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Learning orthogonal working memory representations protects from task interferences

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Motivations

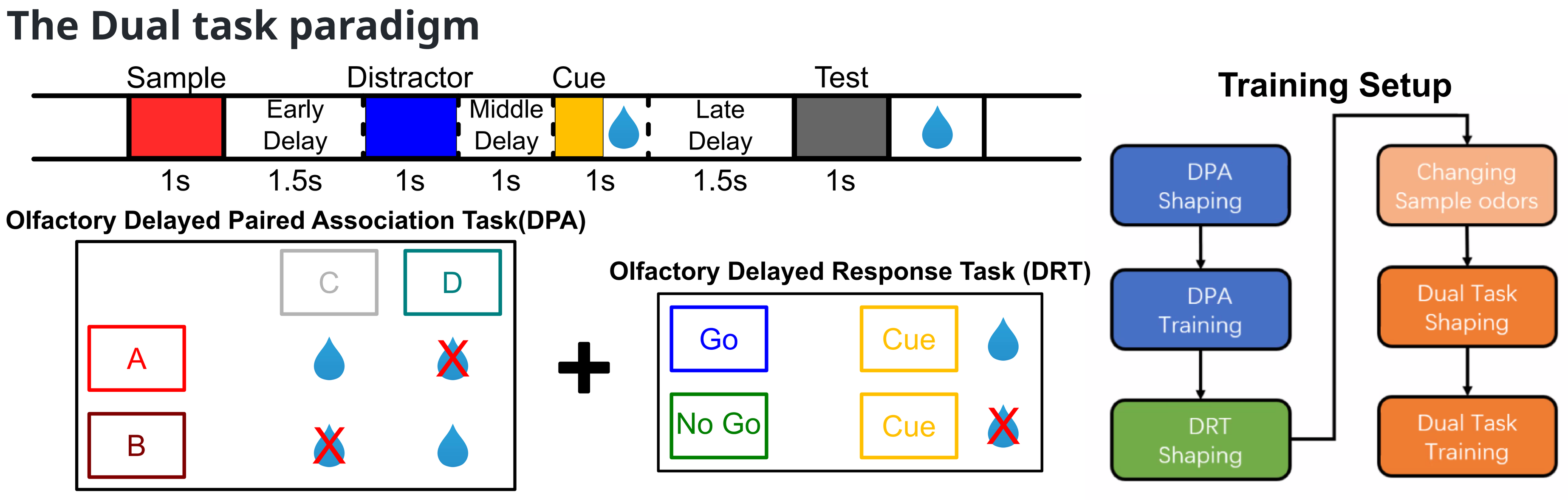
Neural activity in prefrontal cortex before and after distraction decomposes into orthogonal subspaces, one invariant across distraction, to protect the mnemonic code from interferences.

Whether orthogonalization is a general mechanism for WM preservation remains an open question, and the network mechanisms supporting it are unclear.

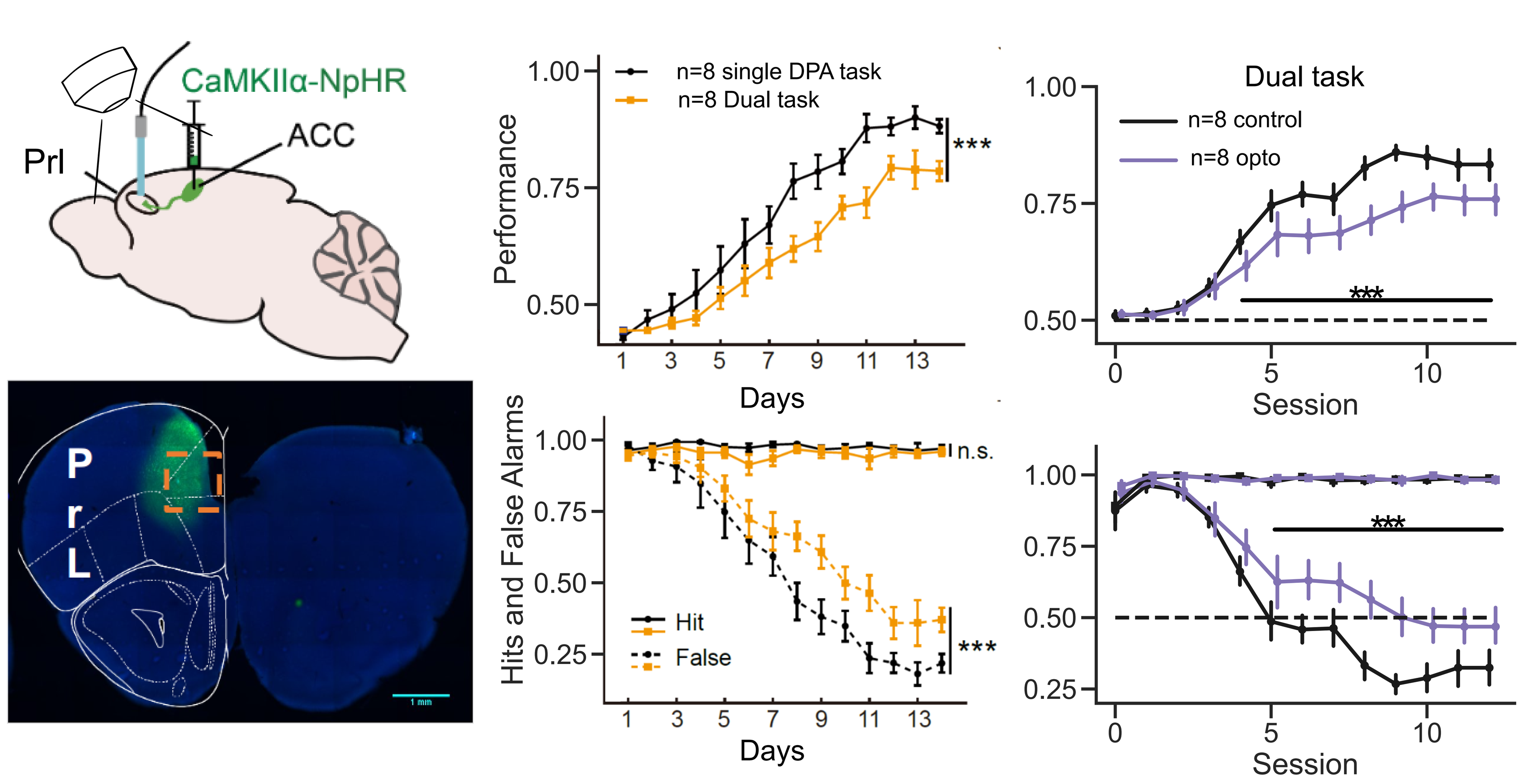
Previous works have linked neural computations in decision-making tasks to low-rank connectivity structures. Here, we extend this theoretical framework to account for orthogonalization in a novel WM task in mice: the Dual task.

Task interference in a WM task

The Dual task paradigm

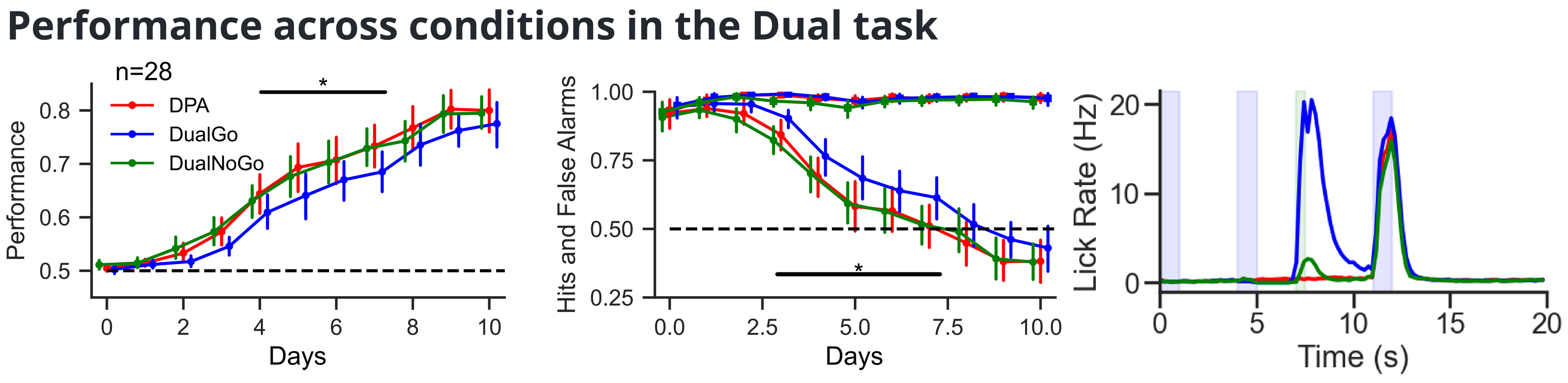


Setup and Animal Performance



Dual task performance is worse than single DPA task performance
Optogenetic inactivation of ACC inputs impairs Dual task performance

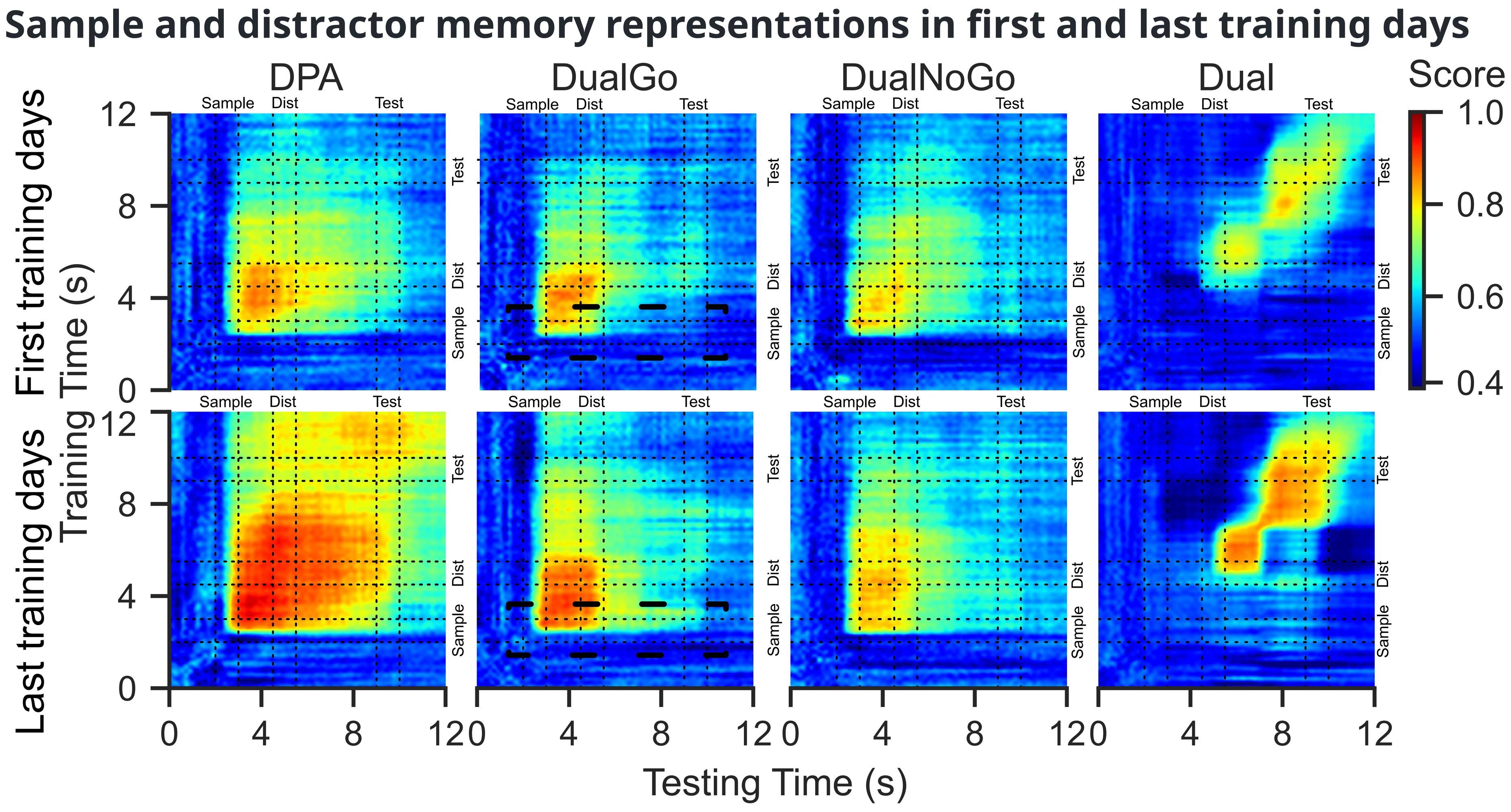
Performance across conditions in the Dual task



Learning is slower in DRT rewarded trials (Dual Go) than in other trials

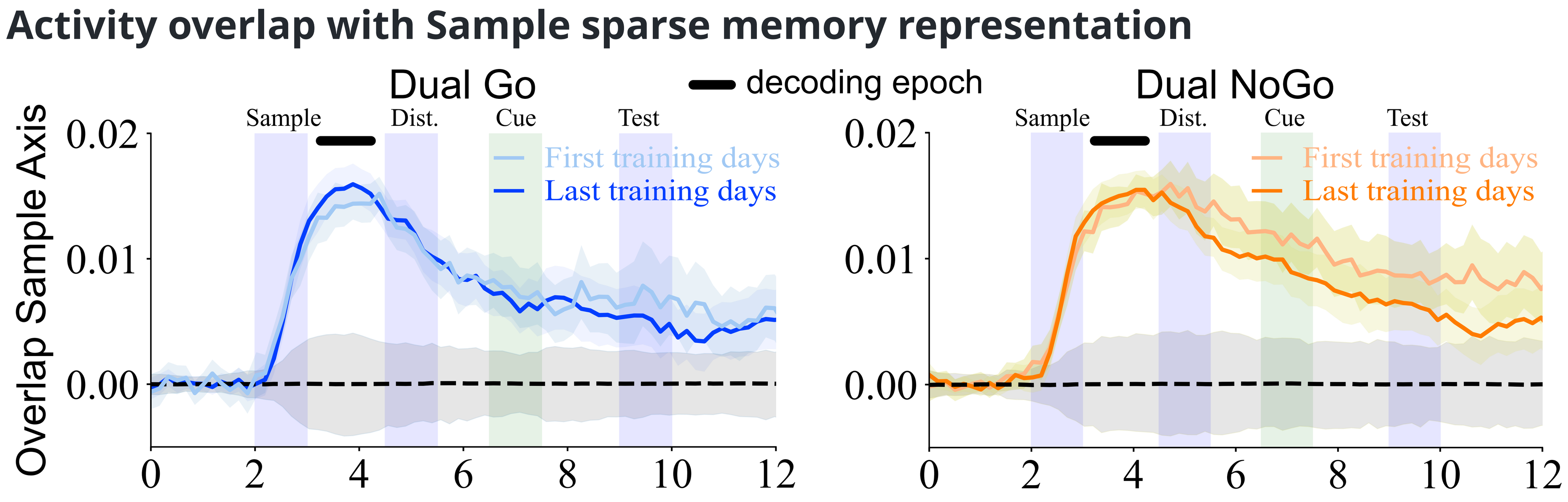
WM representations in the dual task

Sample and distractor memory representations in first and last training days



Early delay sample code is less stable in DRT rewarded (Dual Go) trials

Activity overlap with Sample sparse memory representation



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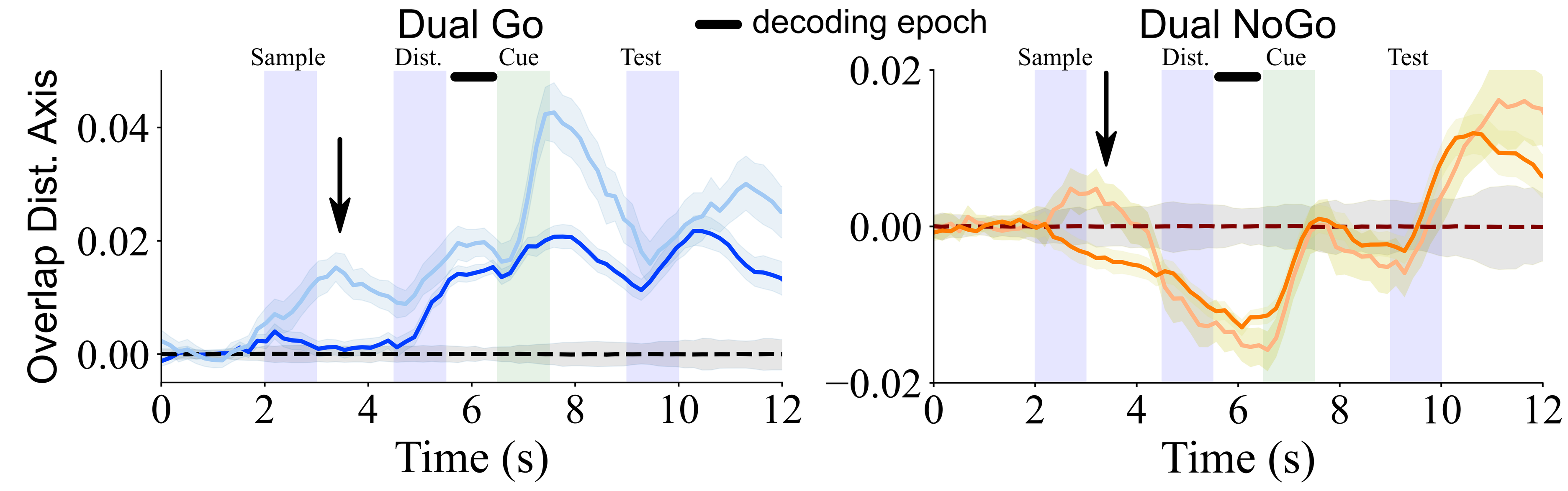
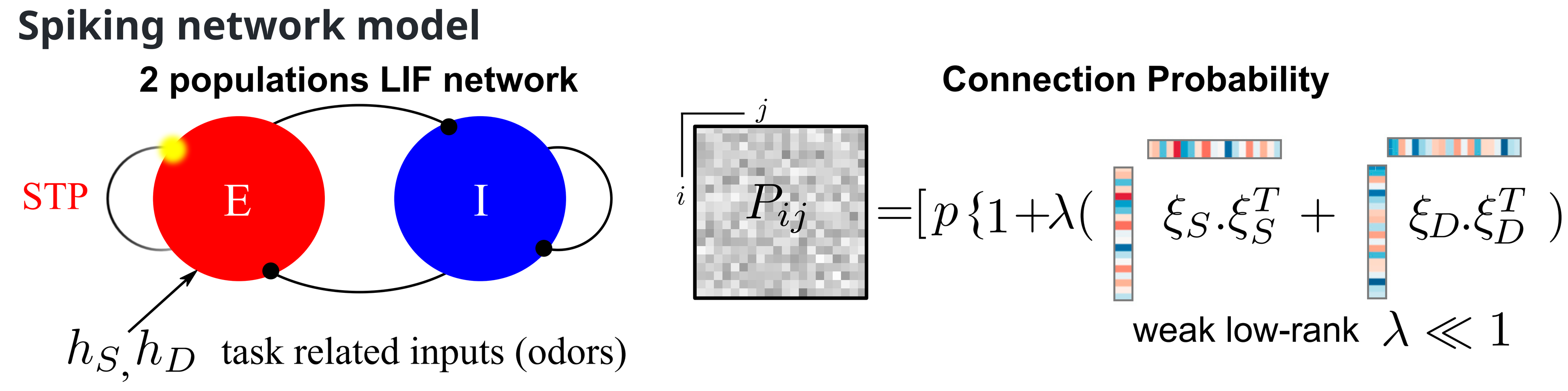
Activity overlap with Distractor sparse memory representation



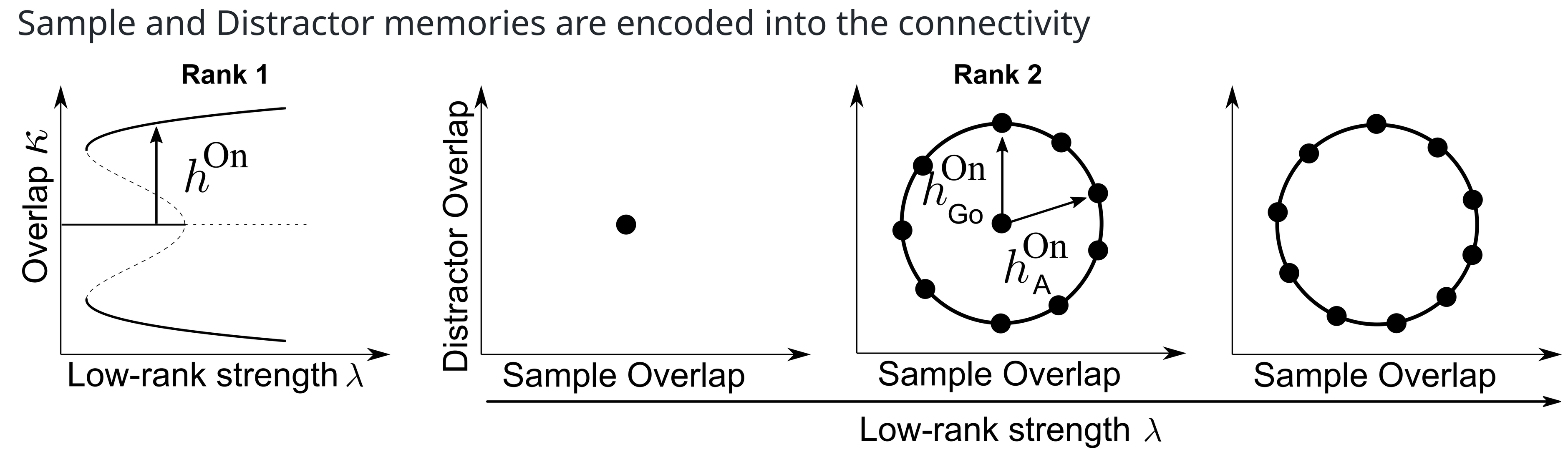
Samples elicit responses on distractor memory axis in early training

Linking WM to low rank connectivity

Spiking network model

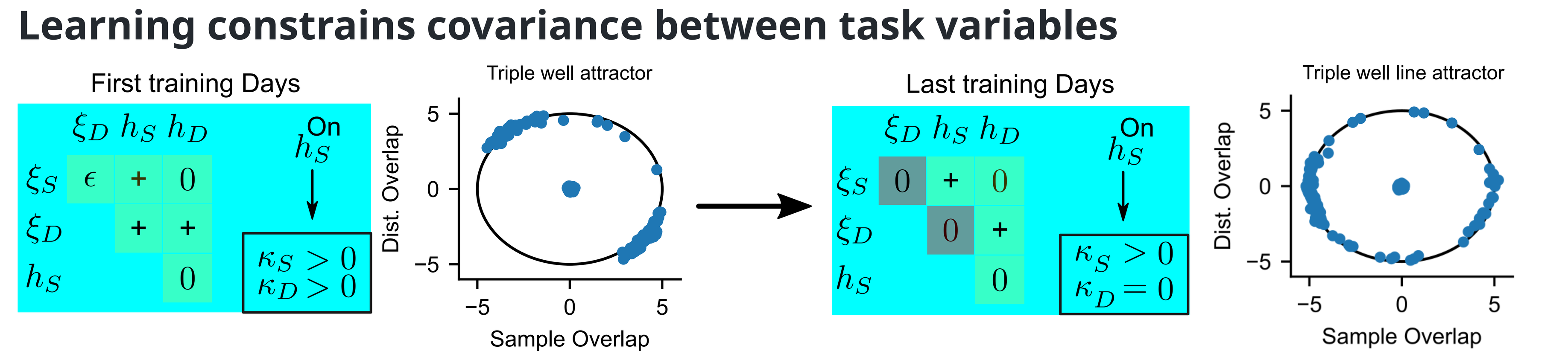


Sample and Distractor memories are encoded into the connectivity



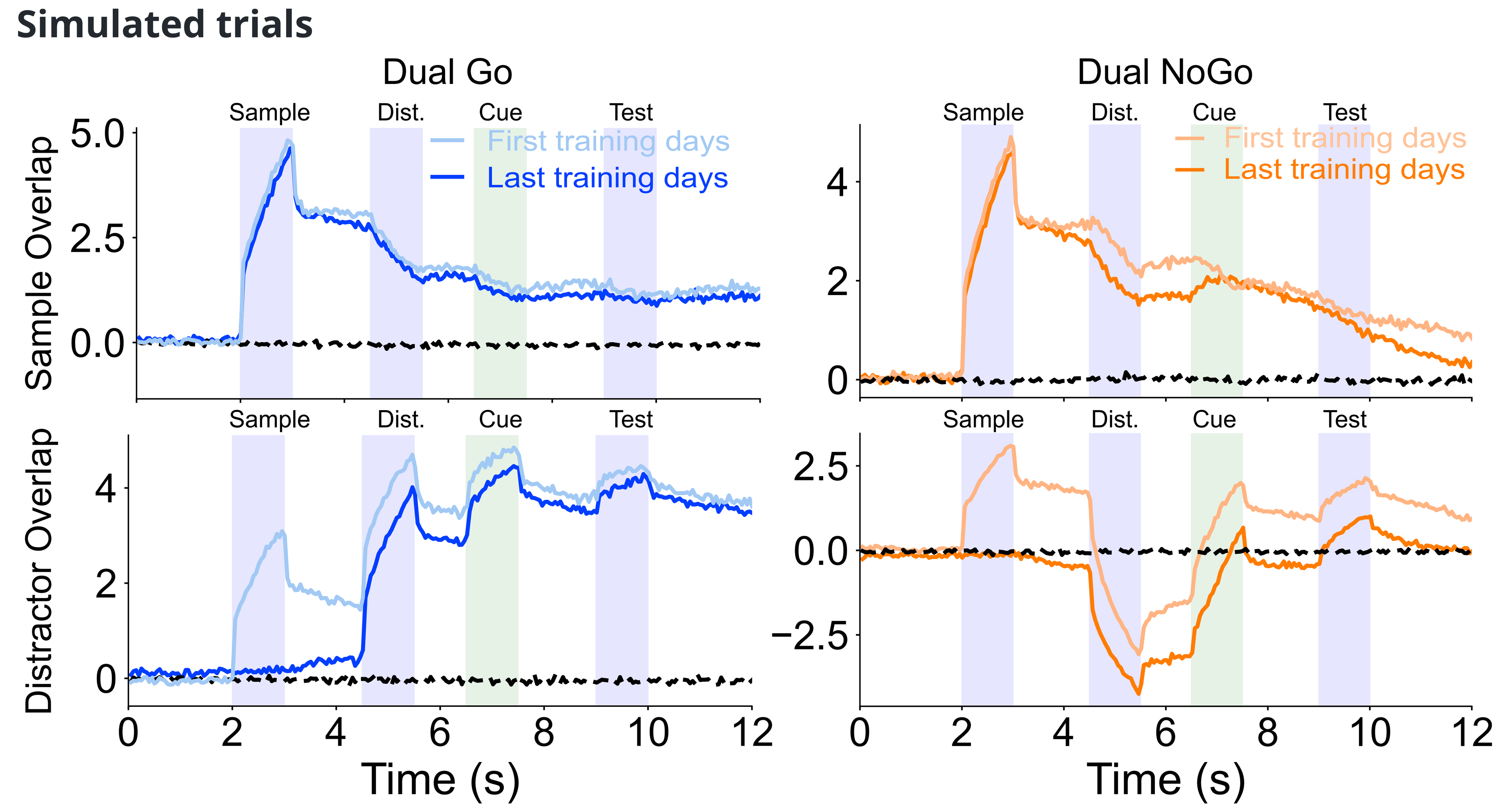
STP and Rank 2 structure leads to triple-well attractor dynamics

Learning constrains covariance between task variables

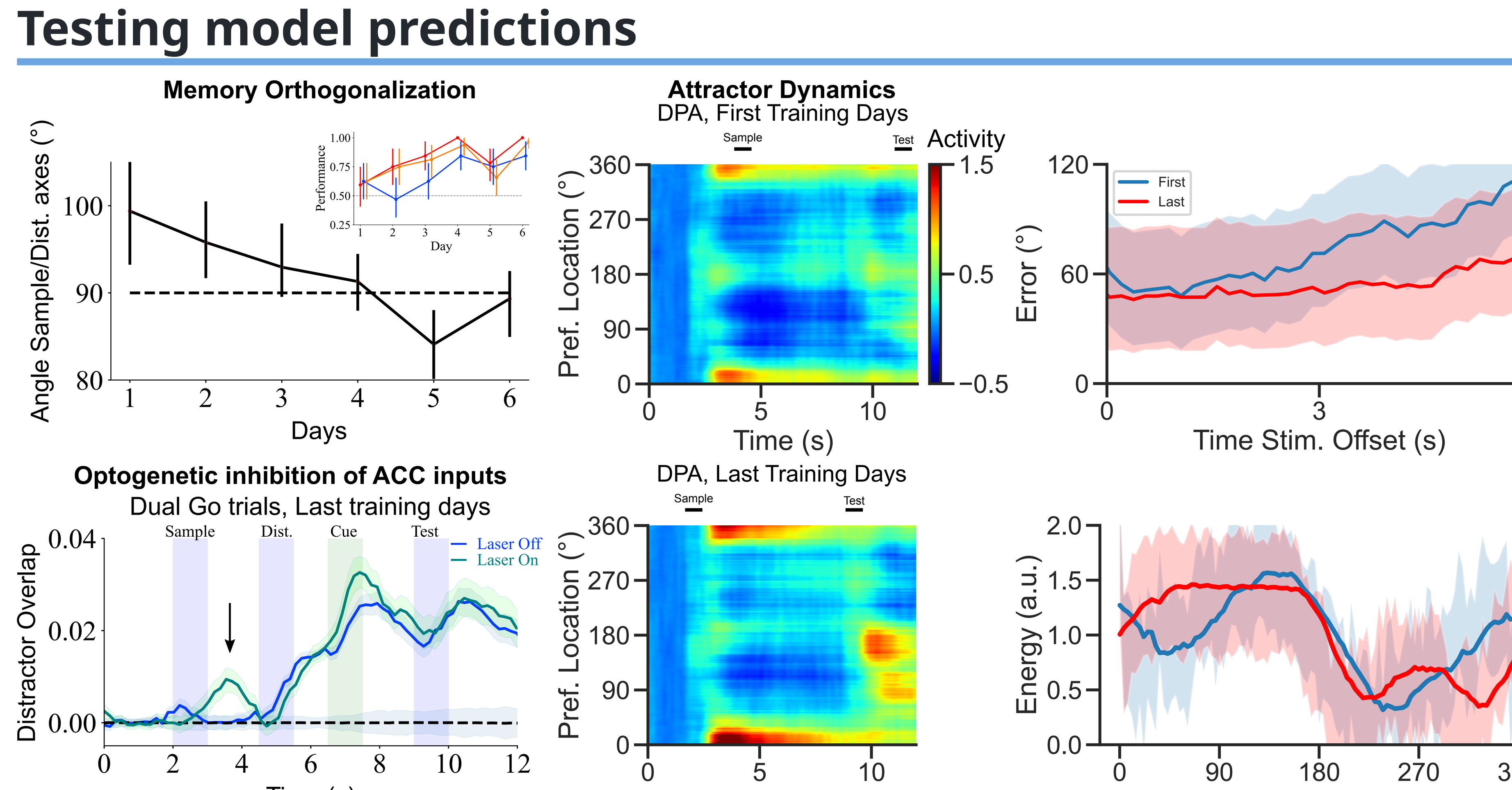


Predictions: orthogonal sample and distractor memories and stimuli and distractor memory

Simulated trials



Testing model predictions



Summary

Rotations of WM representations in PrL preserve WM from interference.
Learning leads to orthogonalization of distractor and sample and memory.
Low-rank attractor dynamics accounts for PrL's activity and its behavioral correlates.