used to compare strategies.

Conclusion

Subjects optimally integrate prior information with varying levels of target uncertainty.

[1] Körding & Wolpert, *Nature*, *427*, 244-247, (2004)
[2] Trommershäuser, Maloney & Landy, *JOSA A*, *20*, 1419-1433, (2003)

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