# Neural Correlates of Serial Dependence: Synaptic Short-term Plasticity Orchestrates Repulsion and Attraction

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Visual Perceptual Stability

- The visual world casts dynamic images on the retina.

- From moment to moment, internal and external noise fluctuates across changes in lighting, occlusion, and viewpoint in the environment.

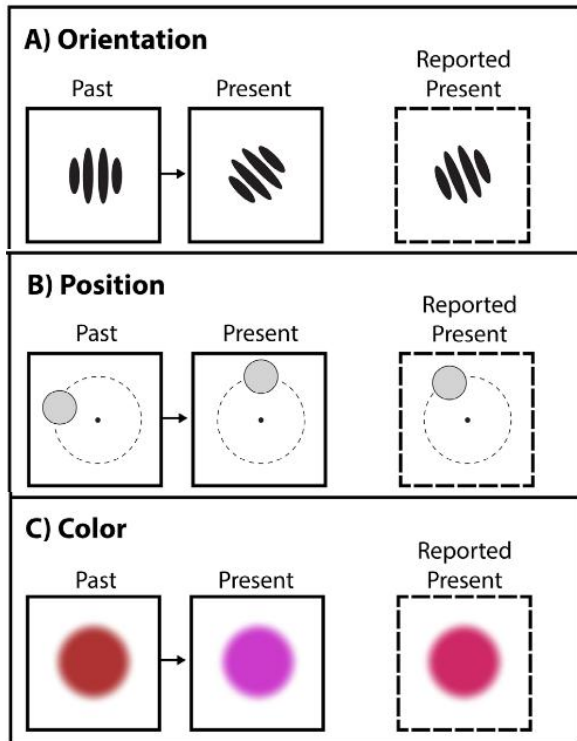- Yet we perceive coherence and stability in the world.
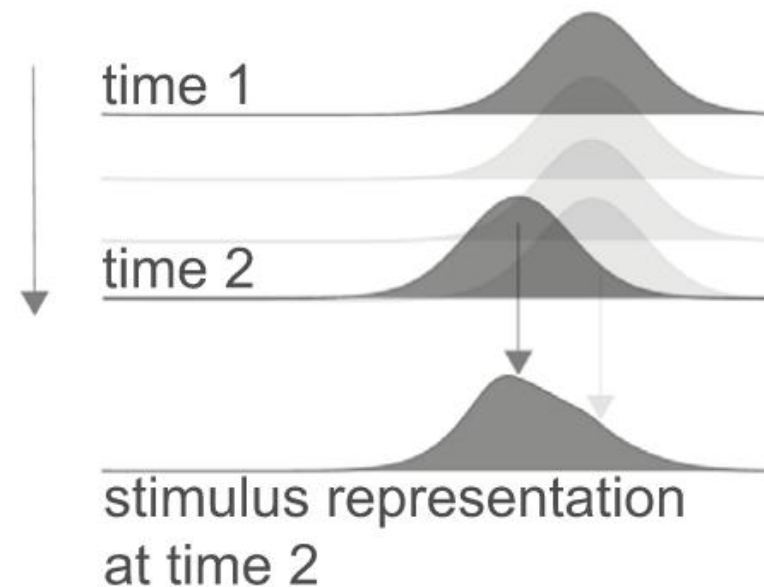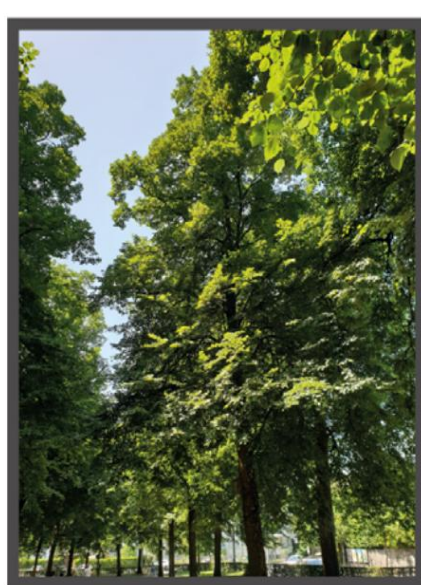
Serial dependence is an intrinsic mechanism through which our visual system exploits temporal correlations and contextual redundancies by merging similar stimuli that slightly changing over time.

Pascucci *et al.*, 2023

positive serial dependencies
(attractive)

➡ stability

negative serial dependencies
(repulsive)

➡ sensitivity

Manassi *et al.*, 2023
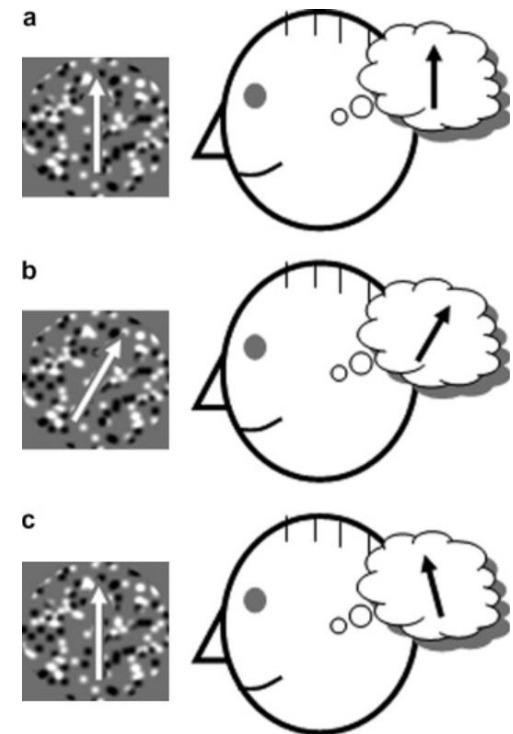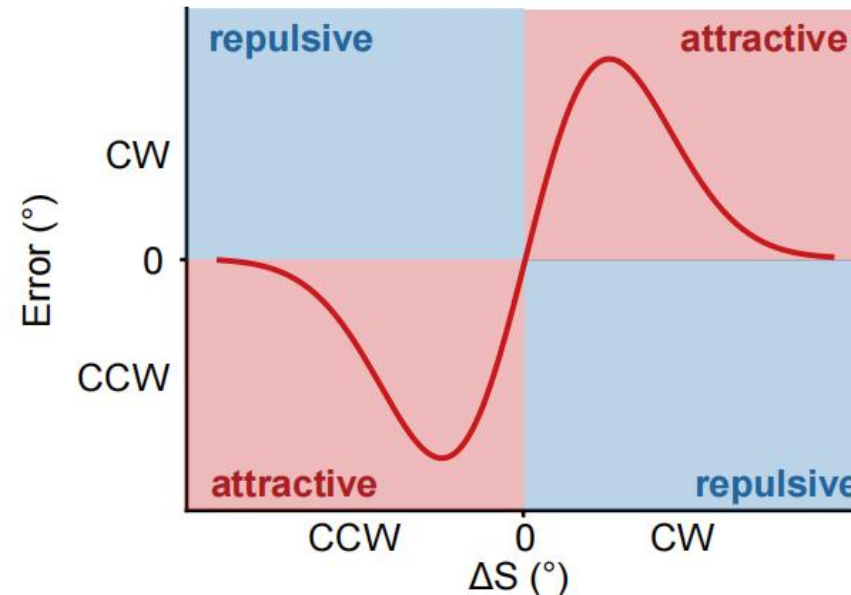
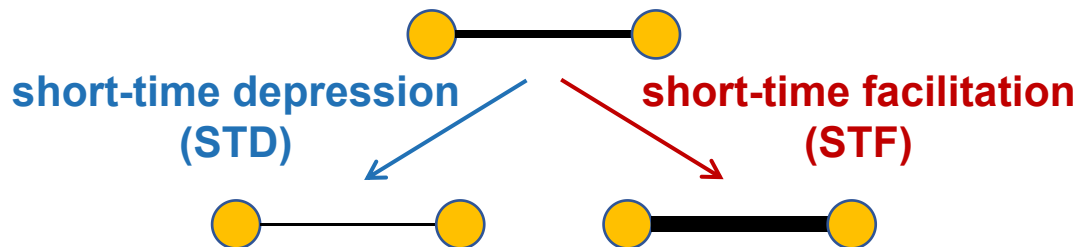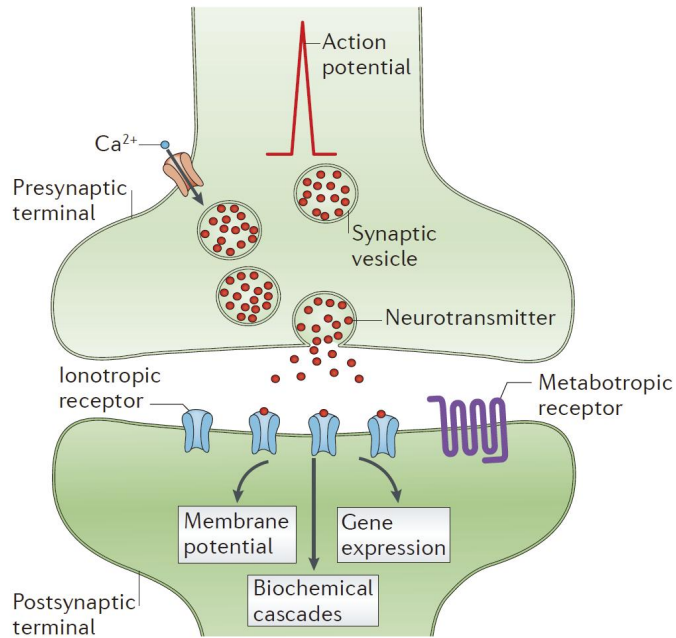

Clifford *et al.*, 2007

This balance of stability and sensitivity is a remarkable ability of the brain!

Short-term synaptic plasticity (STP) in the neural network

short-time depression (STD)
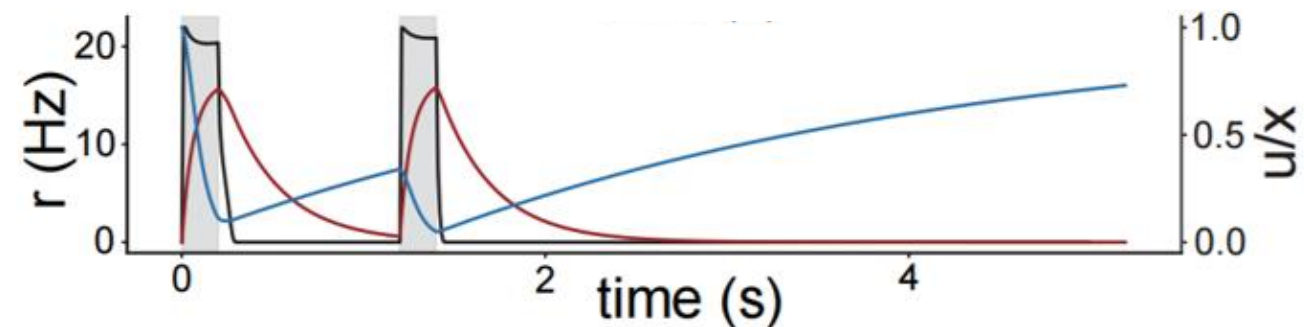
short-time facilitation (STF)

High level Cortex (e.g., PFC)
STF dominated: $\tau_f \gg \tau_d$ → stability
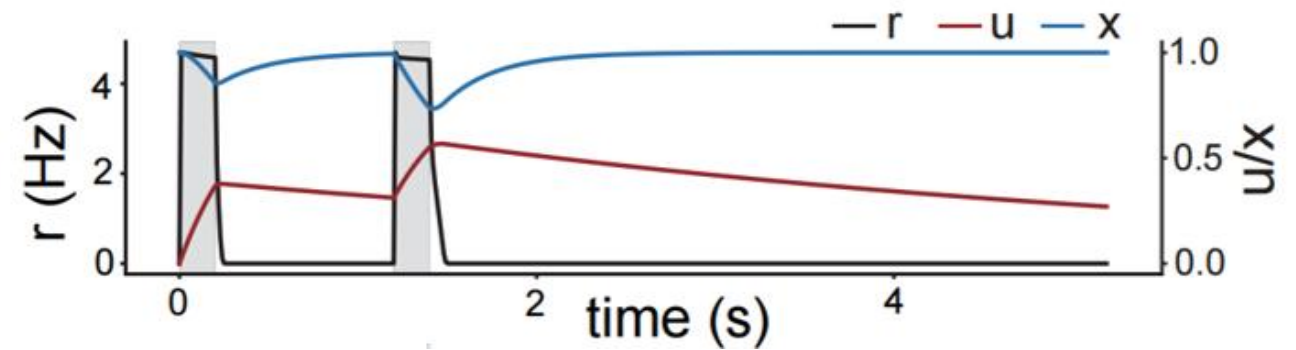
Sensory Cortex (e.g., V1)
STD-dominated : $\tau_d \gg \tau_f$ → sensitivity

Our Two-layer Network Model with Heterosynaptic STP

There has been growing evidence suggesting that :

- repulsion typically occurs in the sensory stage,
- attraction appears in the post-perception stage.

Schwiedrzik *et al.*, 2014,
Fritsche *et al.*, 2017,
Sheehan *et al.*, 2022,
Hajonides *et al.*, 2023,
Luo *et al.*, 2025,
......

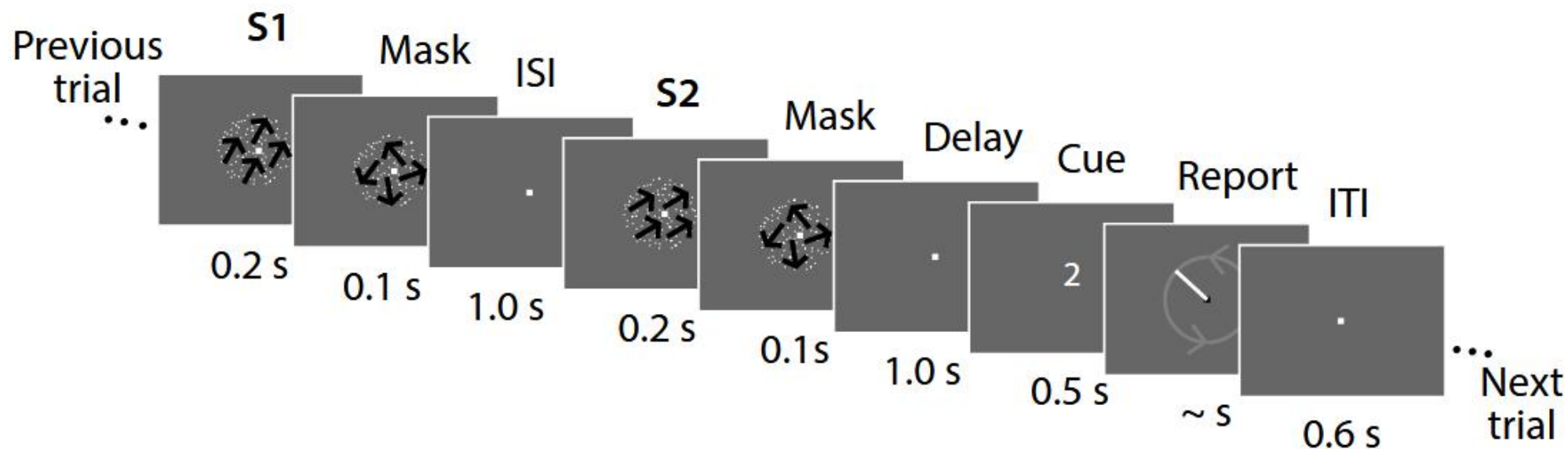Continuous attractor neural network (CANN)

High Level (STF-dominated)

Low Level (STD-dominated)
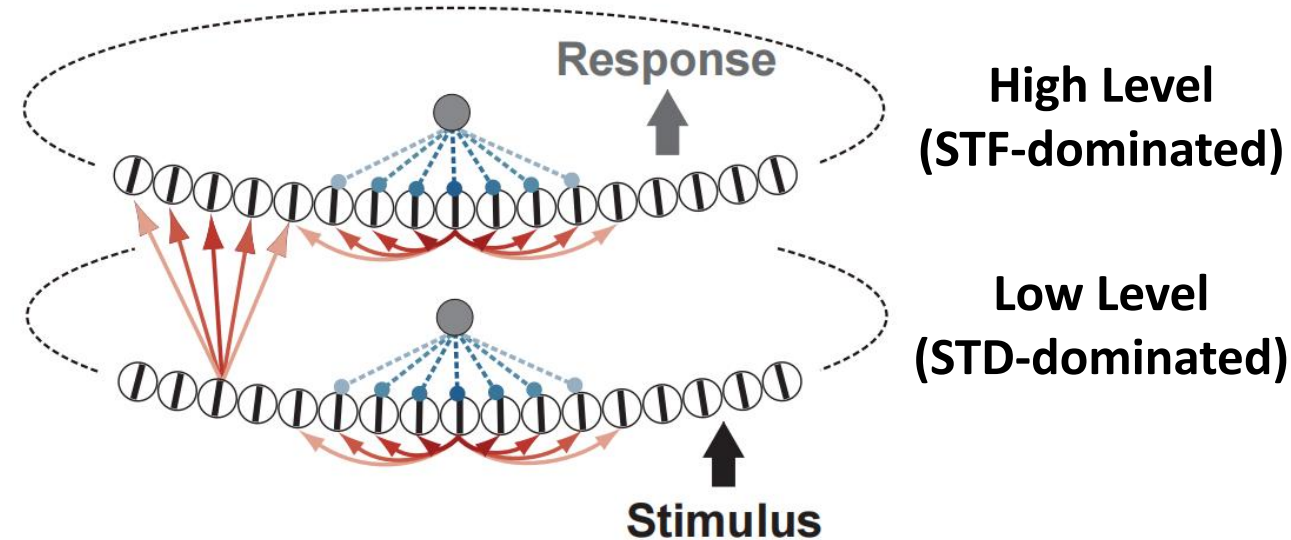
STF-dominated high level: modeling high-level cortex (e.g., PFC)

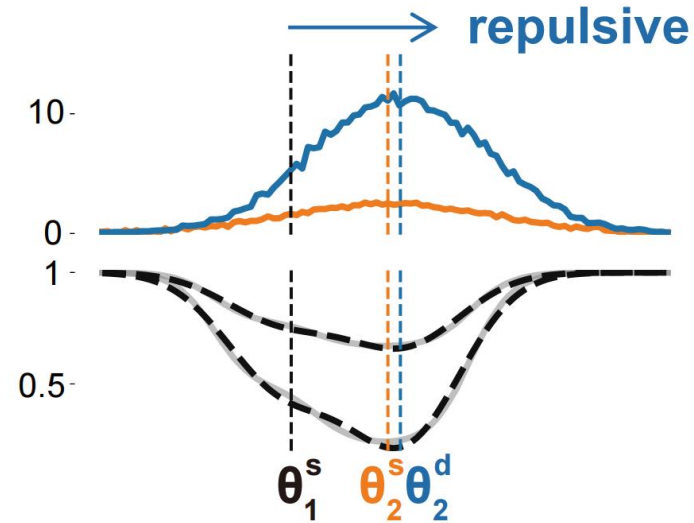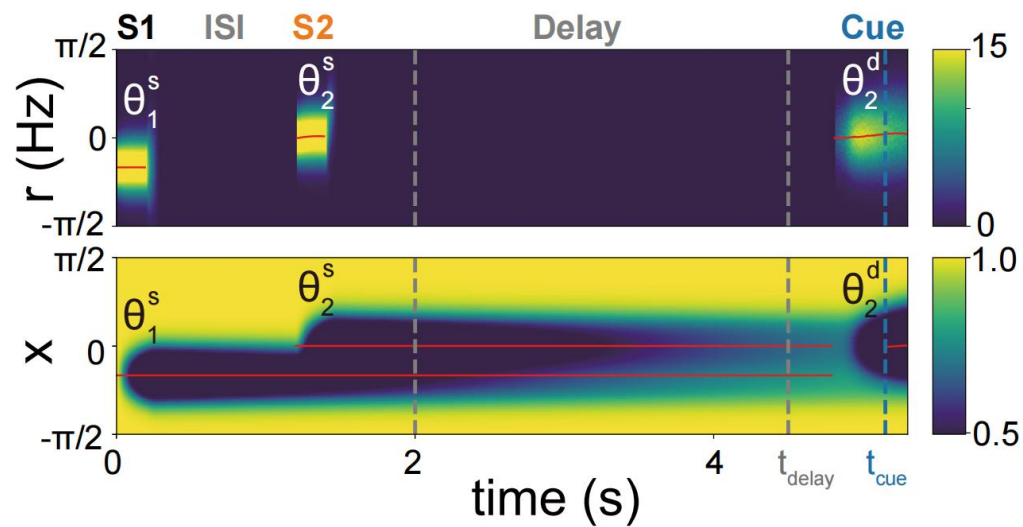STD-dominated low level: modeling visual cortex (e.g., V1)

☐ Experimental paradigm

Czoschke *et al.*, 2018

θ_2^d is repelled away from θ_1^s
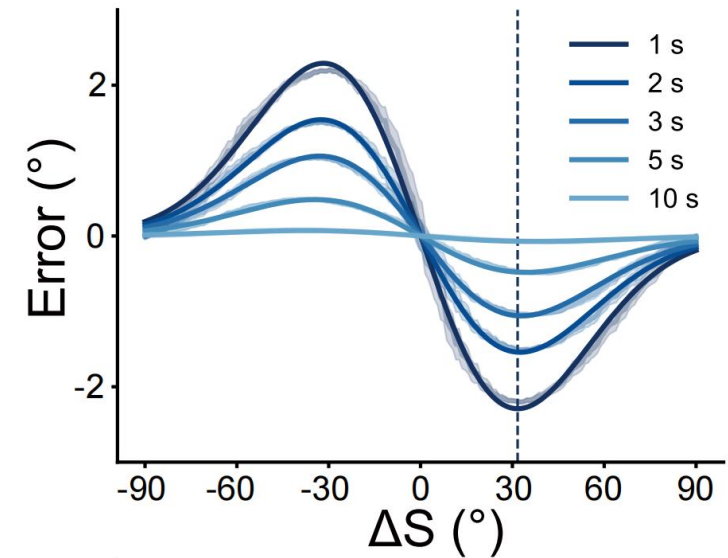
manipulating ISI

$\Delta t_{ISI} < \tau_d$:
significant repulsion

θ_2^d is attracted toward θ_1^s
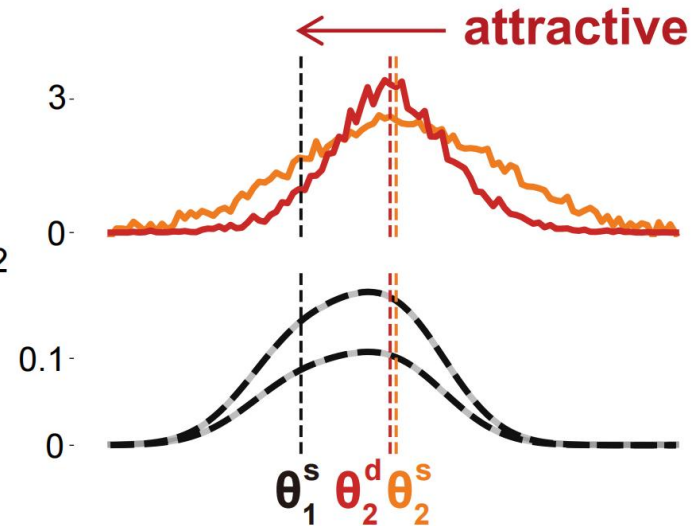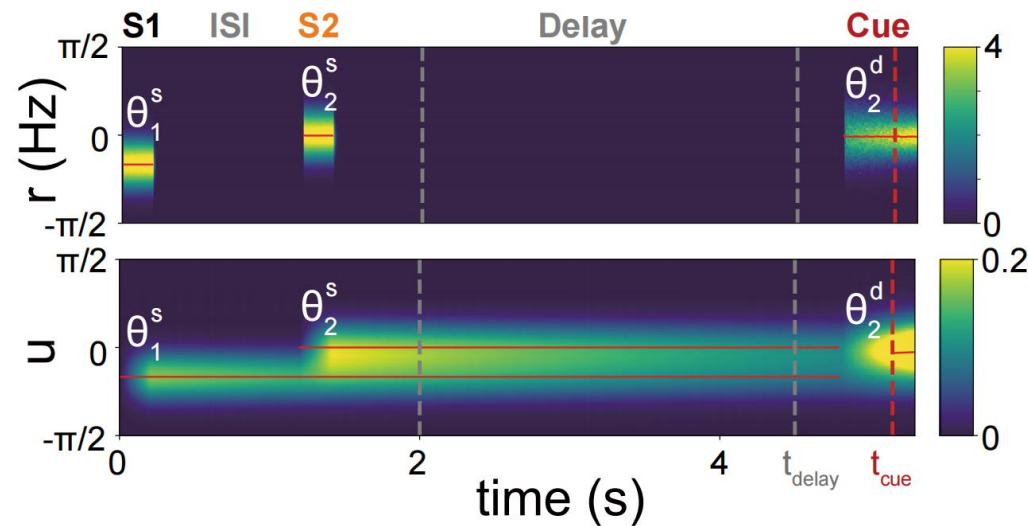
manipulating ISI
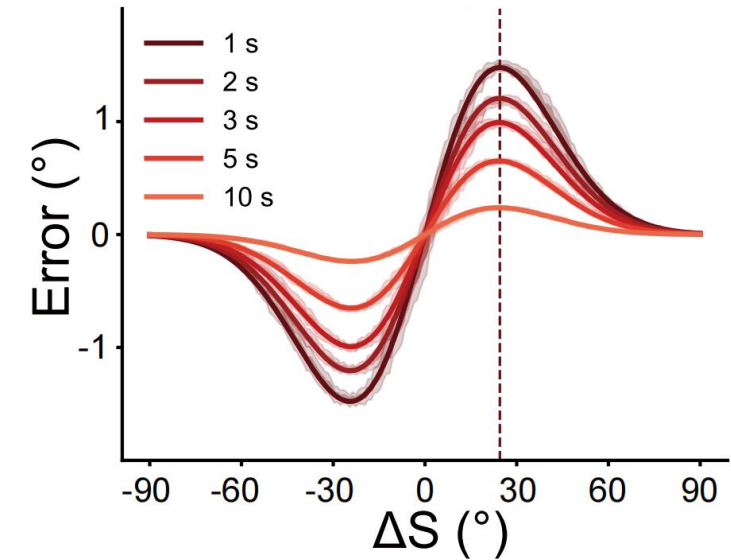
$\Delta t_{ISI} < \tau_f$:
significant attraction
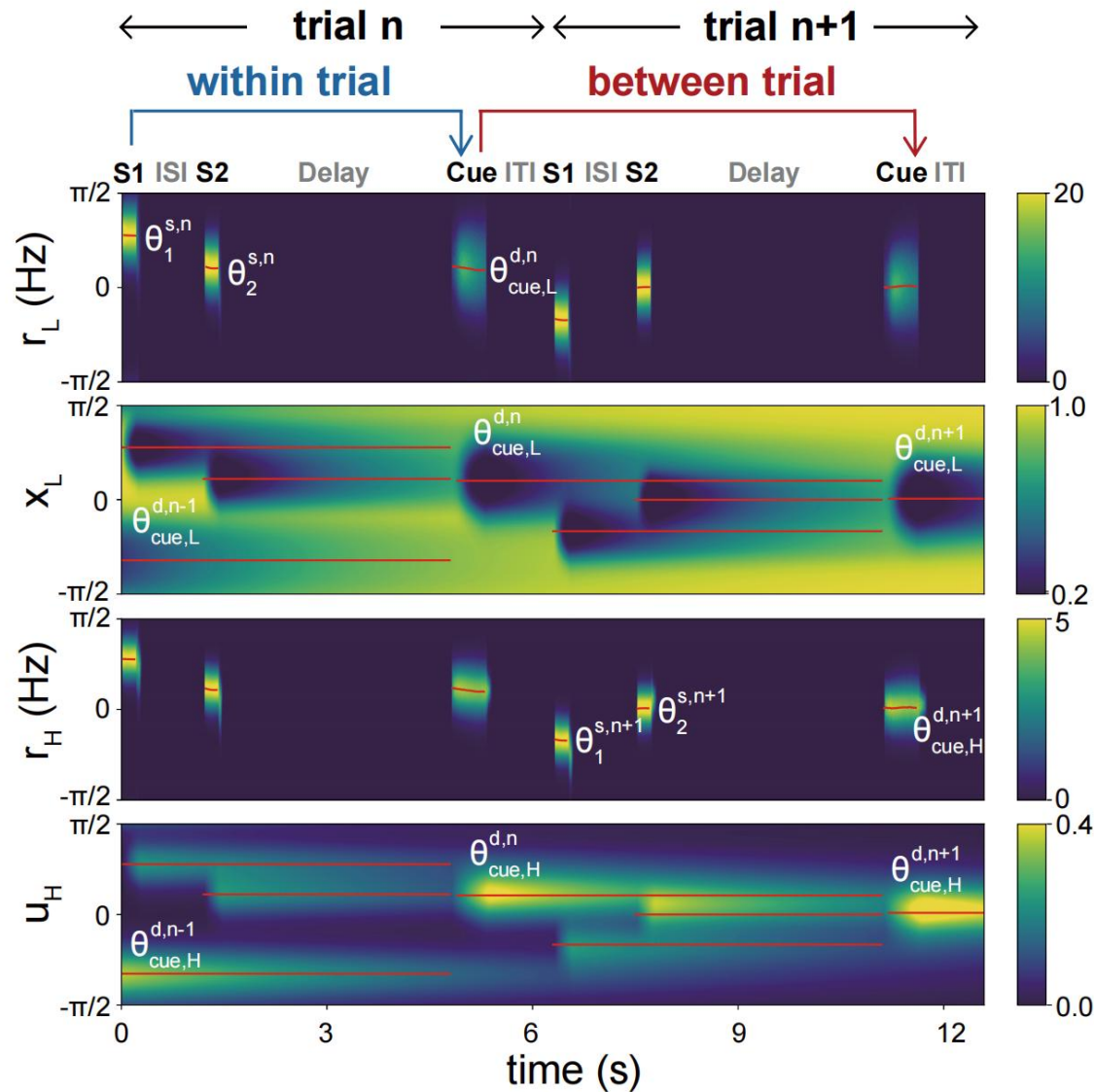
simulation results

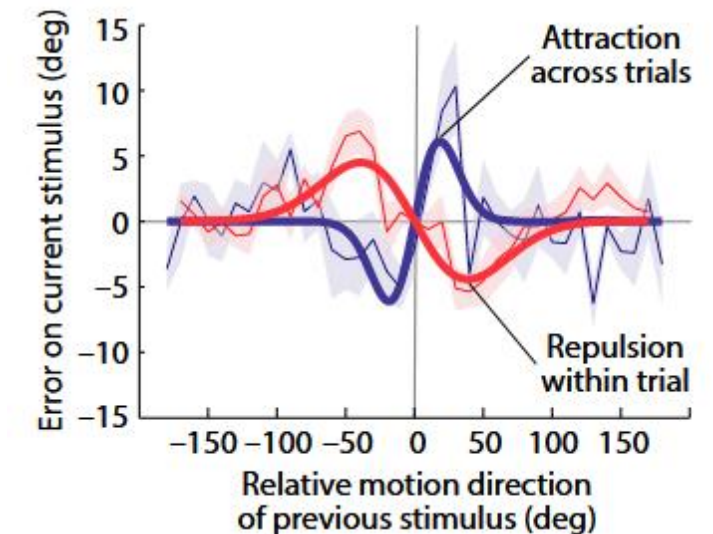behavioral results

Low layer

High layer

Czoschke *et al.*, 2018

schematic of Bayesian interpretation
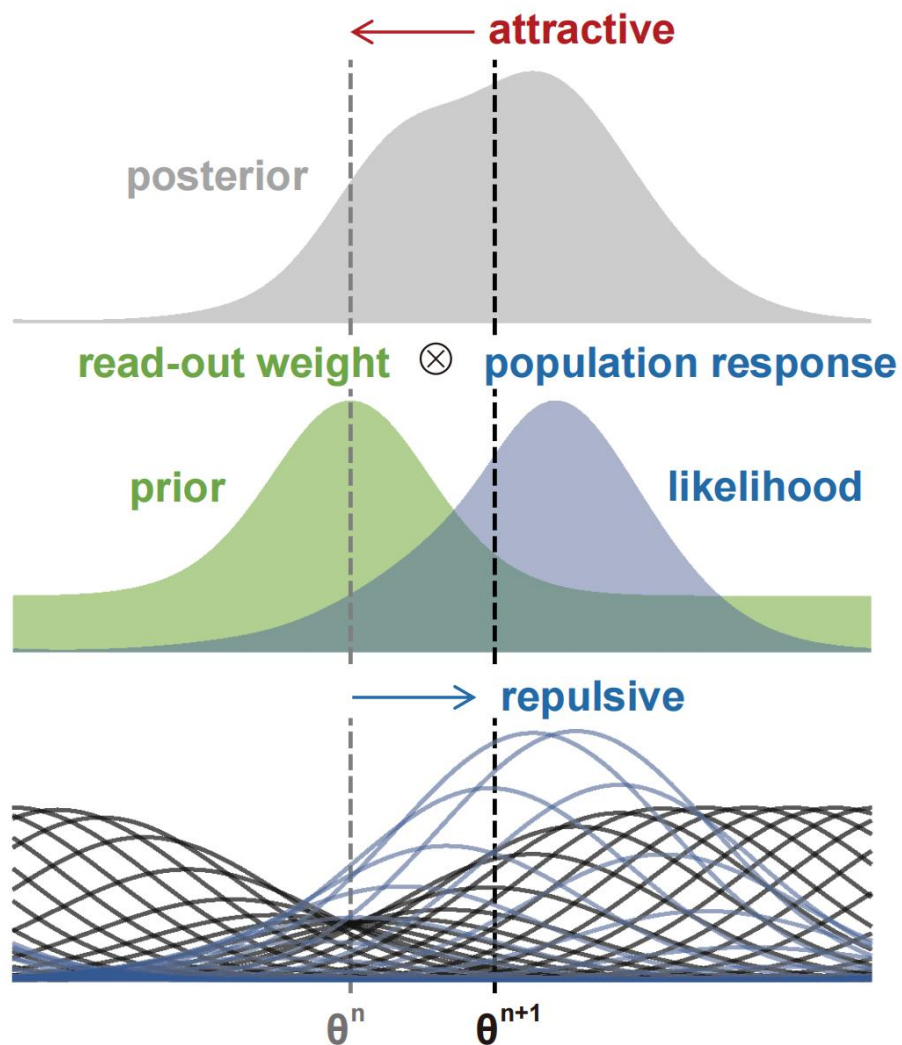
STP correlations of Bayesian inference
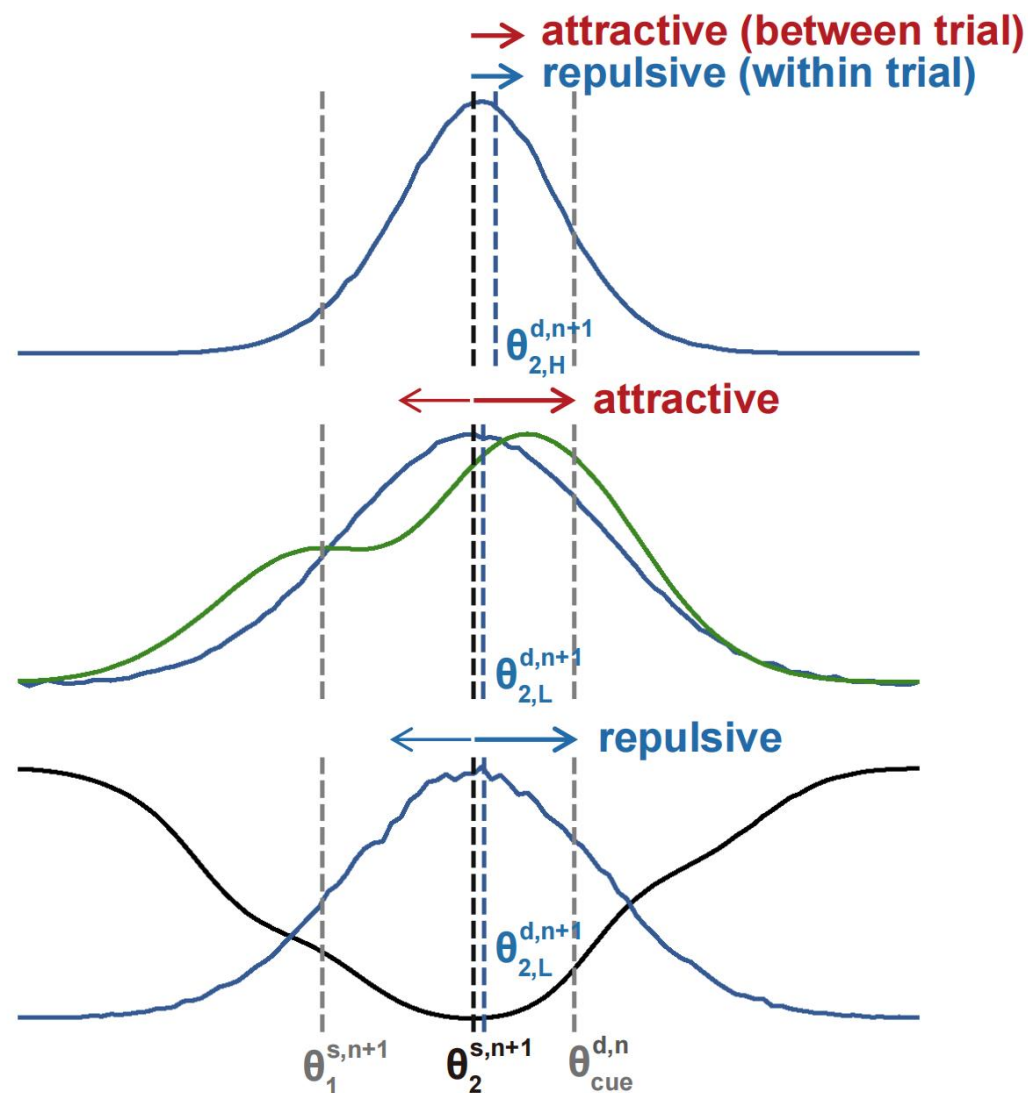
information segregation window

information integration window

STD time constant τ_d

STF time constant τ_f
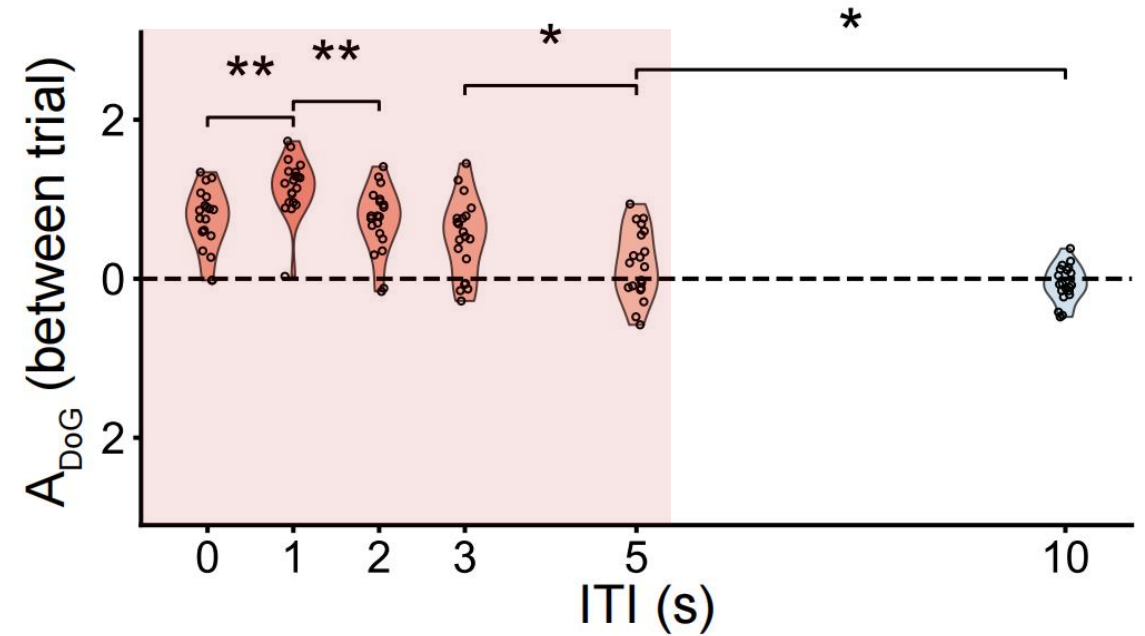
Summary

- [ ] We developed a two-layer CANN model with heterosynaptic STP, successfully explaining the repulsive and attractive biases in the visual orientation judgment experiments.

- [ ] The model provides a neural foundation for the Bayesian interpretation of serial dependence.

- [ ] This study advances our understanding of the neural system leverages STP to balance sensitivity in sensory perception with stability in post-perceptual cognition.

Two-layer CANN model with heterosynaptic STP

Serial dependence
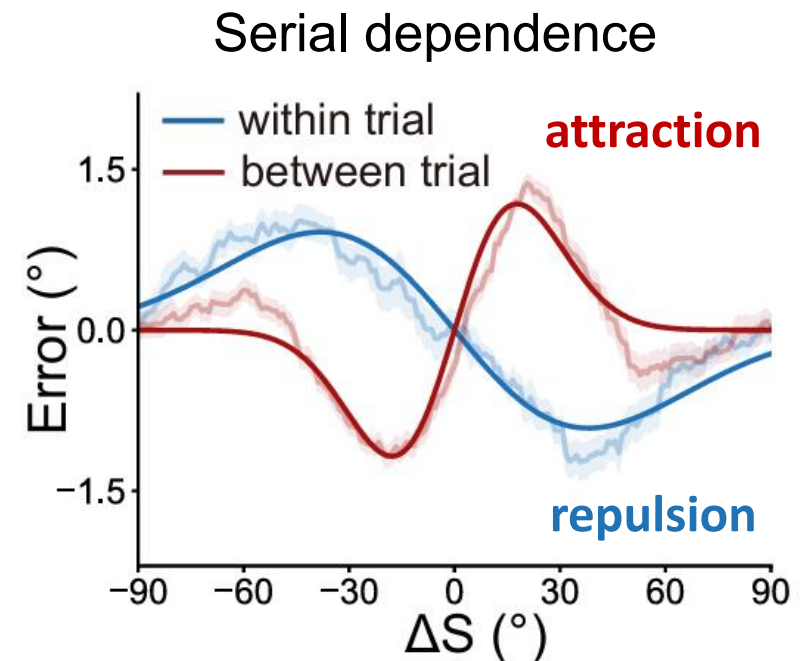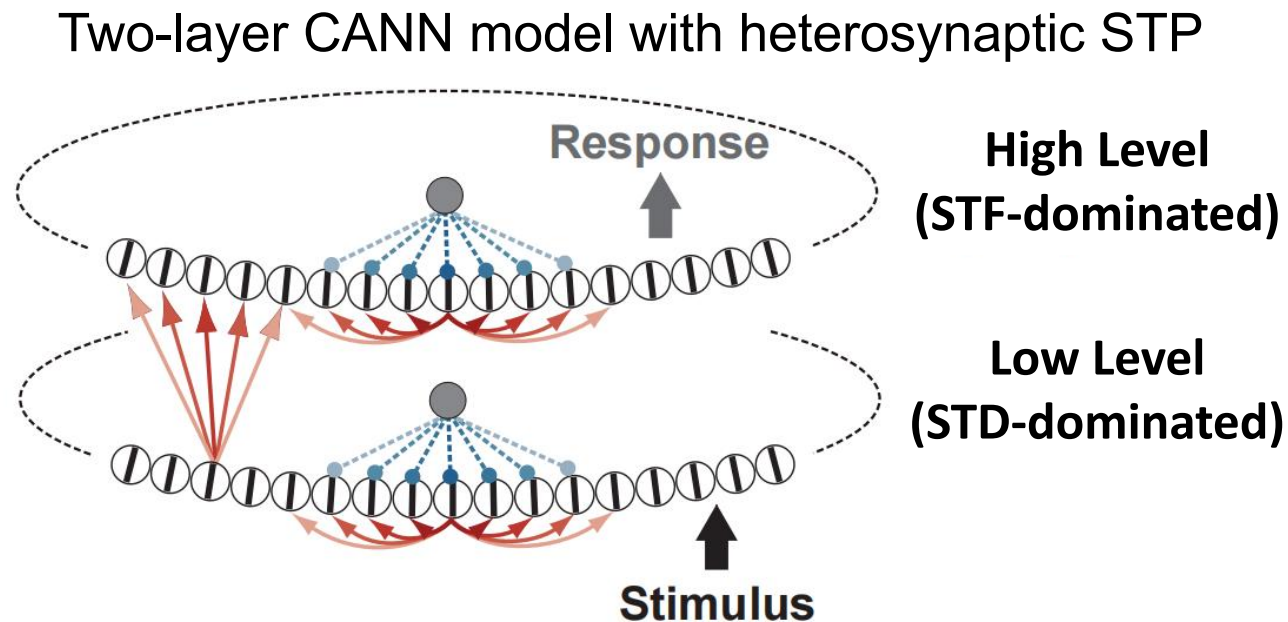
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Thanks for your attention!