



Temporal dynamics of serial dependence in ocular tracking

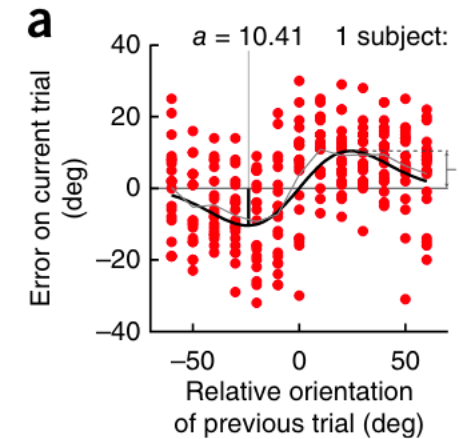
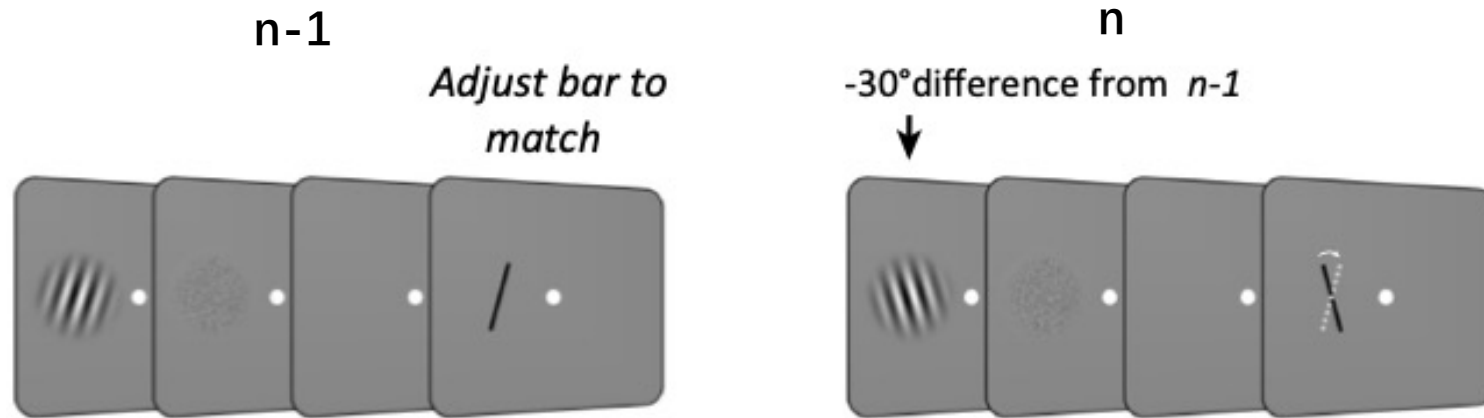
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Serial dependence

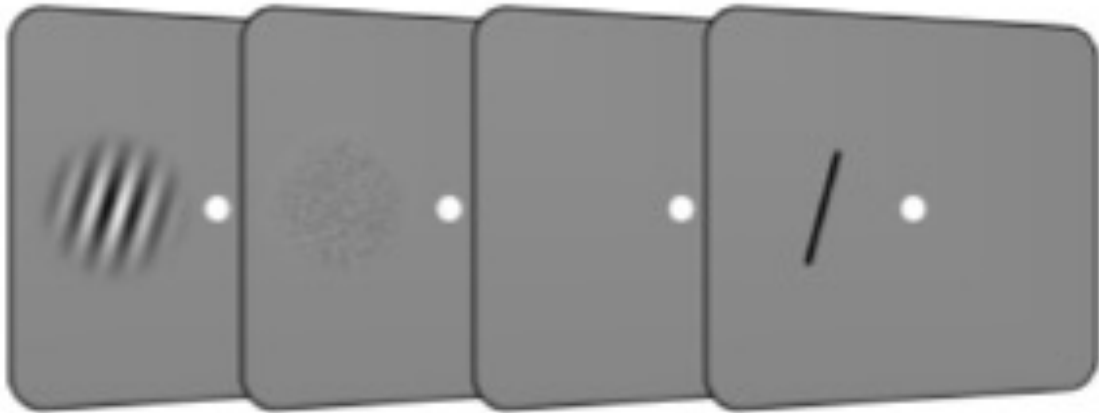


Perceived orientation was systematically biased toward recently seen stimuli.

Whether serial dependence occurs in perception?

Method of adjustments

*Adjust bar to
match*



~~Memory~~
Decisions

?

Attractive serial dependence



Repulsive adaptation effect
(perceptual phenomenon)

Remove post-perceptual processes

- Memory
 - Remove the time delay between stimulus presentation and response
 - Spatial location tasks
 - **Repulsive** (Bliss et al., 2017)
 - **Attractive** (Manassi et al., 2018)
- Memory and decision processes
 - Use the alternative forced-choice task
 - Orientation tasks
 - **Repulsive** (Fritsche et al., 2017; Pascucci et al., 2019)
 - **Attractive** (Cicchini et al., 2017; Fischer & Whitney, 2014)

Inconsistent results!

Temporal dynamics of serial dependence

Attractive serial dependence



Repulsive adaptation effect

Temporal interaction of serial dependence and adaptation



When serial dependence appears and disappears

Research goals

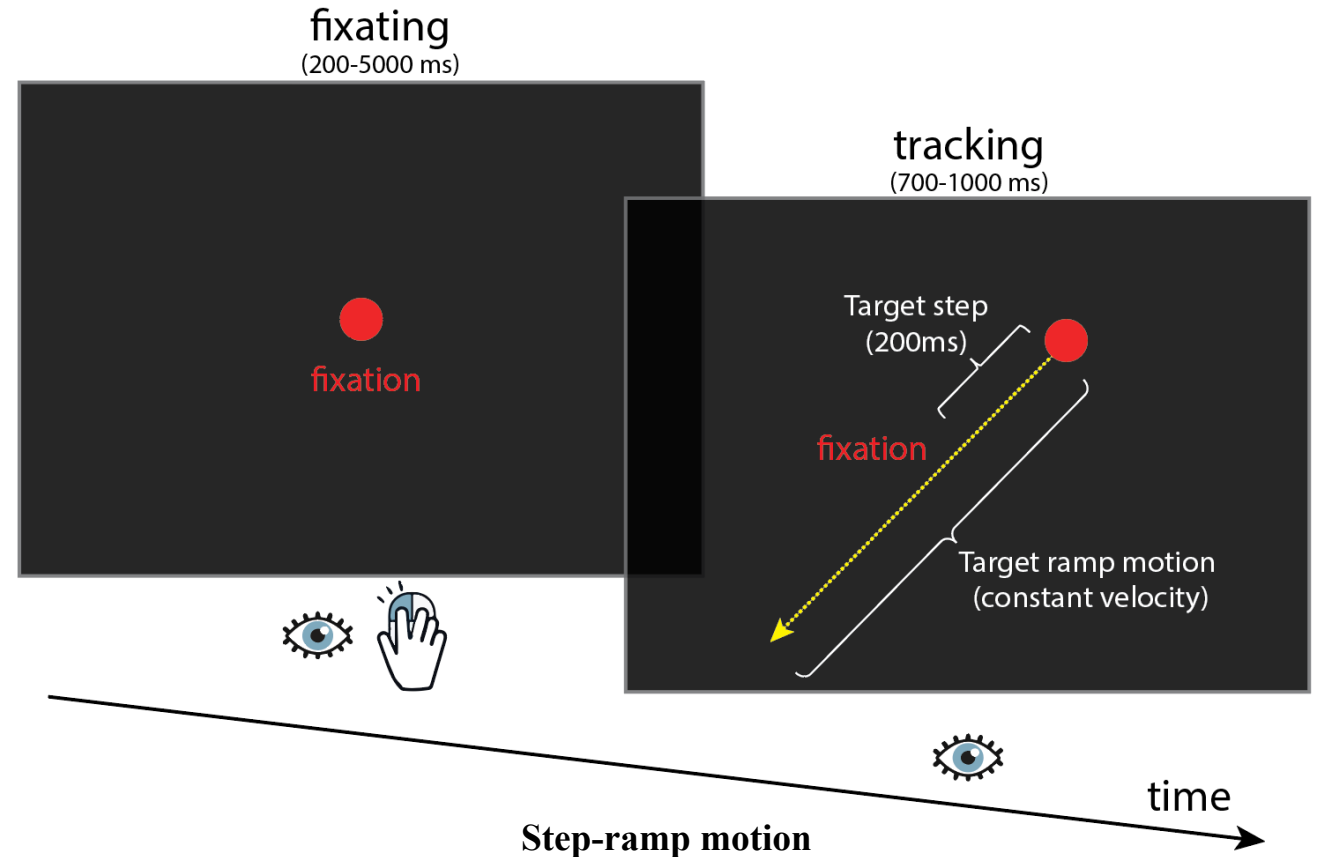
- Temporal dynamics of serial dependence
 - Whether serial dependence occurs in perception?
- The mechanism underlying the temporal dynamics of serial dependence
 - Temporal Bayesian ideal observer model constrained by efficient coding
 - The relationship between the temporal dynamics of the serial dependence and the sensory noise over time

Ocular tracking task



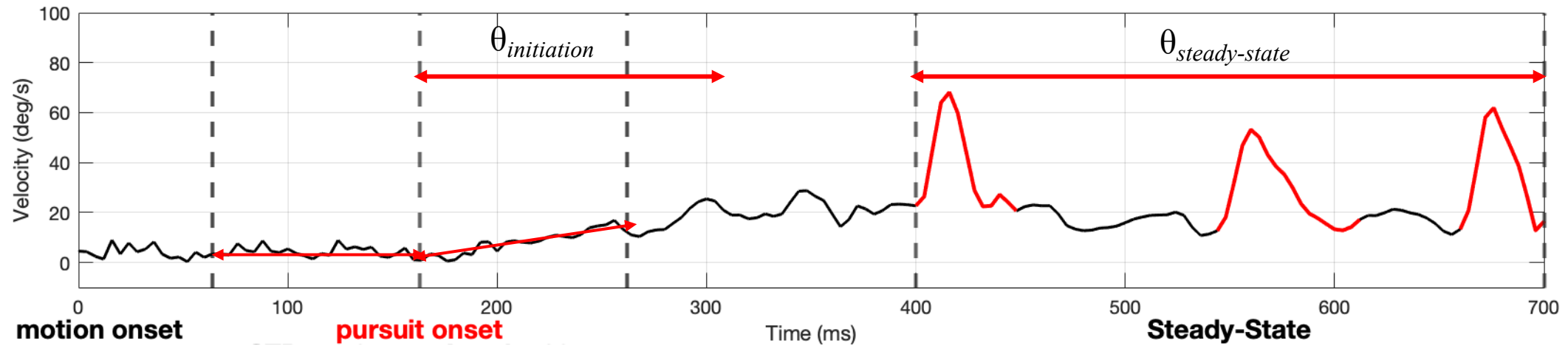
EyeLink 1000 Plus

Trial number 1440 = 16 blocks * 90 trials
 Motion direction 0 - 360°, in 12° step, 48 trials each
 Motion speed 16 deg/s



Rashbass, C. (1961). *The Journal of Physiology*
 Chen, Stone, Li (2021). *Journal of Vision*
 Chen et al., (2022). *Movement Disorders*

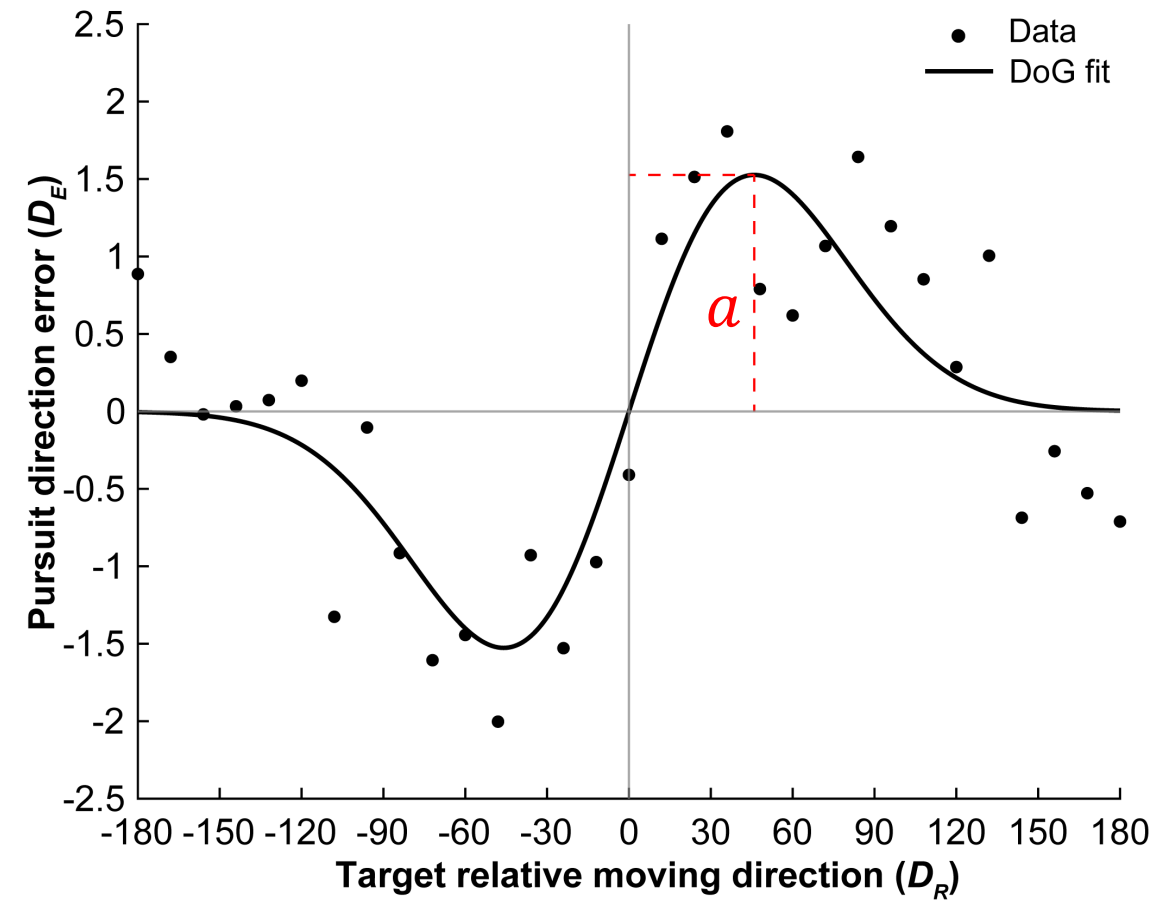
Typical eye velocity trace



$\theta_{response}$

- $\theta_{initiation}$: Driven by retinal motion signal
- $\theta_{steady-state}$: Driven by extra-retinal signal
- θ_t : Pursuit response in each time point

Data analysis



X axis: $D_R = \theta_{current} - \theta_{previous}$
 Y axis: $D_E = \theta_{current} - \theta_{response}$

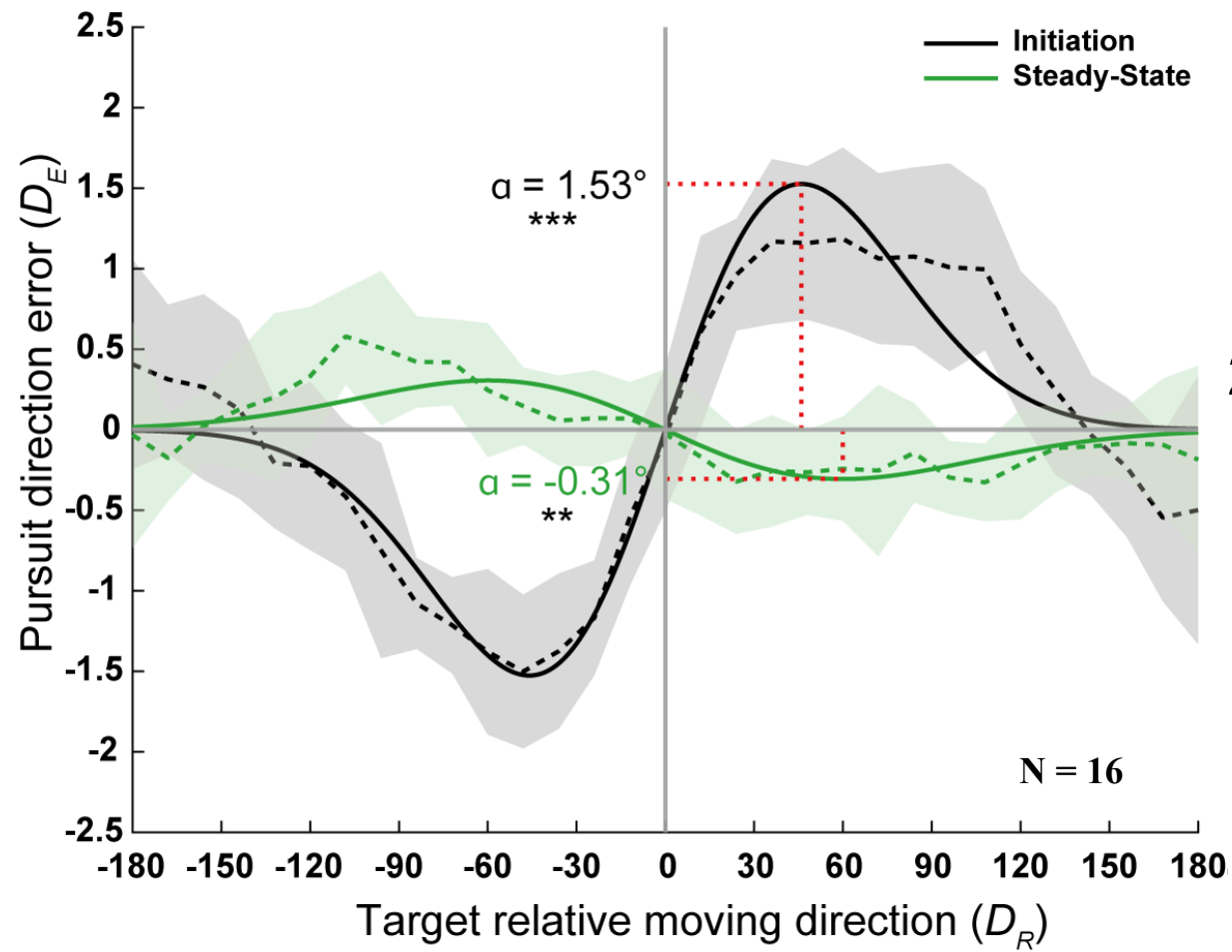
- First derivative of Gaussian (DoG) fitting

$$D_E = awce^{-(wD_R)^2} D_R$$

$a > 0$: attractive serial dependence

$a < 0$: repulsive visual adaption

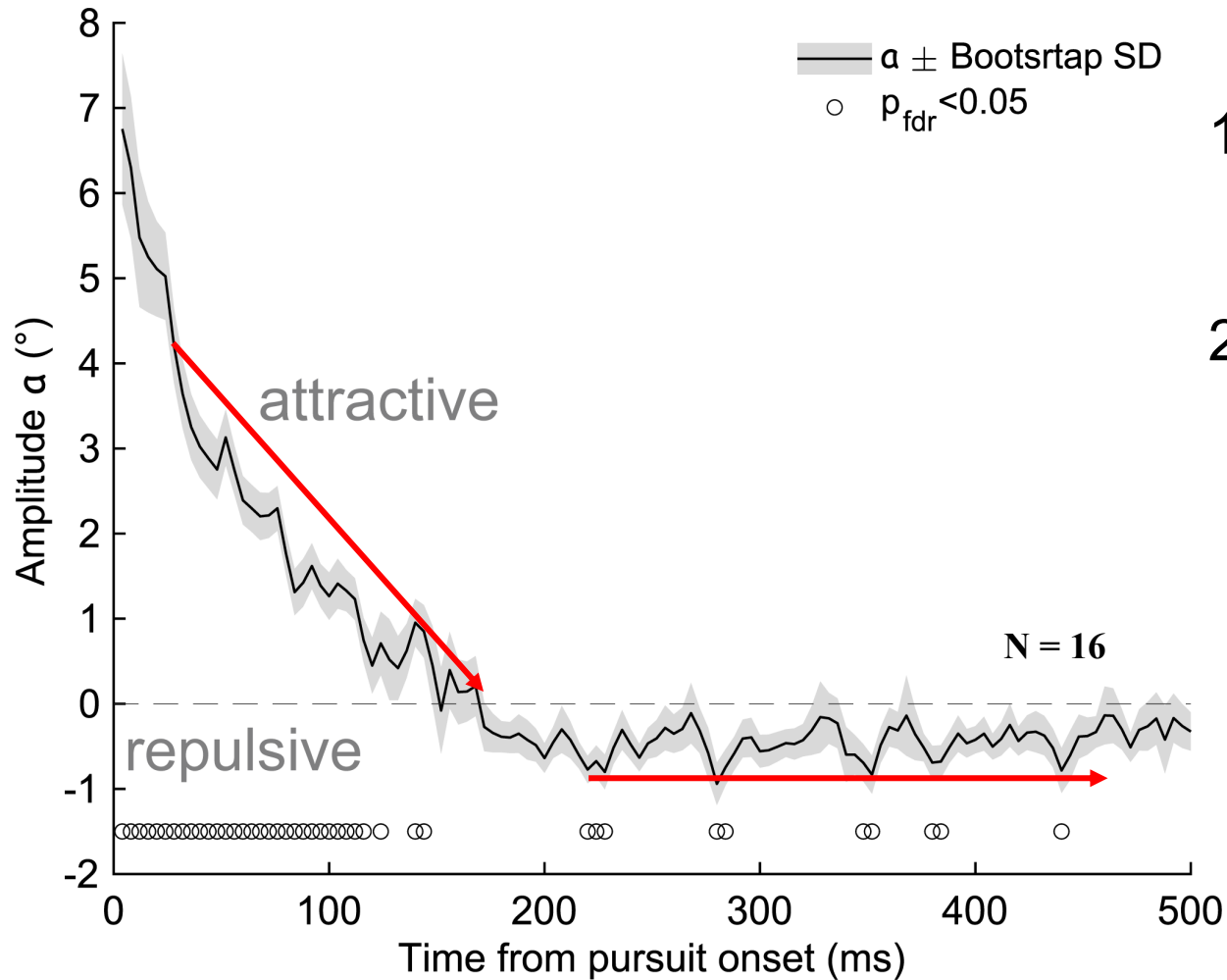
Serial dependence at different pursuit stages



1. Pursuit initiation: Attractive serial dependence
2. Steady-state: Repulsive adaptation

***, $p < 0.001$; **, $p < 0.01$

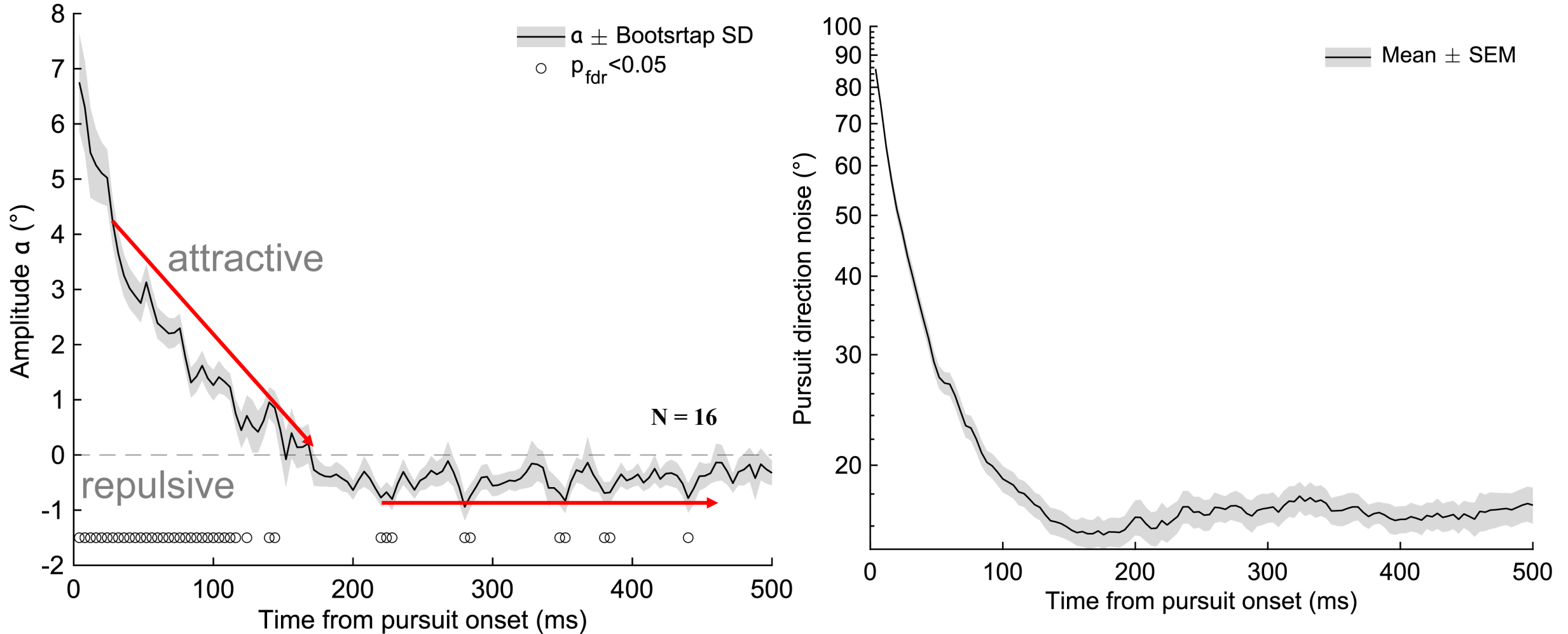
Temporal dynamics of serial dependence



1. A strong serial dependence at pursuit initiation that quickly declines over time.
2. A low-amplitude adaptation that remains stable throughout steady-state.

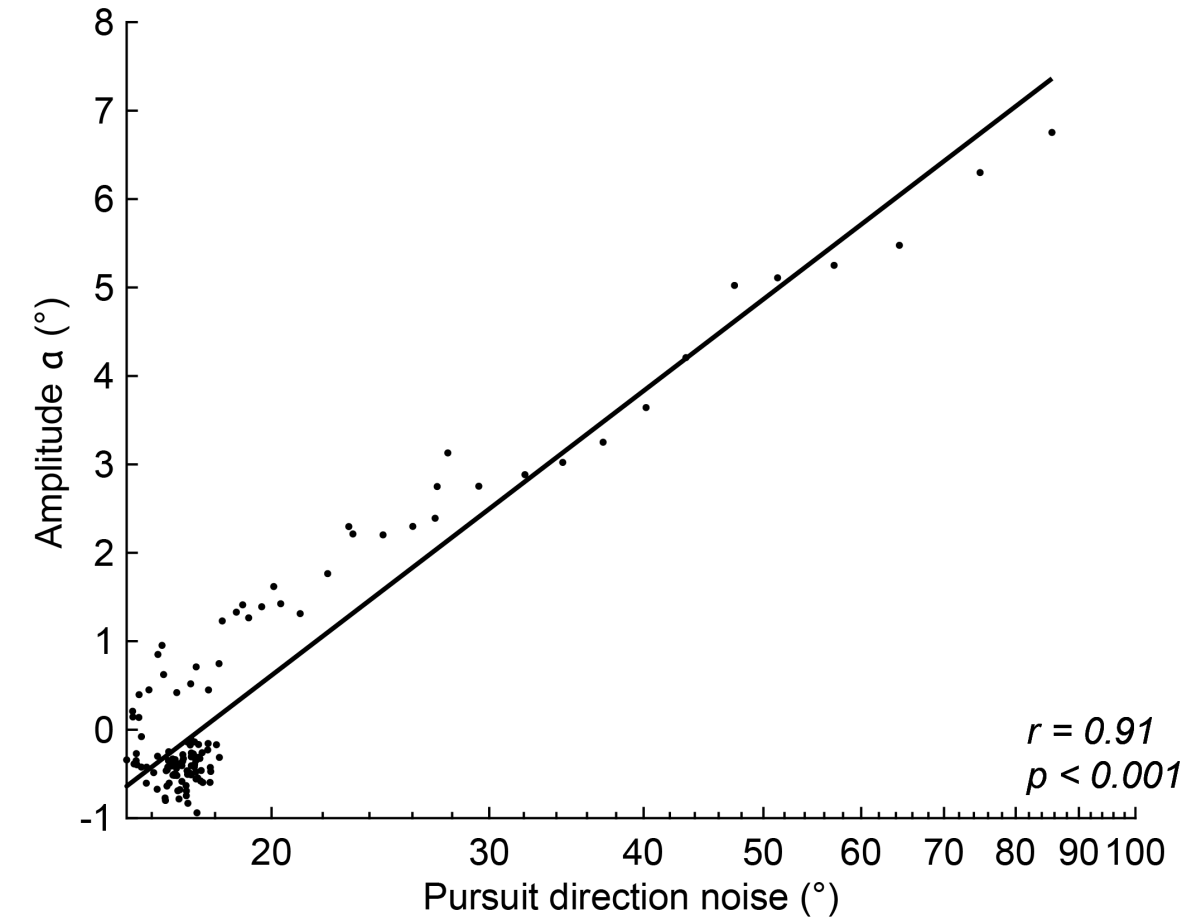
➤ **Serial dependence occurs in perception.**

Time-series of amplitude and pursuit noise



The time-series of amplitude and pursuit direction noise exhibited similar temporal trends

Correlation between amplitude and noise

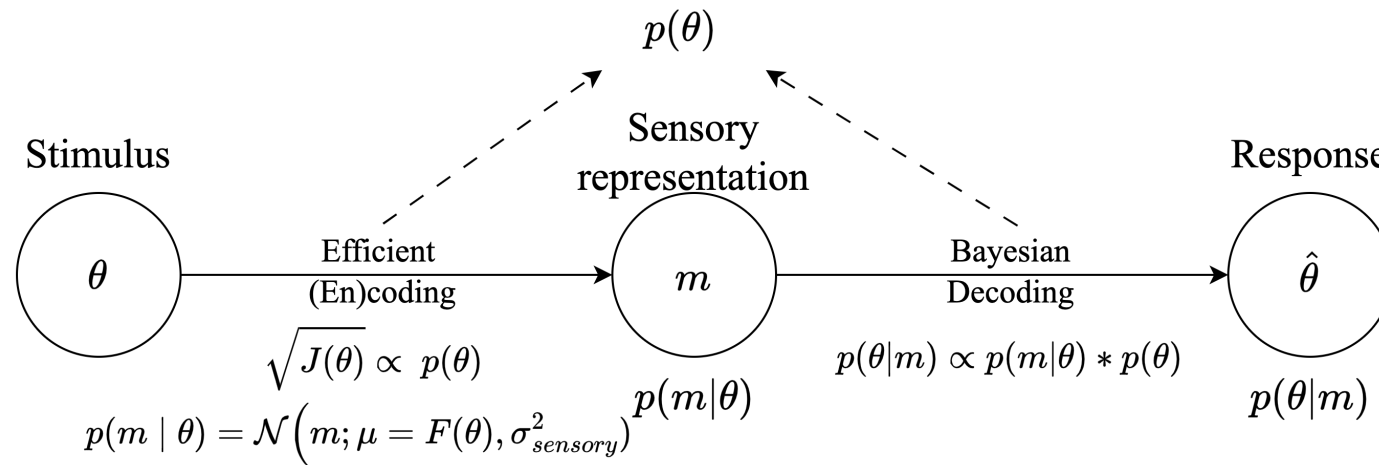


Strong correlation between the temporal dynamics of serial dependence and pursuit direction noise.

Whether serial dependence can be predicted by sensory noise over time ?

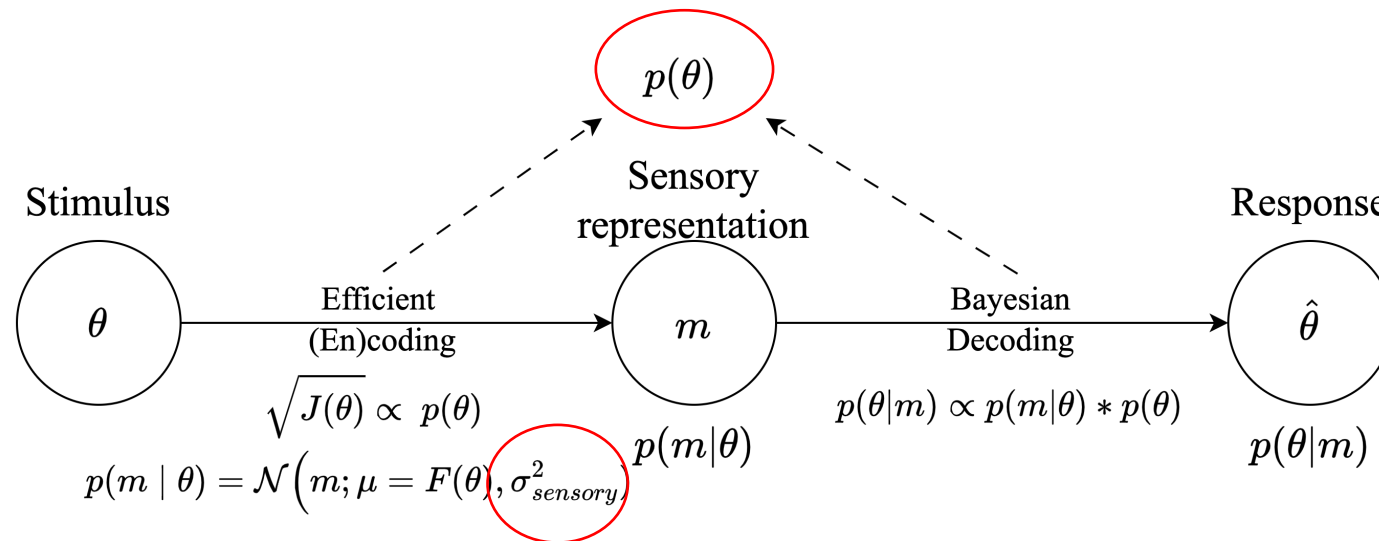
Model

Bayesian ideal observer model constrained by efficient coding



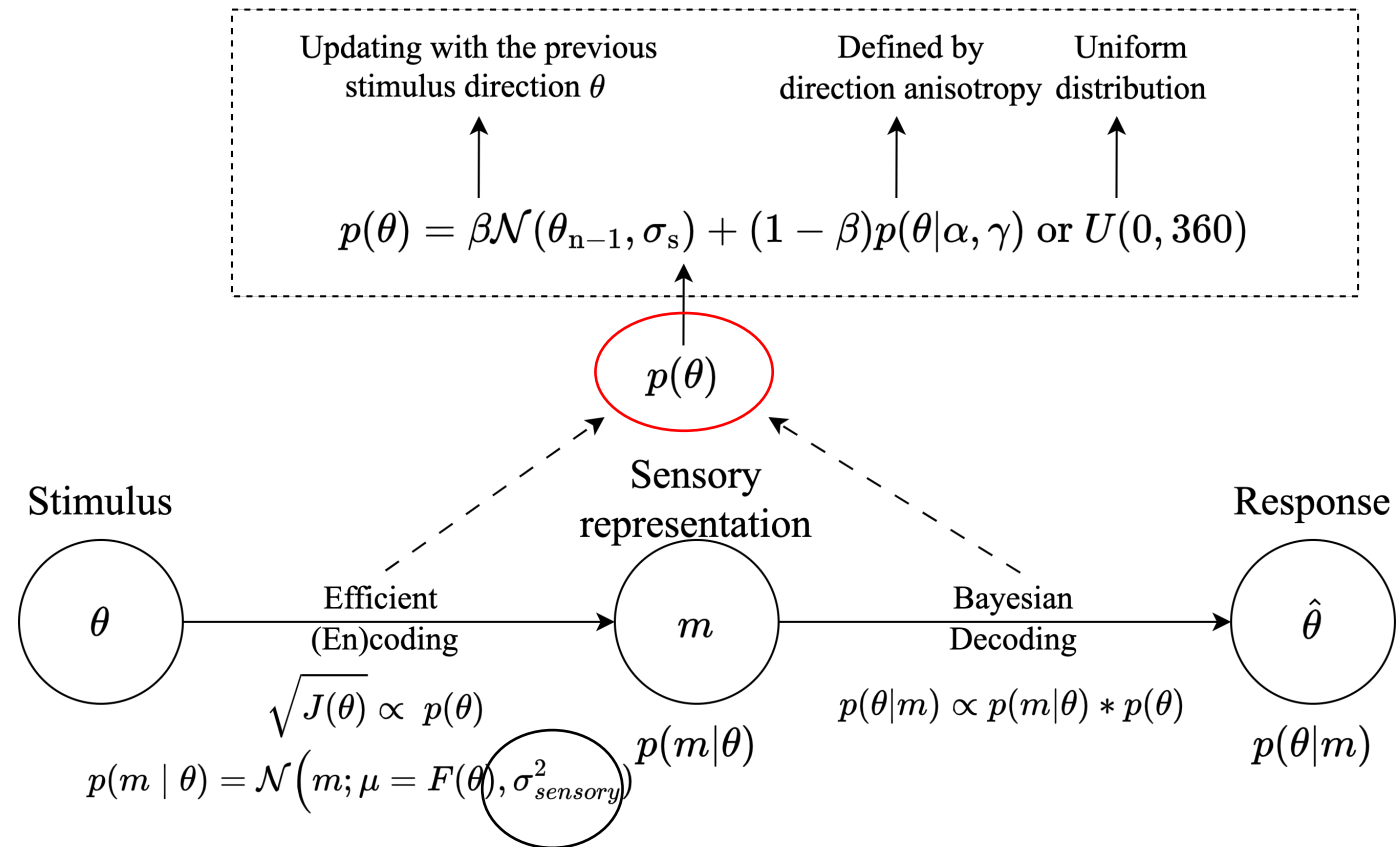
Model

Temporal Bayesian ideal observer model constrained by efficient coding



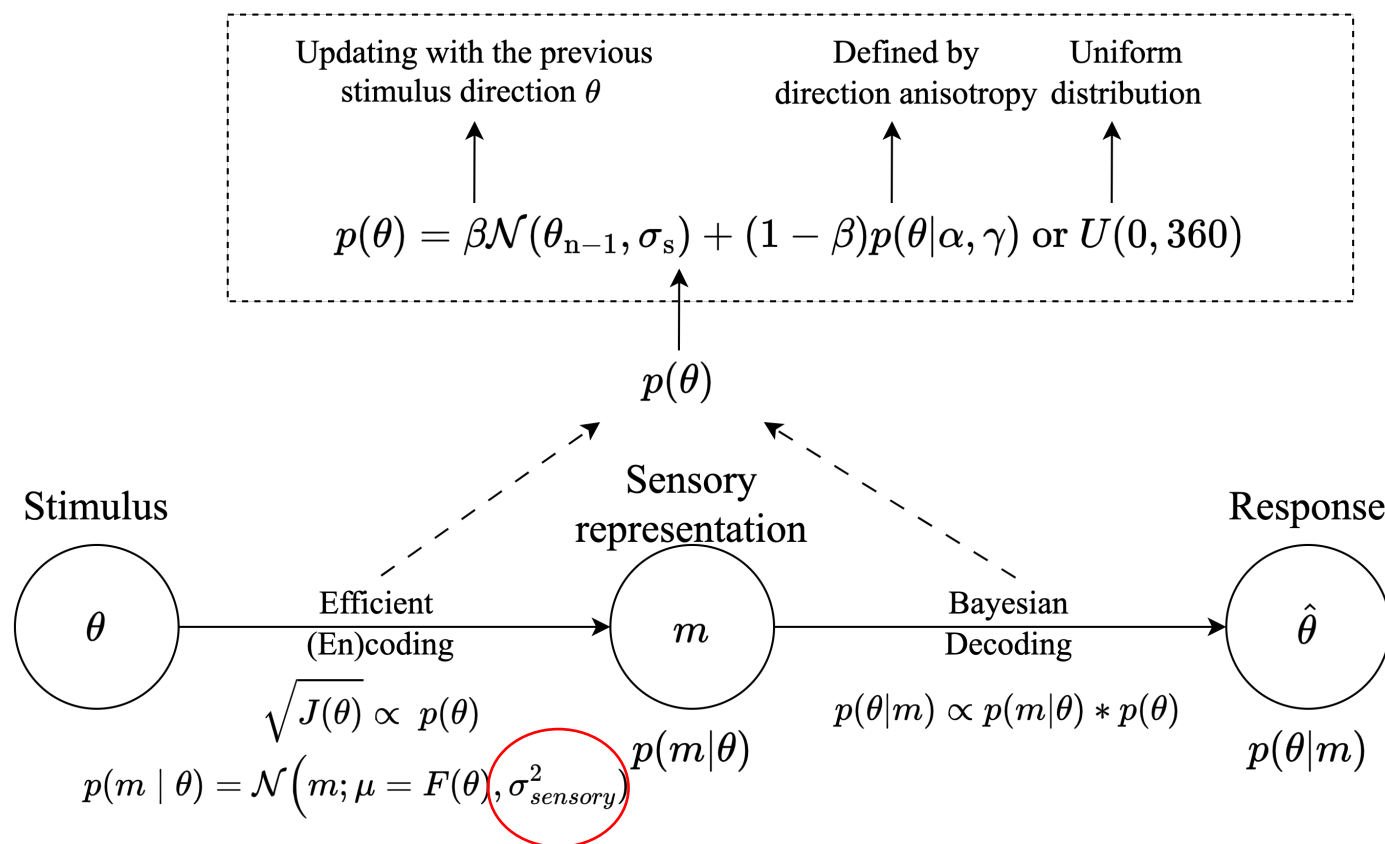
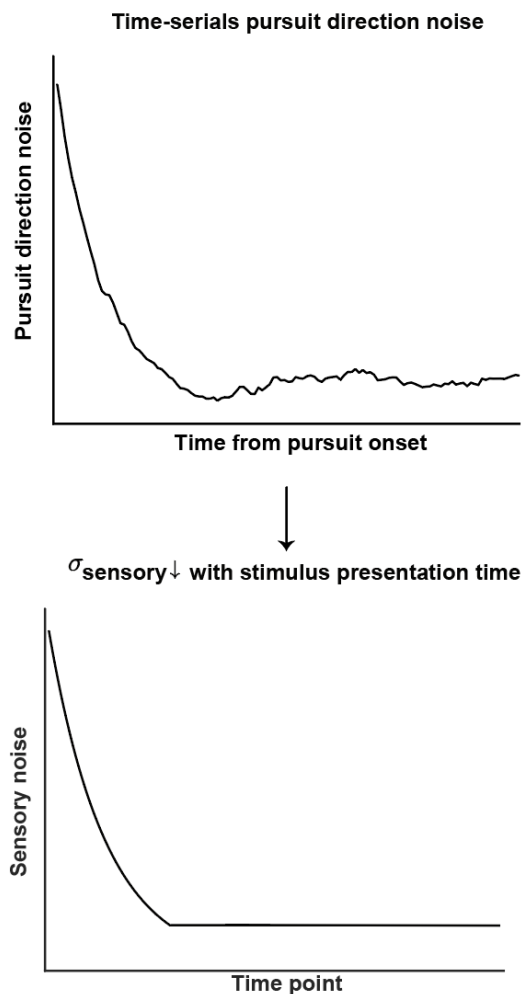
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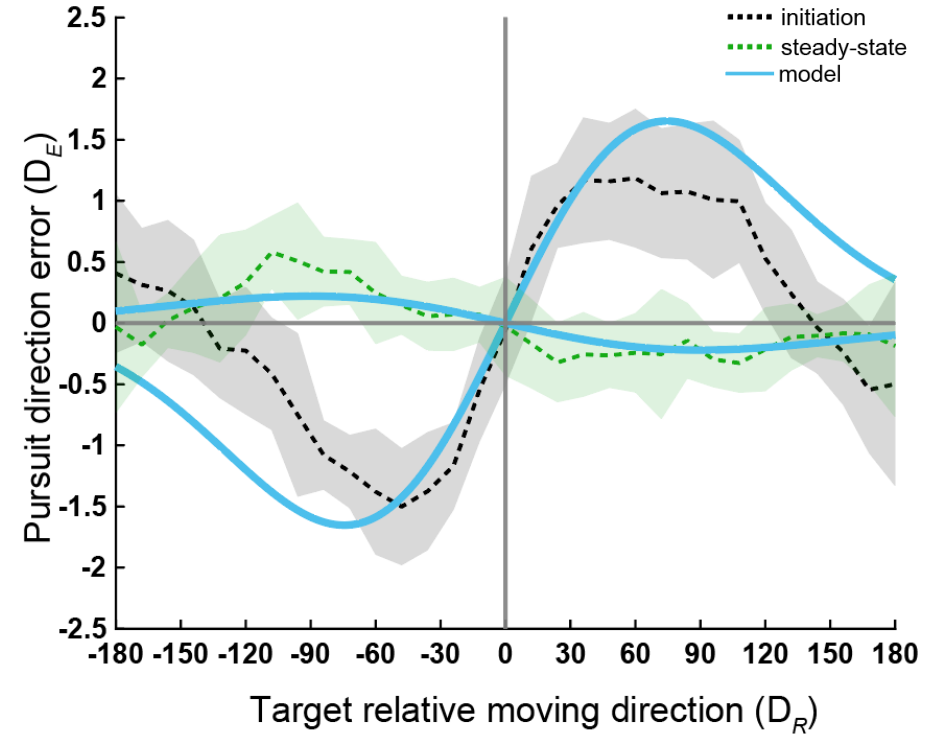
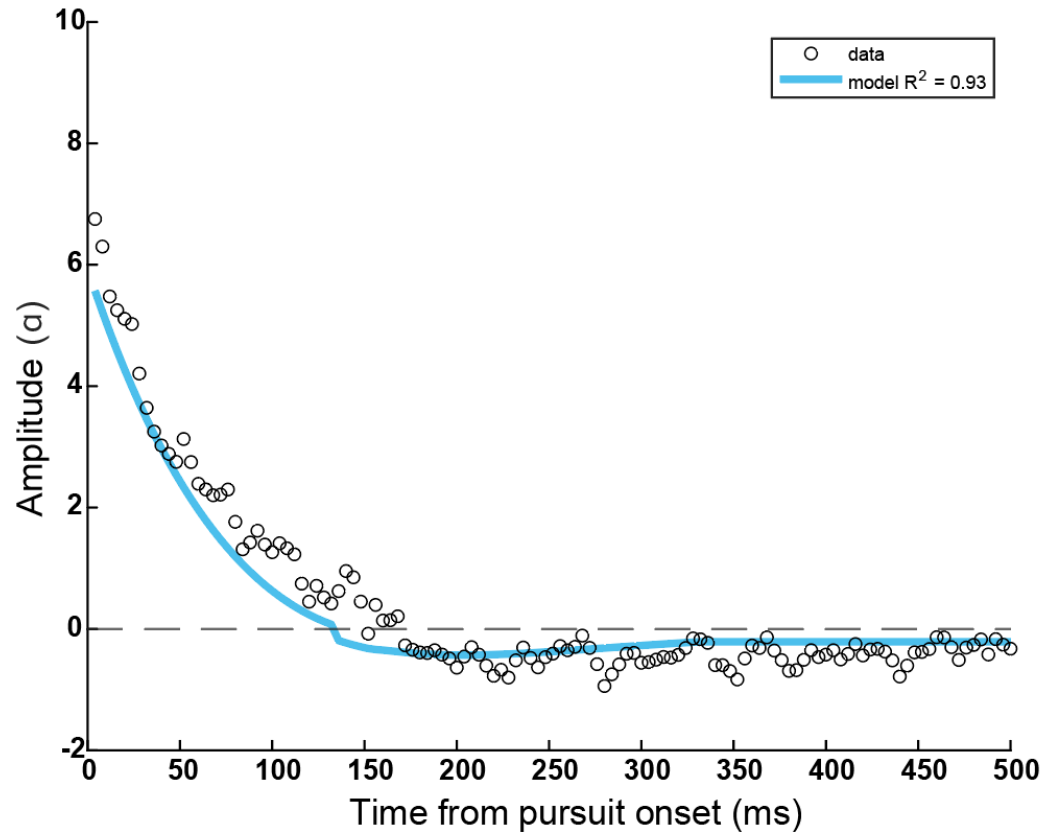


Model

Temporal Bayesian ideal observer model constrained by efficient coding



Model fitting



Temporal dynamics of serial dependence are captured by this Bayesian ideal observer, whose sensory noise decreases with time

Summary

- Attractive serial dependence effect in the retinal-motion-driven pursuit initiation.
 - Serial dependence happens before adaptation in ocular tracking
- **Serial dependence occurs in perception.**
- The temporal dynamics of serial dependence can be predicted by the sensory noise over time.
 - Serial dependence and temporal continuity (large sensory noise)
 - Adaptation and sensitivity optimization (small sensory noise)
- **Visual system regulates the balance of serial dependence and adaptation by sensory noise**

Acknowledgements

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Thank you !