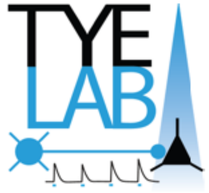
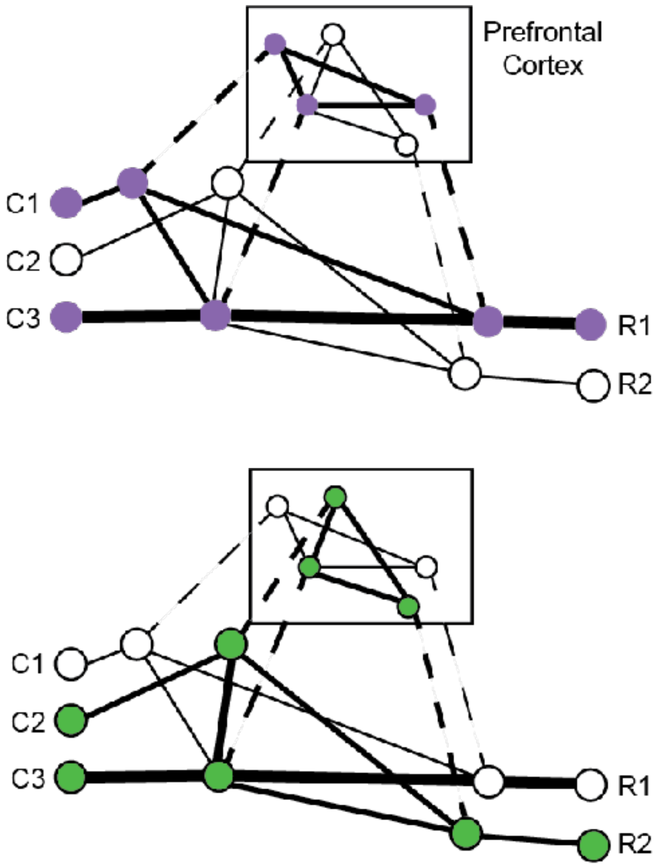
Modeling the prefrontal cortex as a lifelong learning system

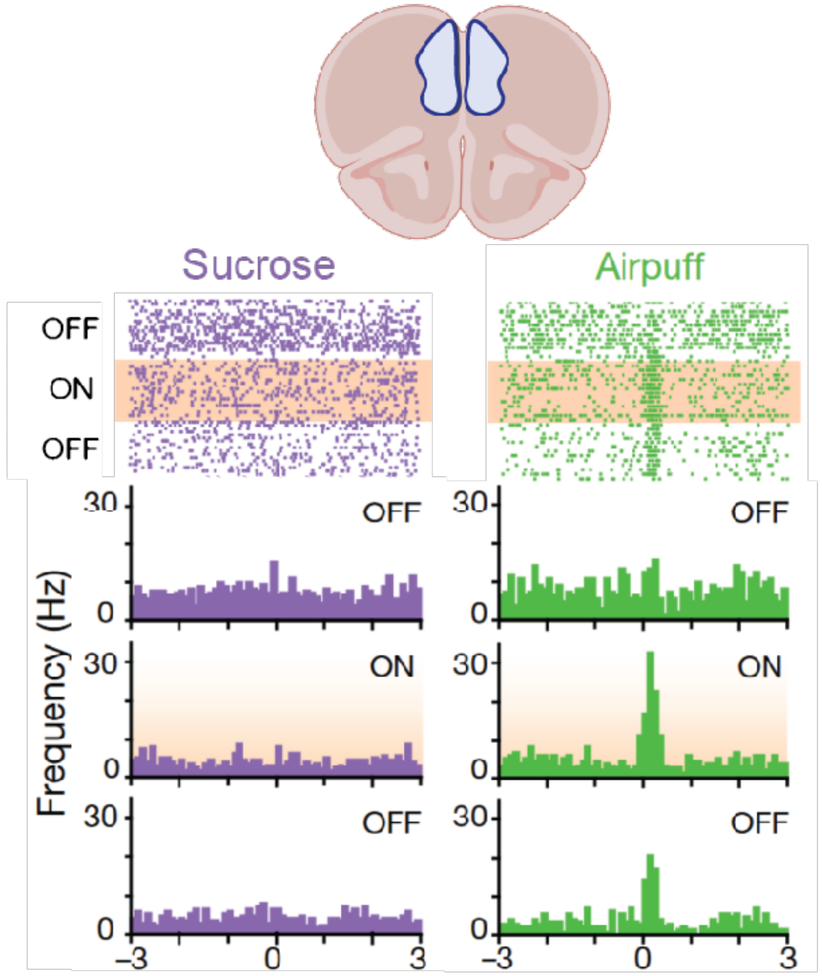
Presented by Clara Yi on the 25th of April 2024 for NICE ‘24



Contextual Processing in the Prefrontal Cortex



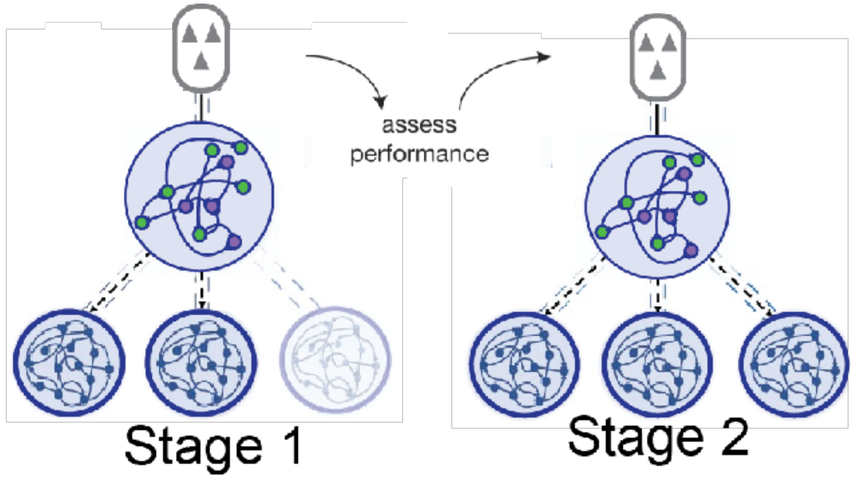
Miller and Cohen, Annual Review of Neuroscience (2001)



Vander Weele et al., Nature (2018)

Dynamic Mixture of Experts (DynaMoE)

Mixture of Experts with dynamic recruitment of new experts with gated transfer learning



Tsuda et al, PNAS (2020)

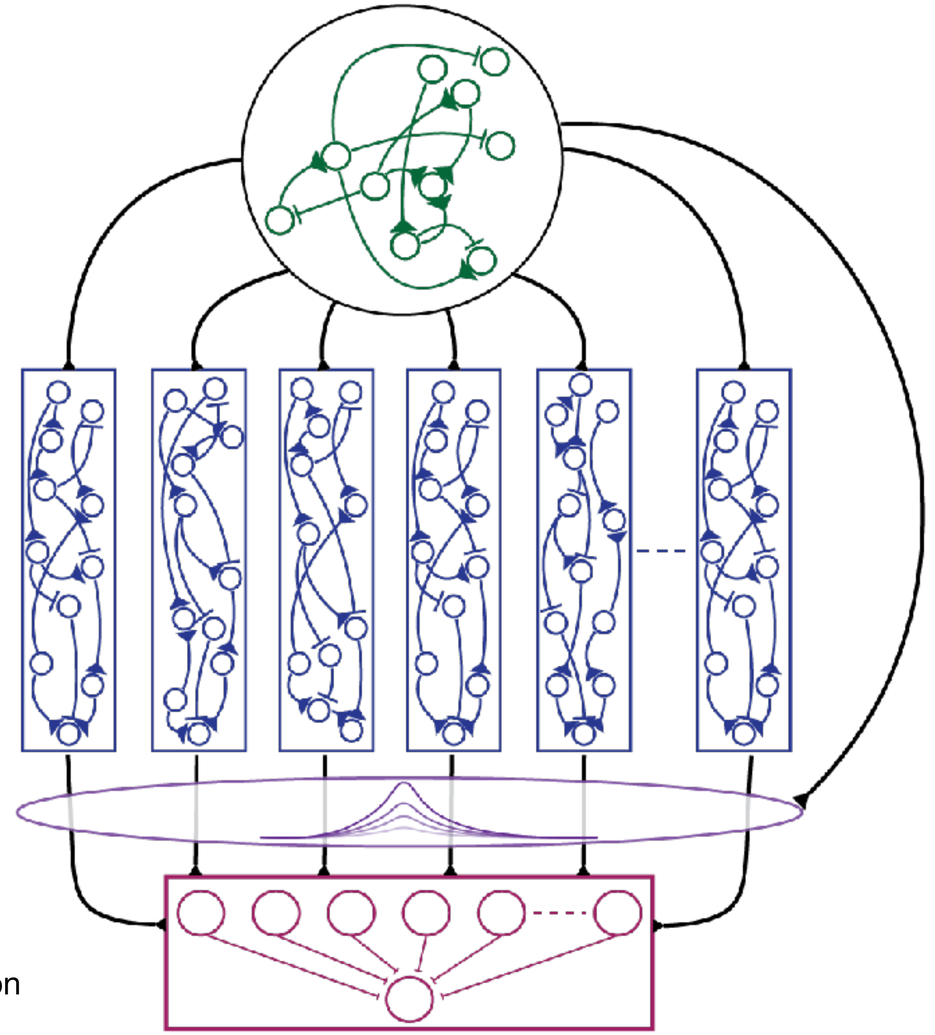
Neuromodulated Mixture of Experts

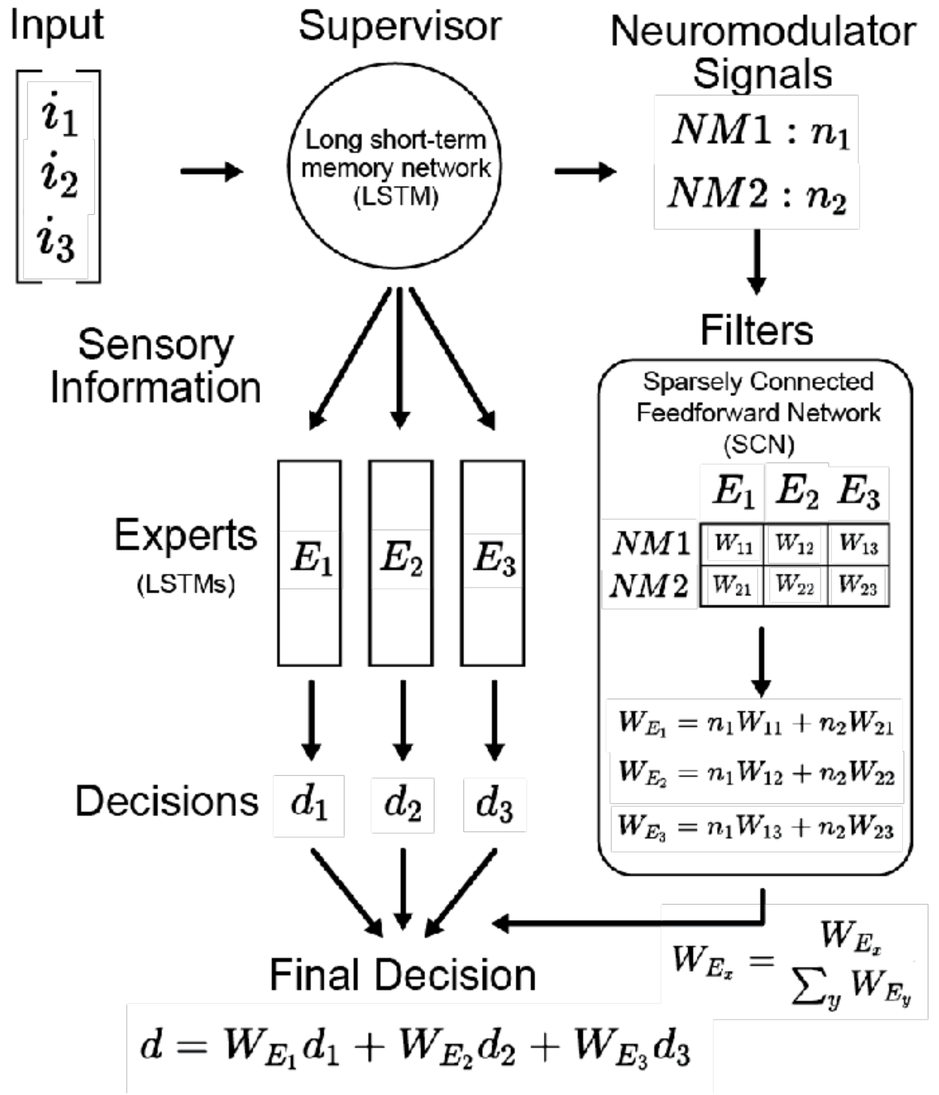
Supervisor Network

Expert Networks

Receptor Network

Inhibitory Action Selection



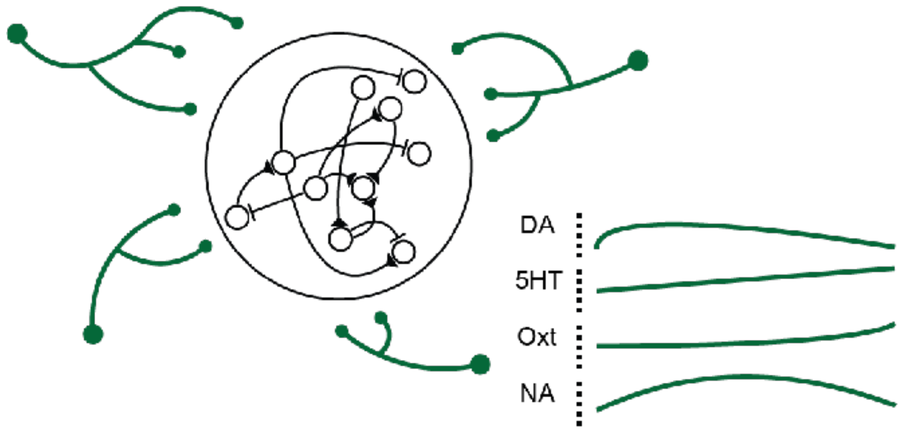


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

NeMoE Model Components

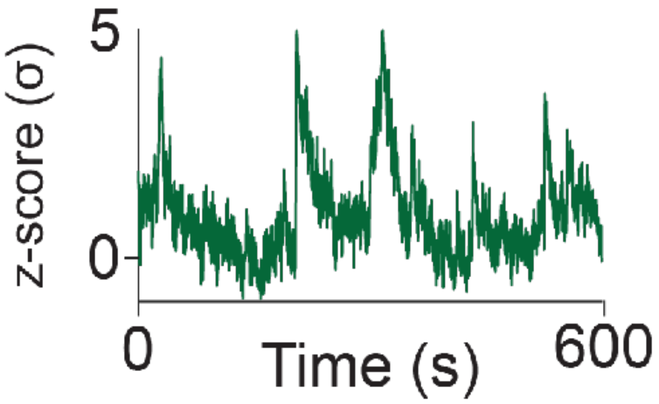
Computational

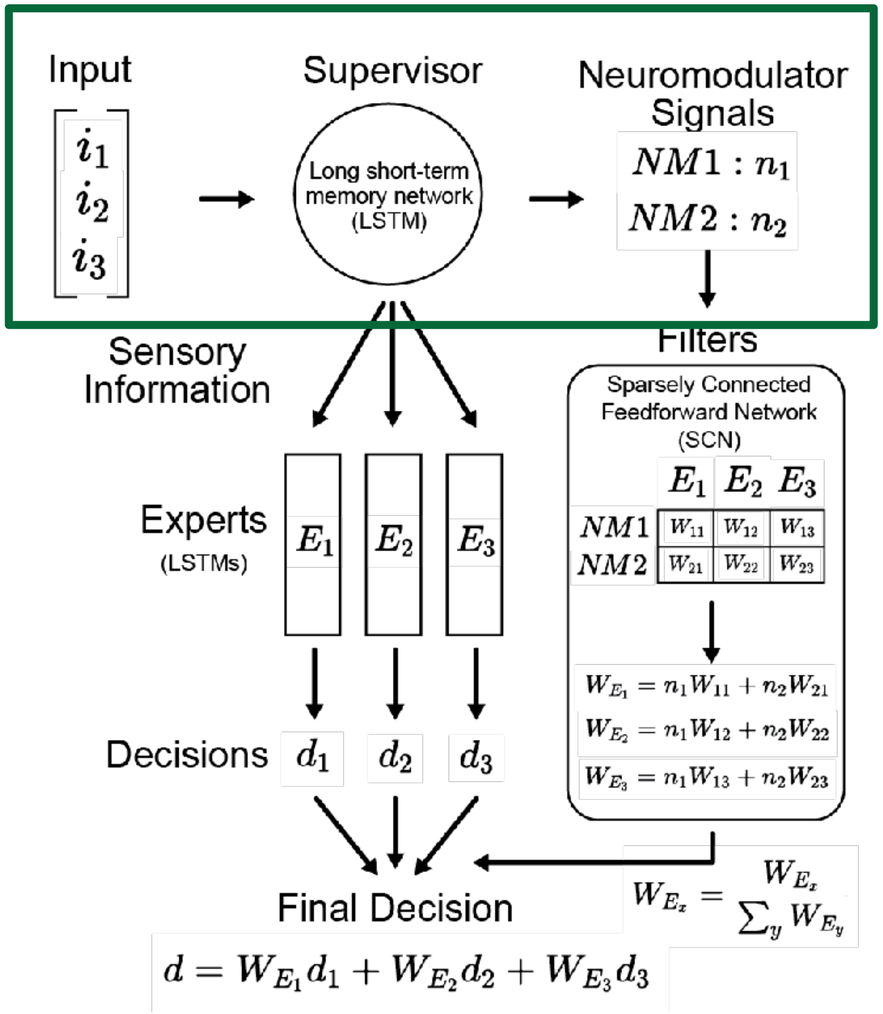
Supervisor Network



Biological

Neuromodulatory Signal



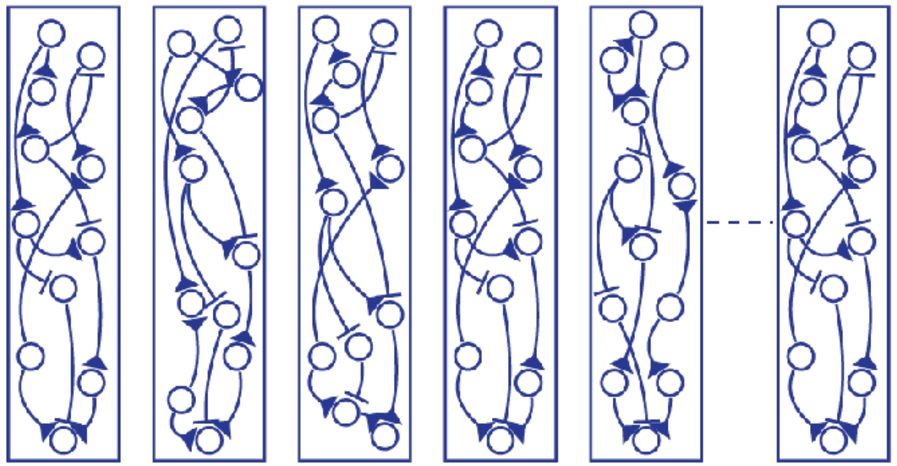


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

NeMoE Model Components

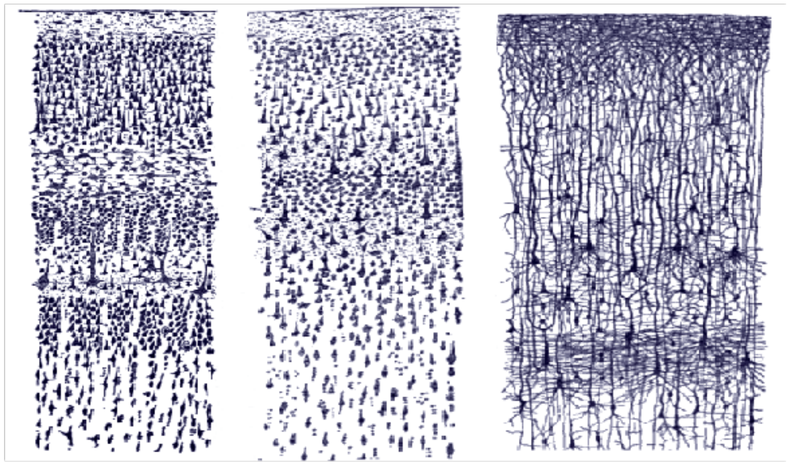
Computational

Expert Networks

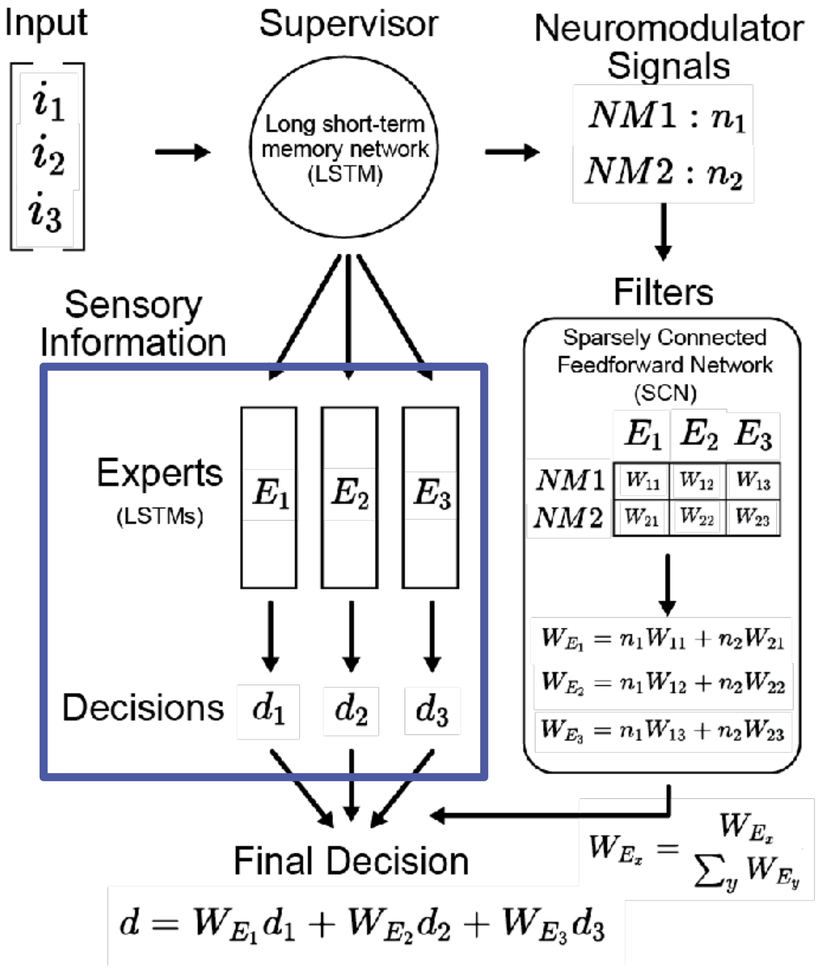


Biological

Cortical Columns



Cajal 1899

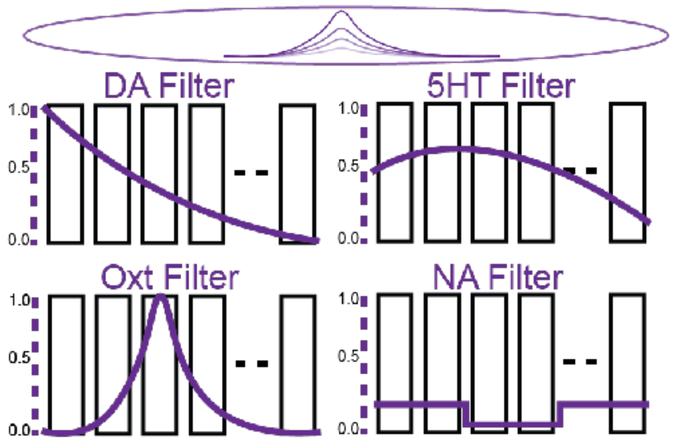


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

NeMoE Model Components

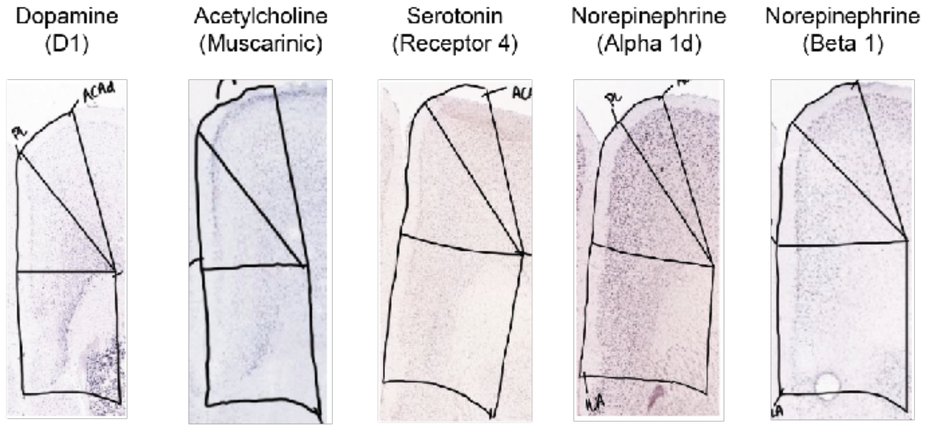
Computational

Receptor Network

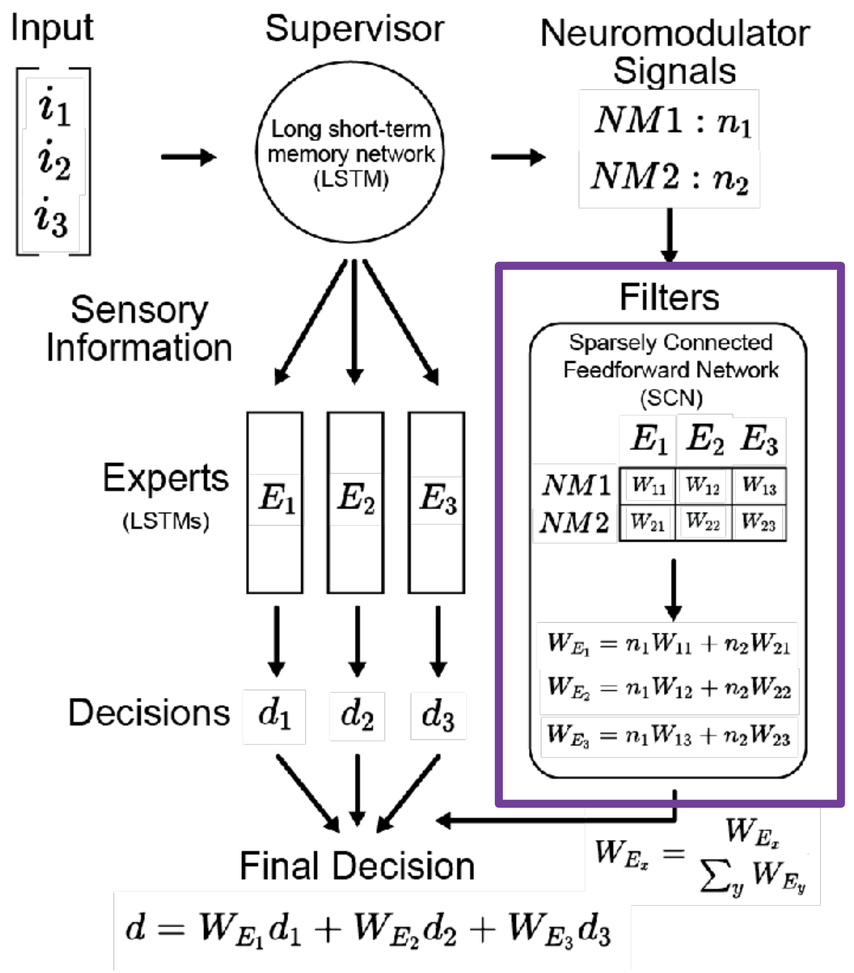


Biological

G-Protein Coupled Receptor Distributions



Allen Institute for Brain Science 2004

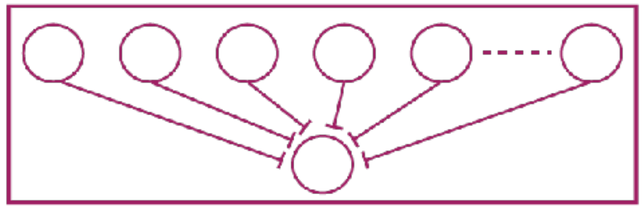


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

NeMoE Model Components

Computational

Inhibitory Action Selection

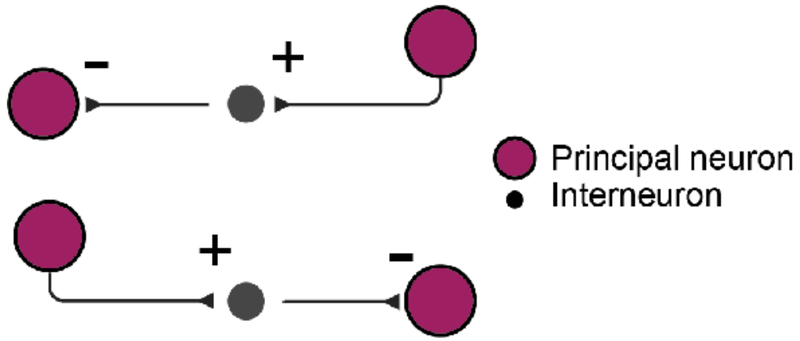


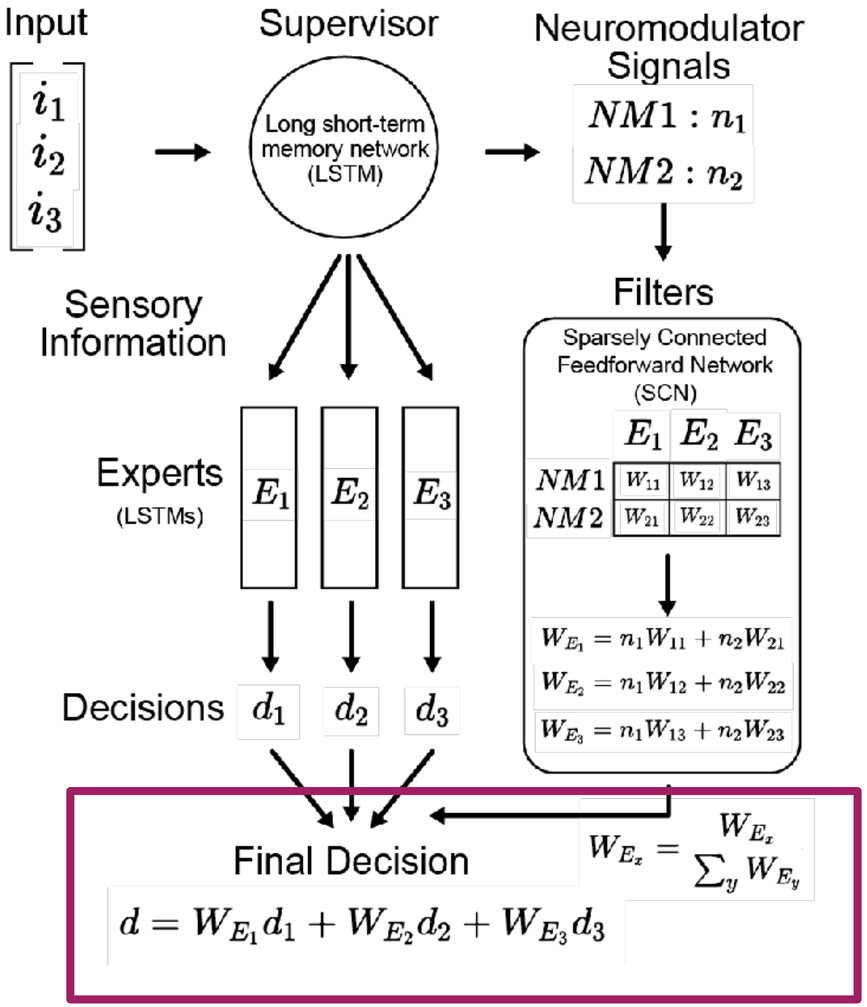
$$P = \sum_{i,j} W_{Ni_j} P_j$$

P_j = Policy of jth expert
N_i = ith Neuromodulator
W = Weight Matrix

Biological

Mutual Inhibition Circuit



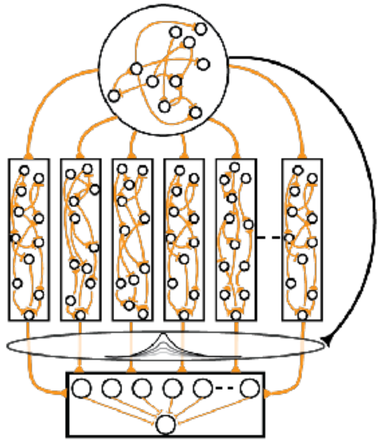


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

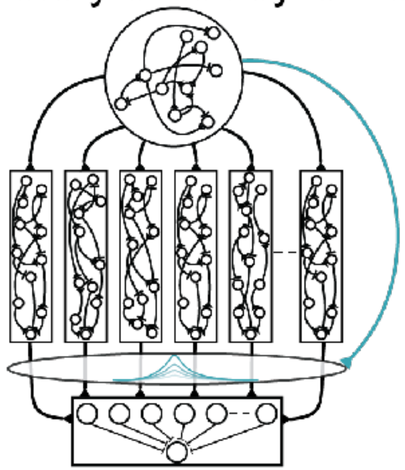
NeMoE Model Components

Computational

Micro-circuit dynamics: Rapid

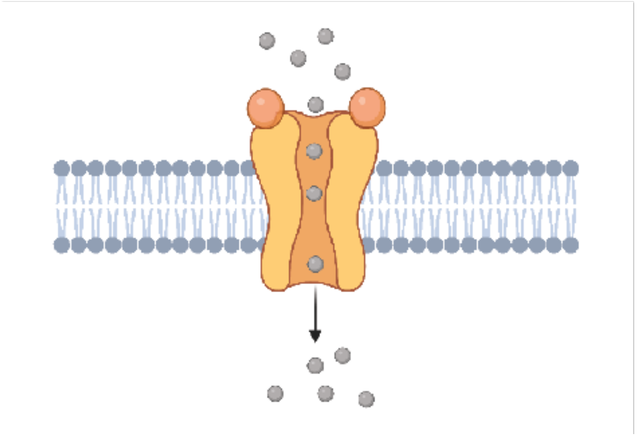


Neuromodulatory-circuit dynamics: Slow

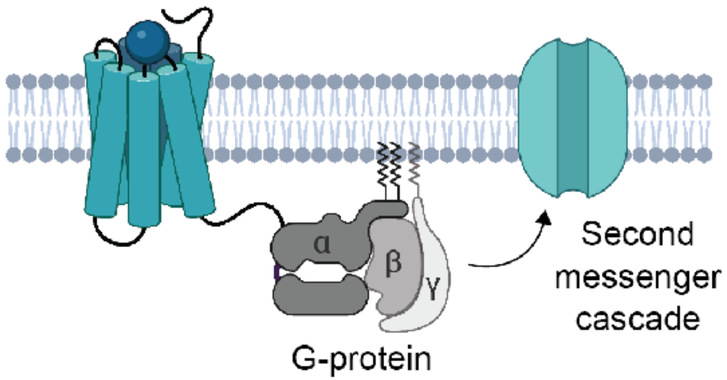


Biological

Ligand-gated Ionic Channel

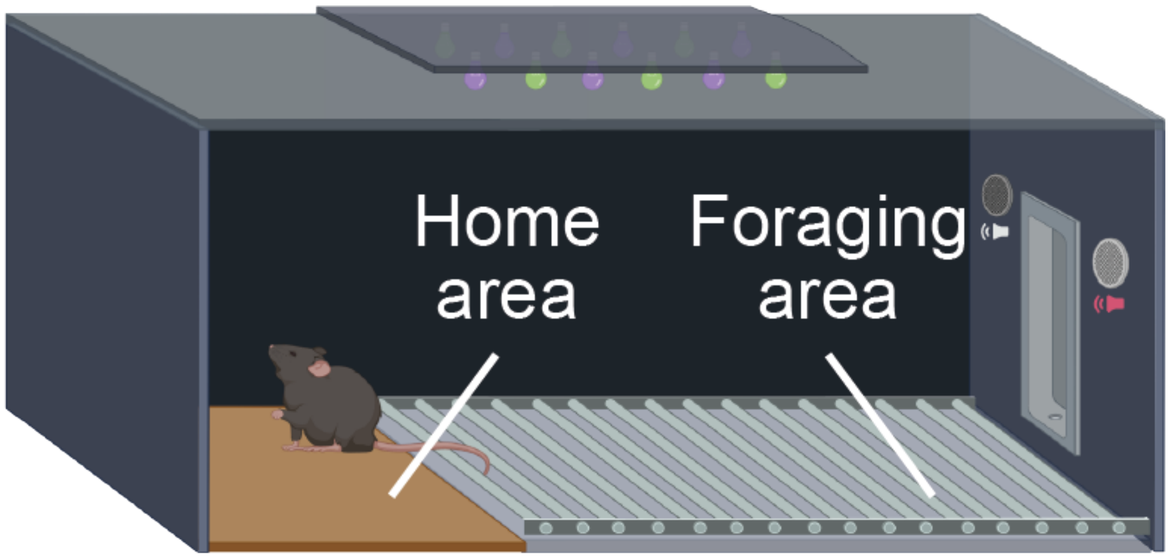


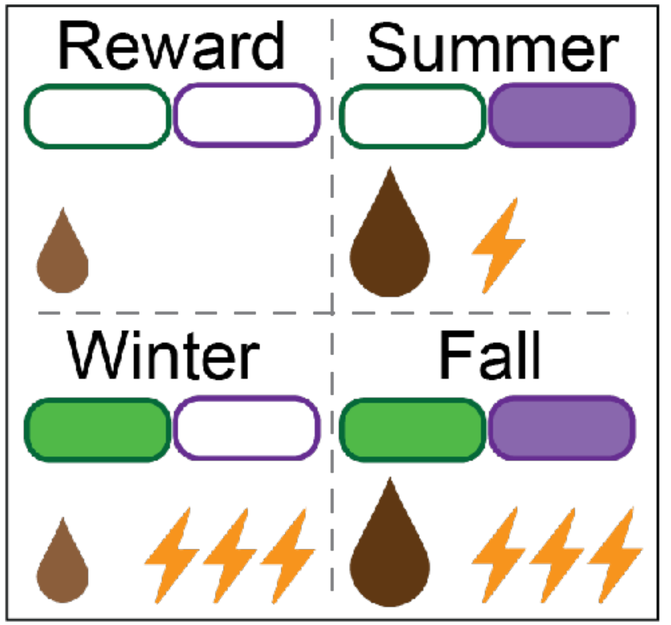
Metabotropic Channel

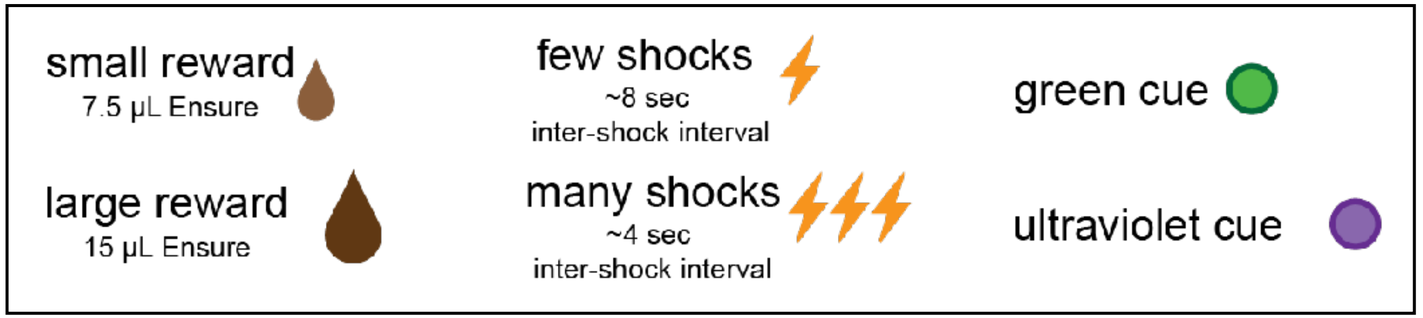


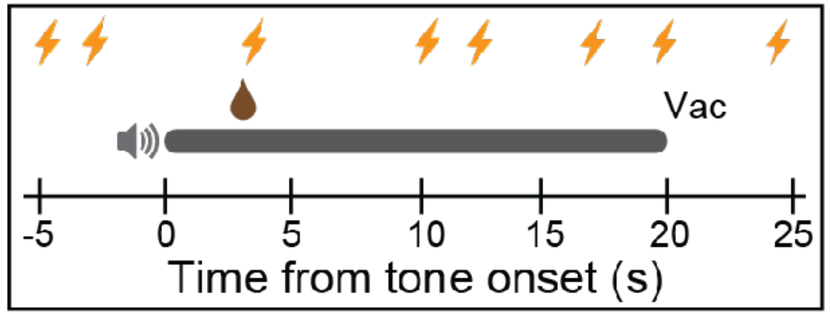
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

Multi-context foraging reveals adaptive behavioral strategies









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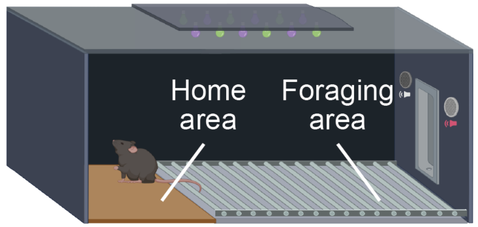
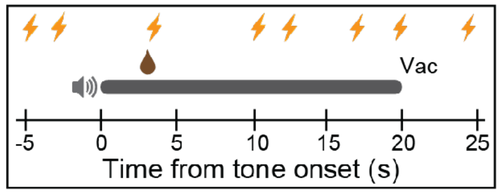
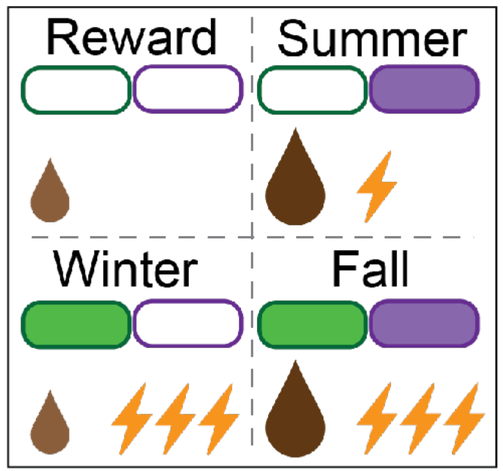
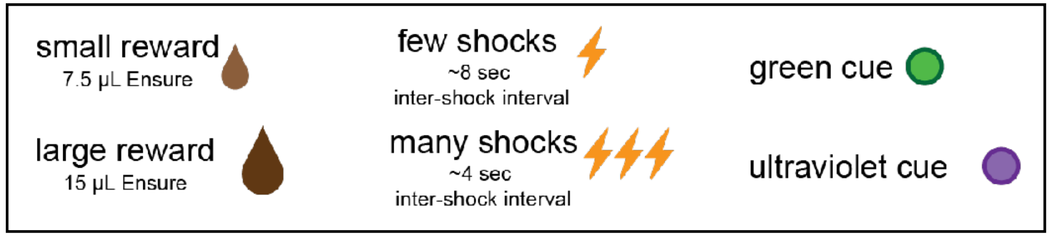
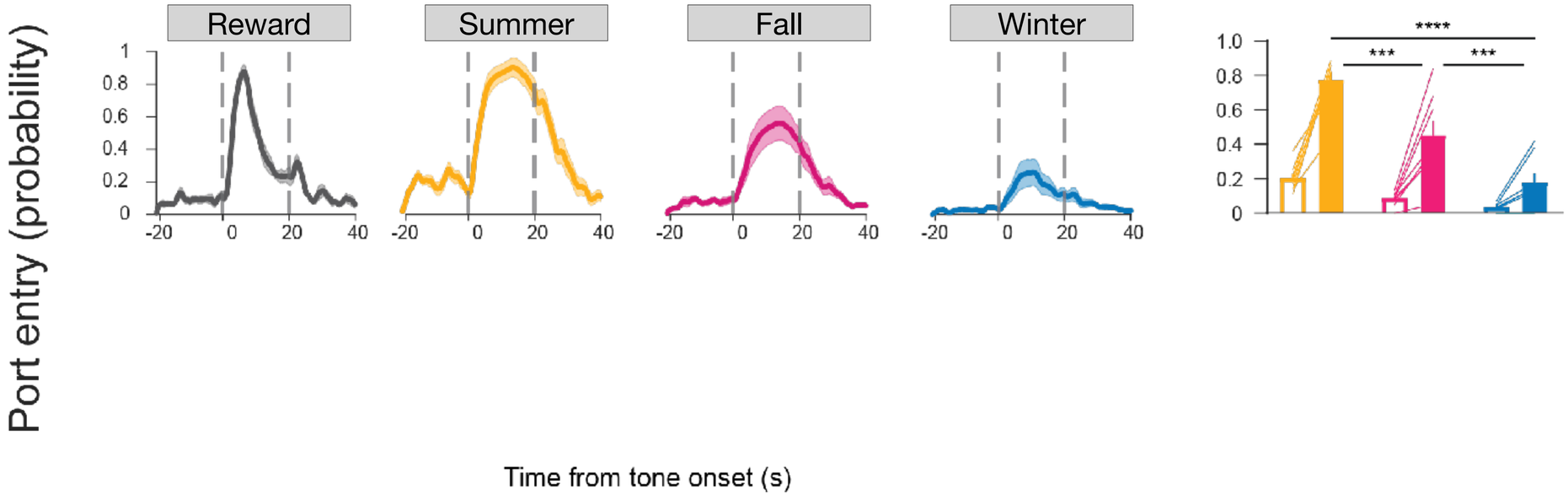
Multi-context foraging reveals adaptive behavioral strategies





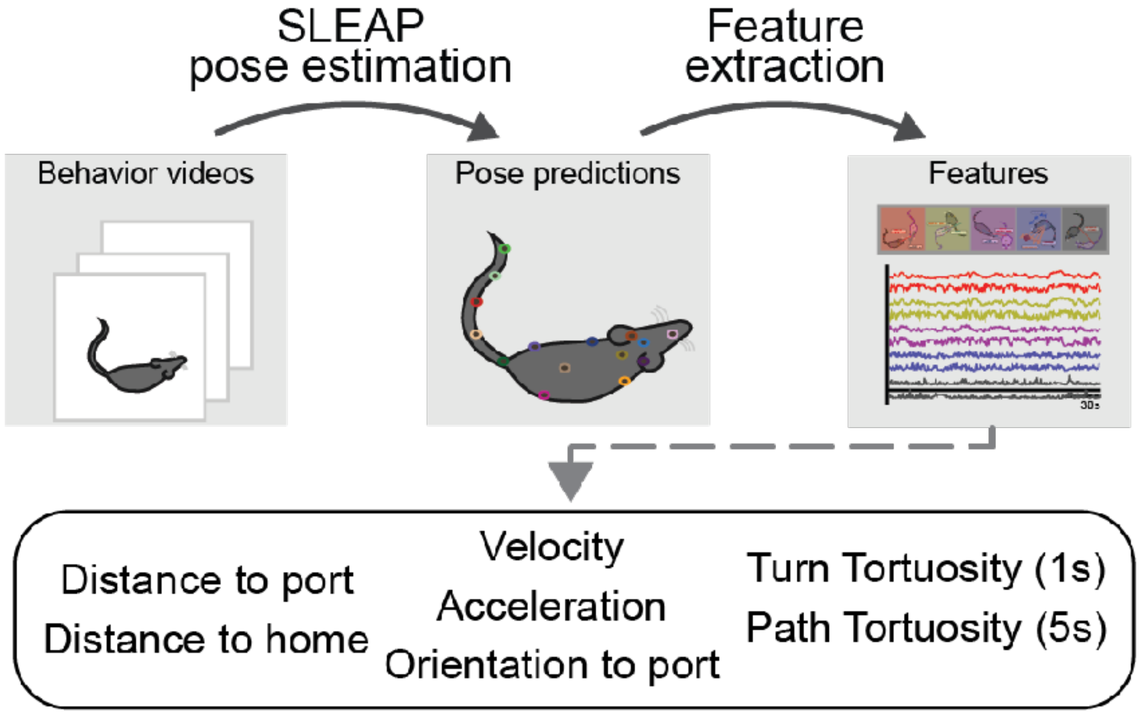


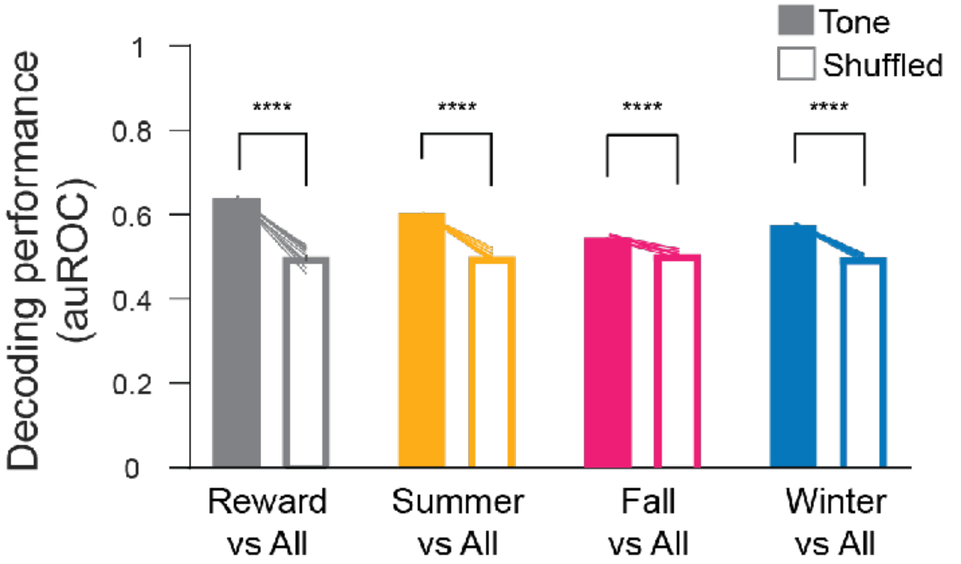


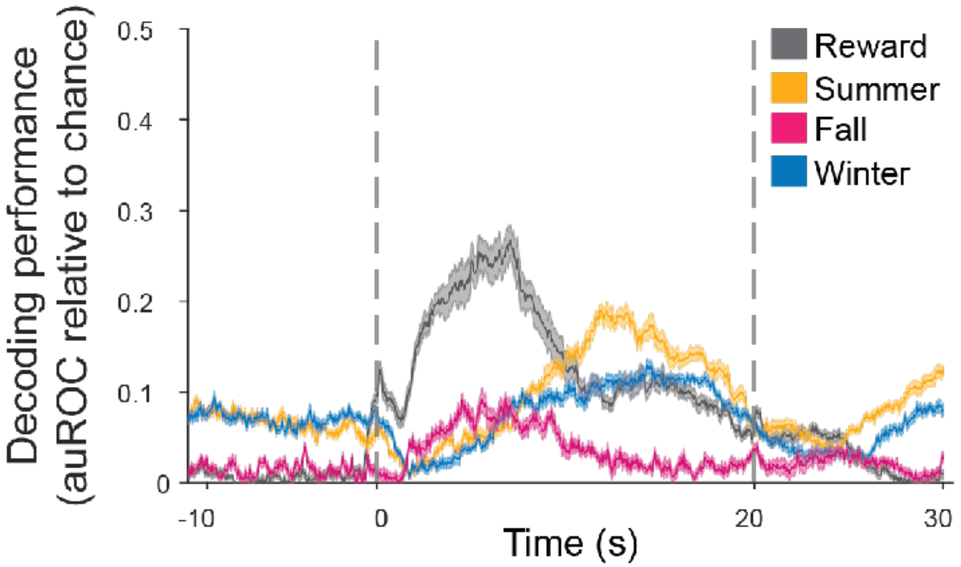


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

Using behavioral features to predict context

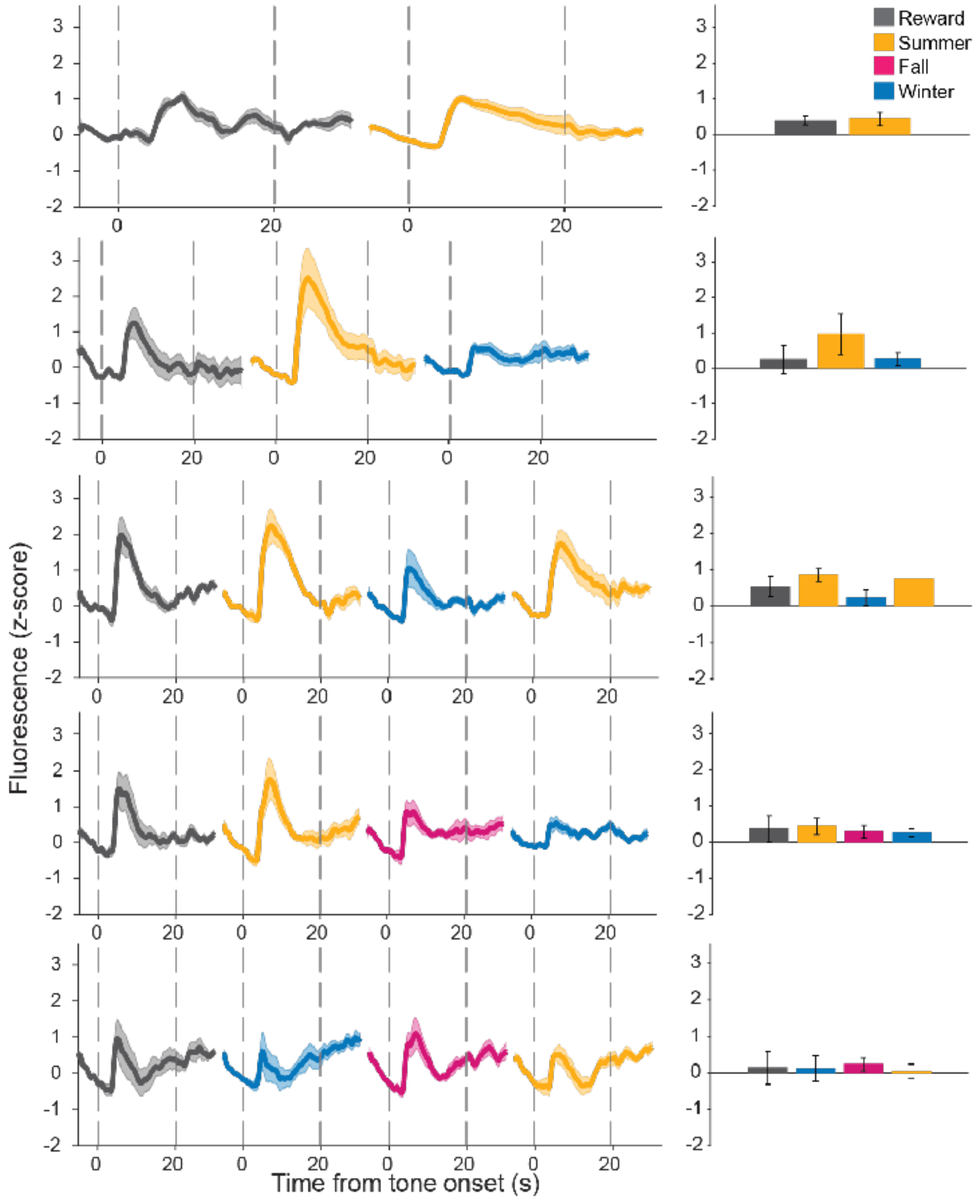


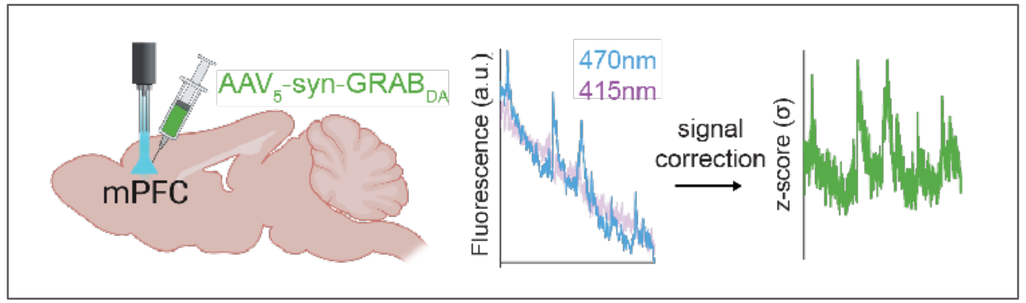


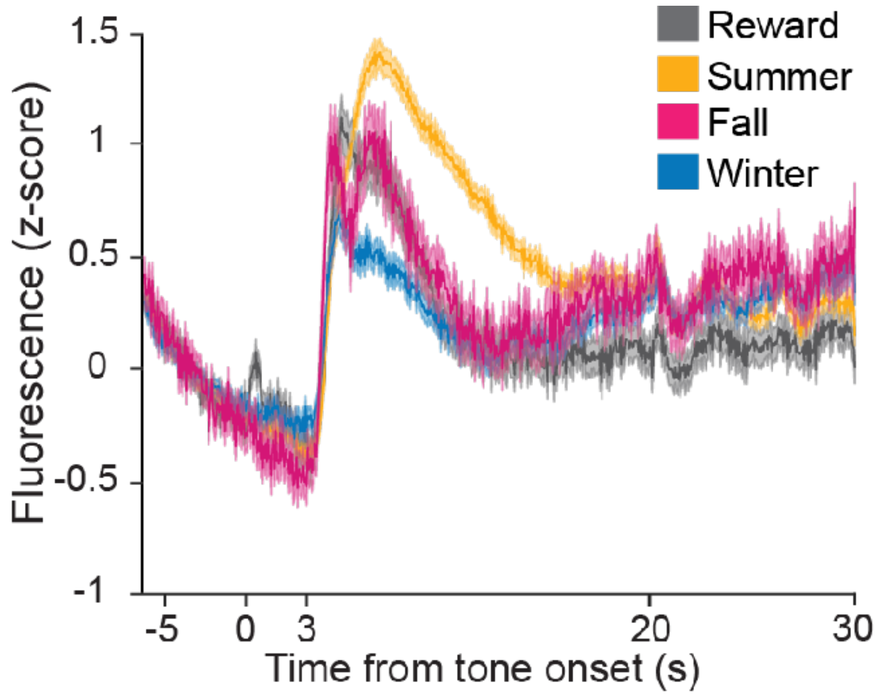


Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

Prefrontal dopamine encodes contextual information

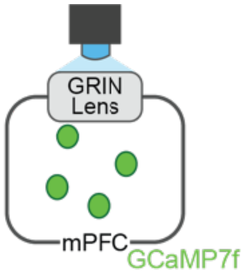


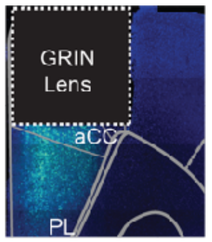


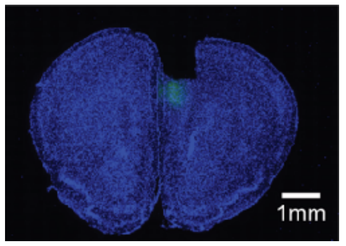


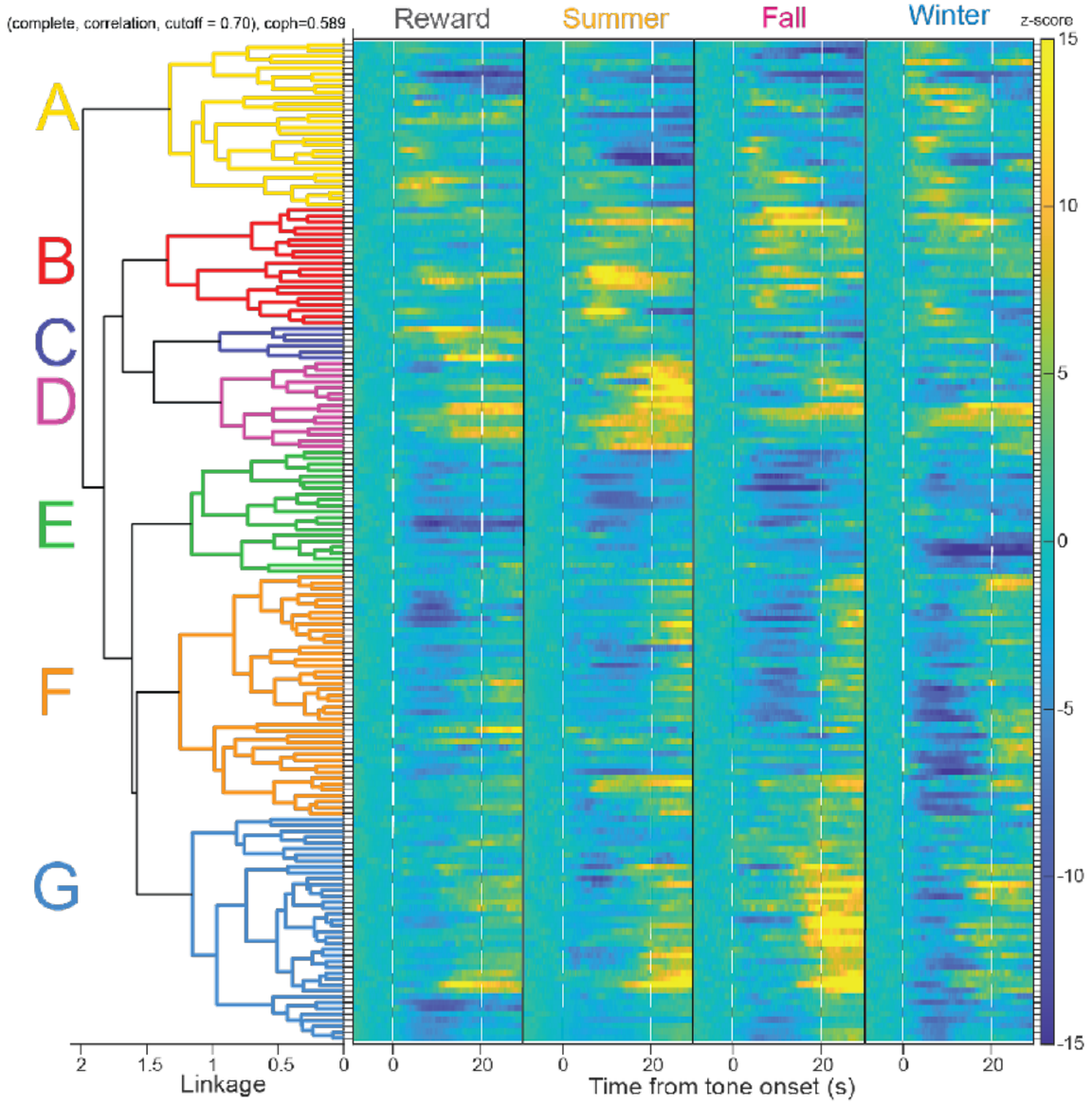
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

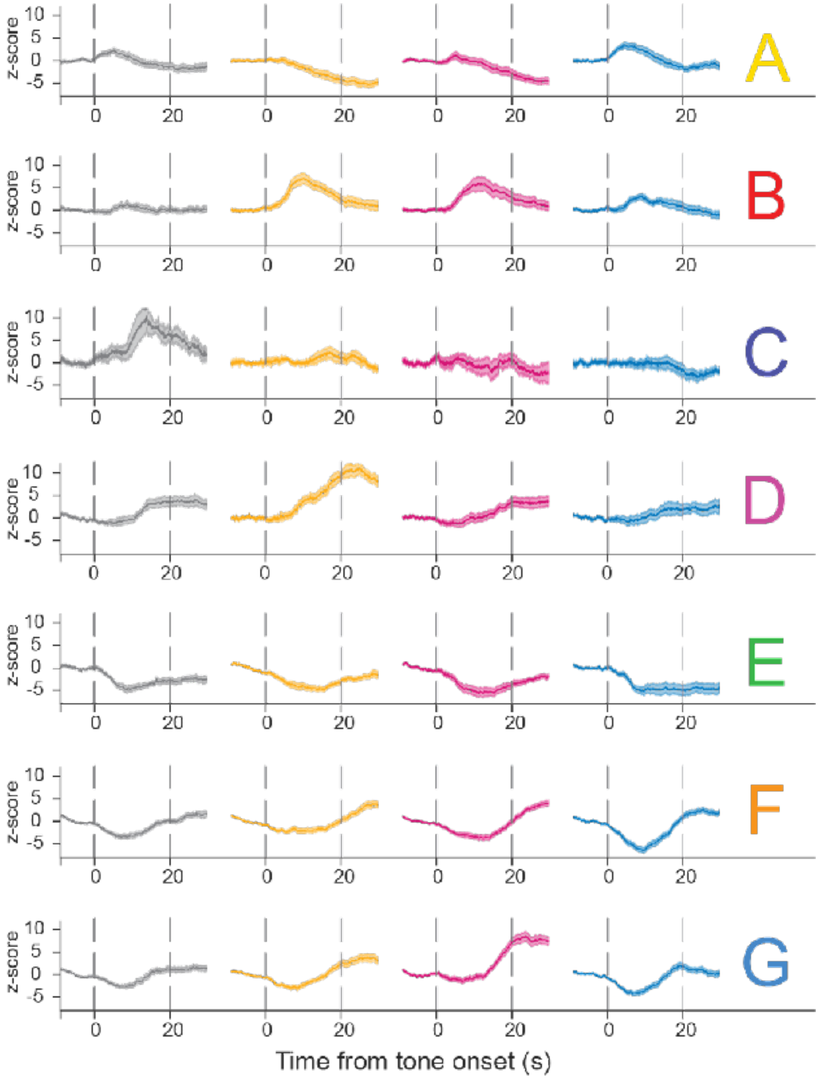
Prefrontal calcium distinguishes neural ensembles









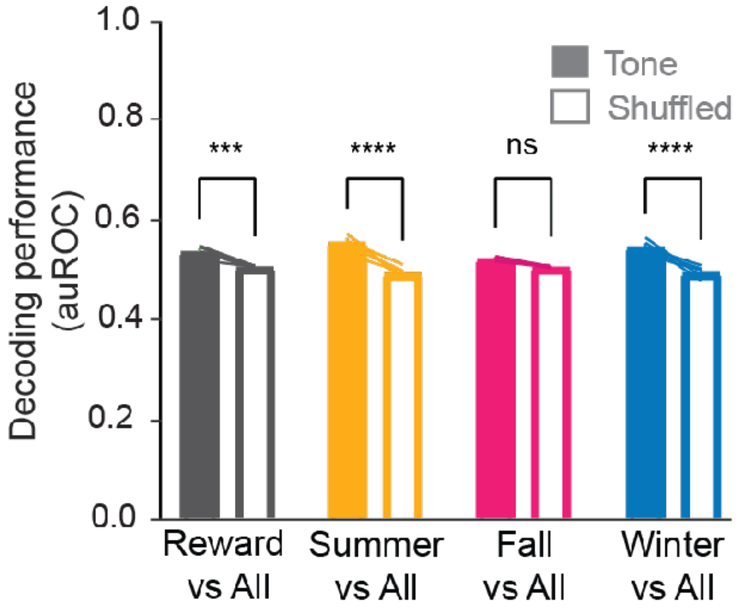


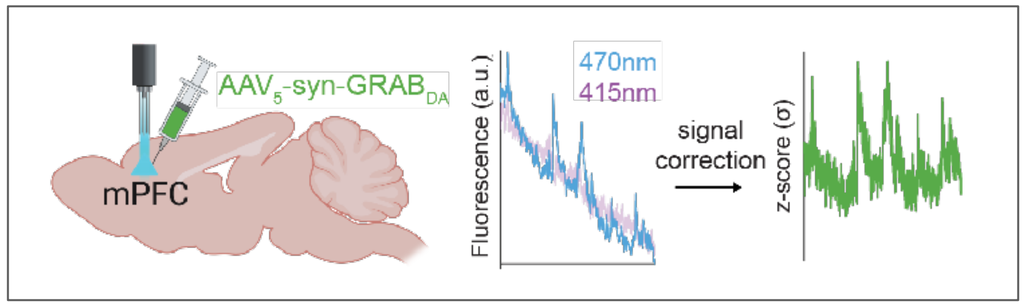
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

Prefrontal calcium distinguishes neural ensembles

Dopamine Biosensor

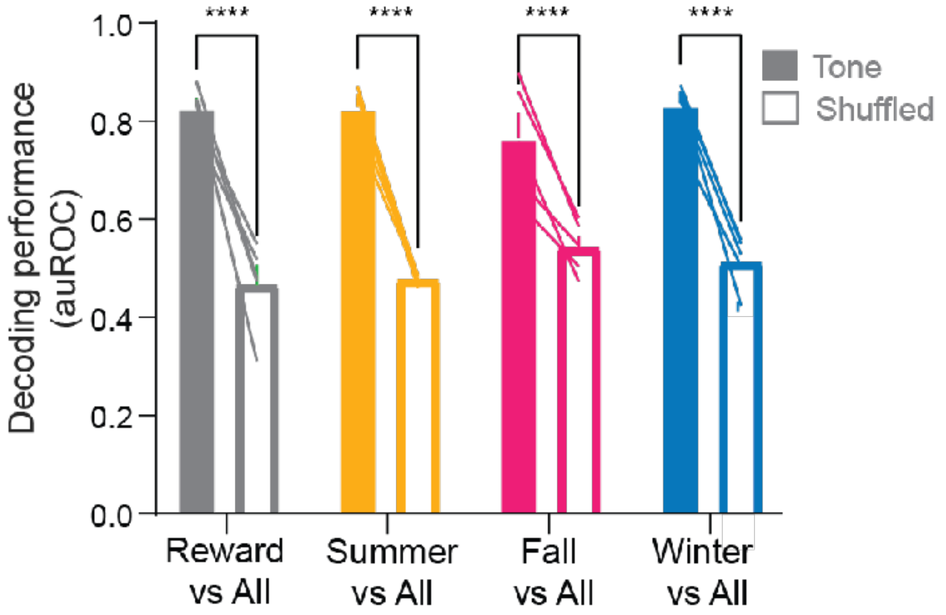
Decoding Performance

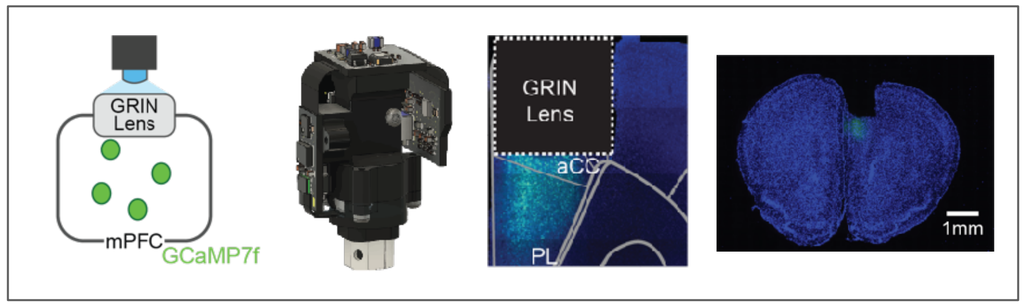




Calcium Imaging

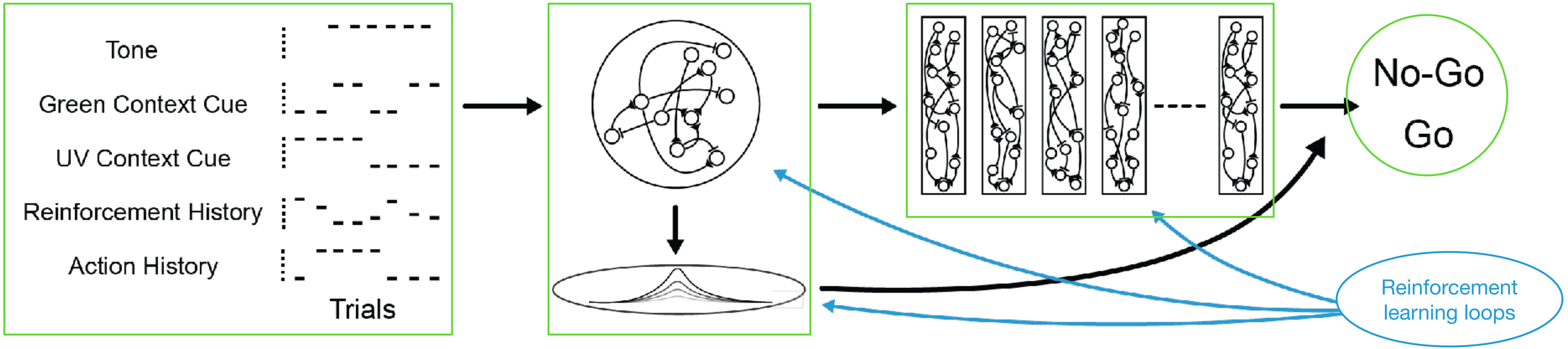
Decoding Performance





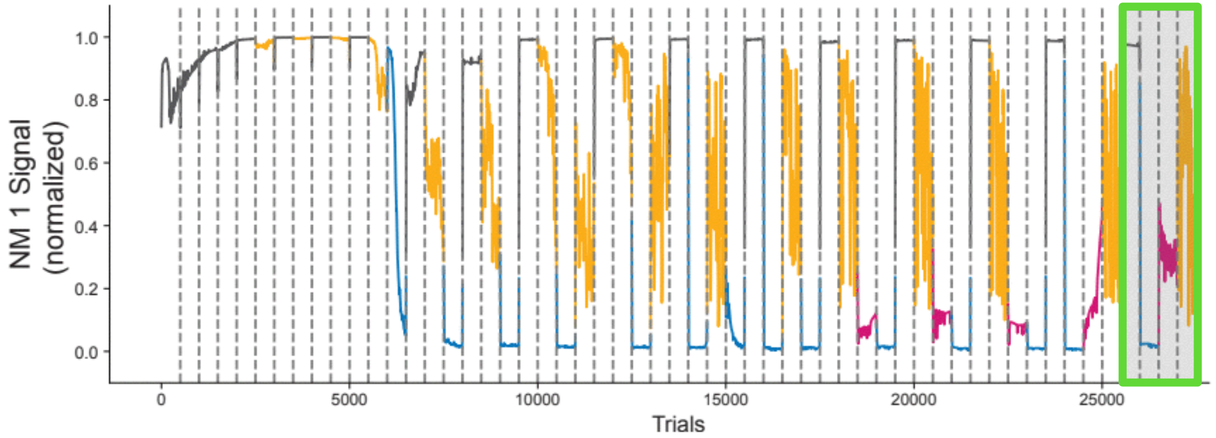
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

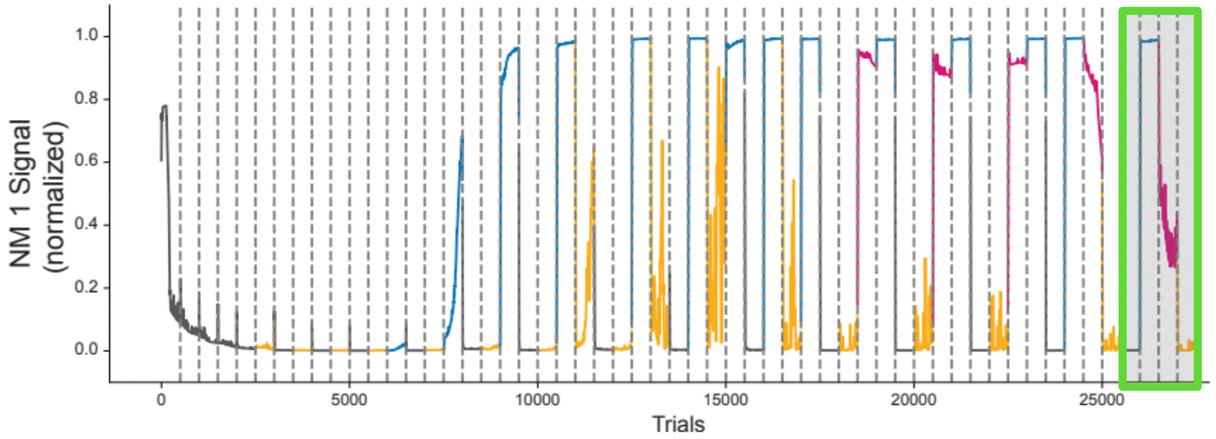
NeMoE modeled by deep reinforcement learning simulation

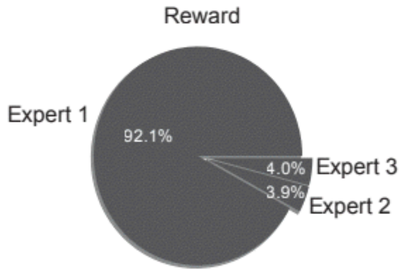


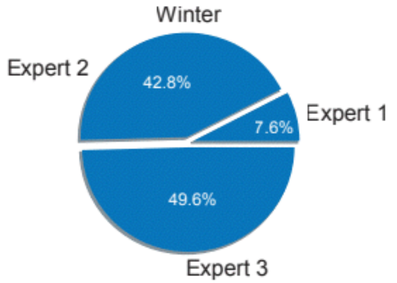
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

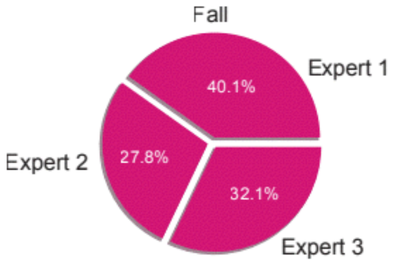
Deep RL Simulation







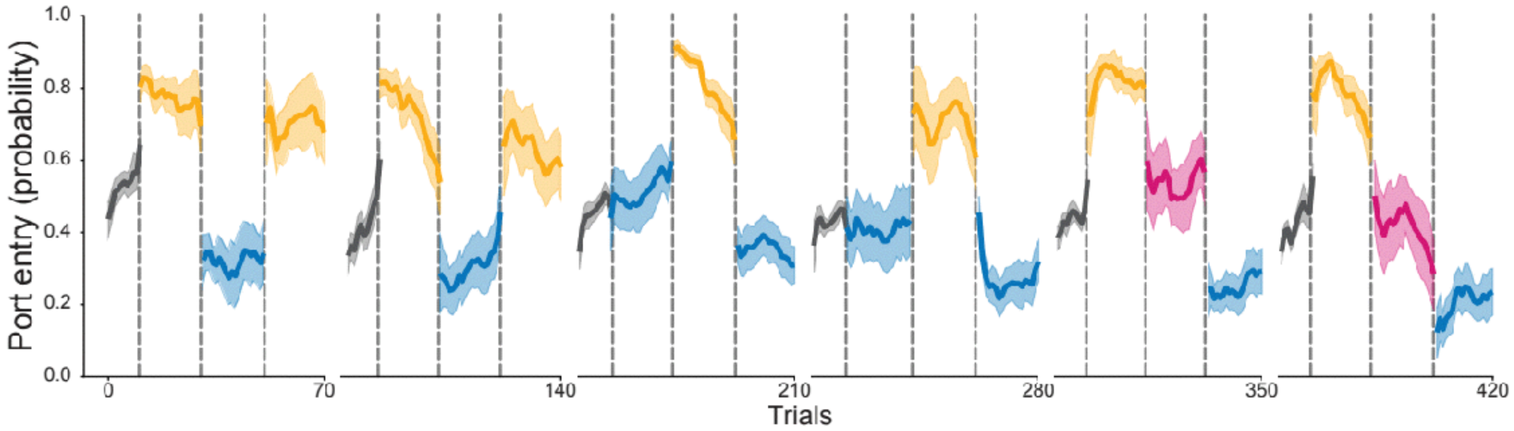




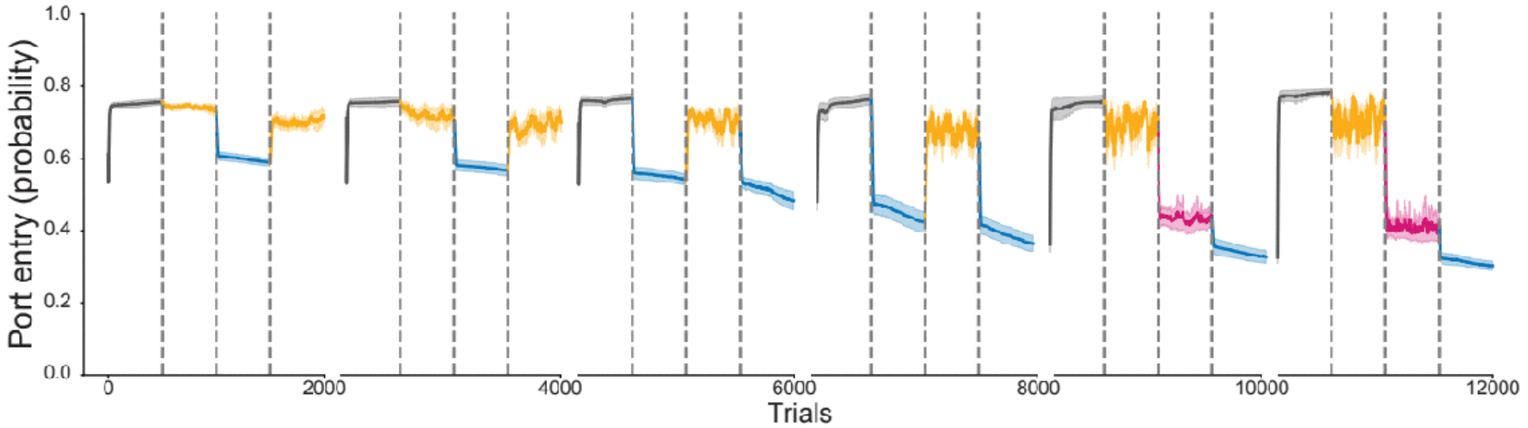
Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

Deep RL Simulation probability mimics real behavior

Behavioral Data



Simulation Data



Batra, Bakhti-Suroosh et al., (Unpublished data from the Tye Lab)

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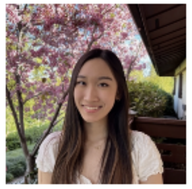

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