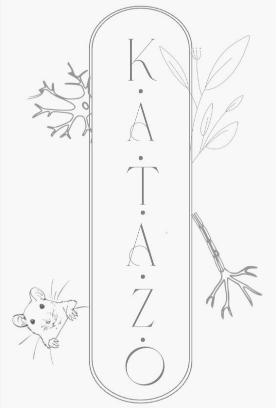
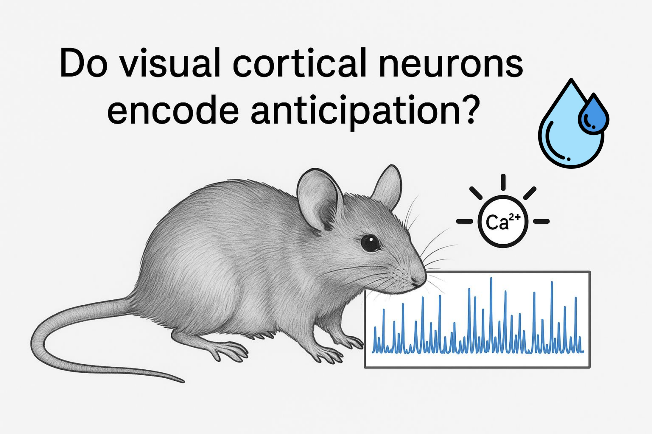
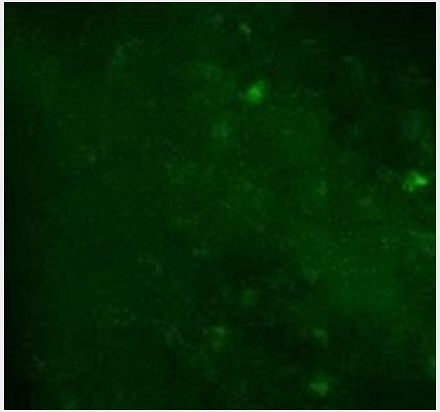
Visual Regions *might* Encode for Anticipatory States in Mice

Krithika Suresh, **A**renski Vazquez, **T**huan Nguyen, **A**rmando Abelho, **Z**ijun Wang, **O**scar Aguilar

Pod: Amaterasu TA: Dafne Soares pTA: Shirin Taghian Mentor: Aharon Ravia







Background:

- Anticipatory states are well-studied in higher-order cortical regions but less so in sensory regions such as the visual cortex
- Anticipation can influence an animal's ability to discriminate similar stimuli

Hypothesis:

- The visual cortex encodes anticipatory states, even without explicit external cues

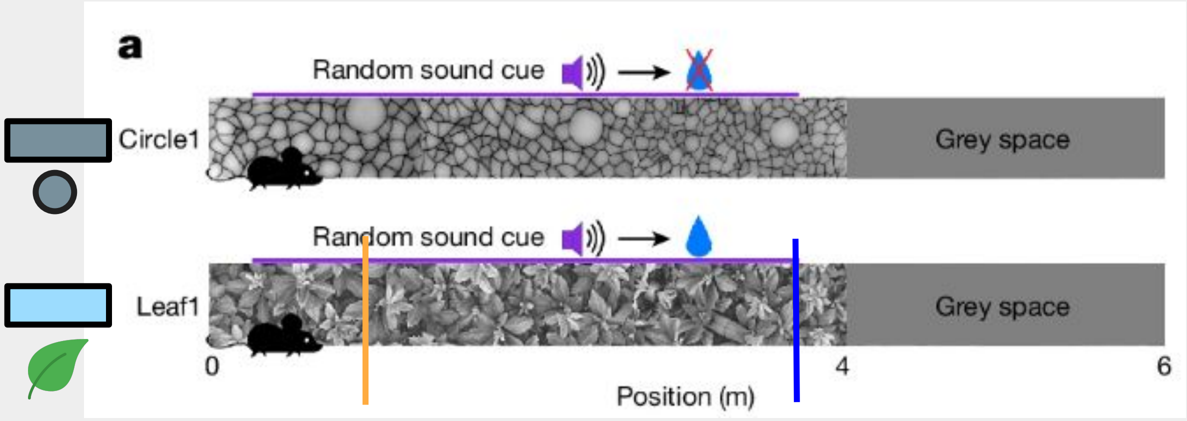
Relevance:

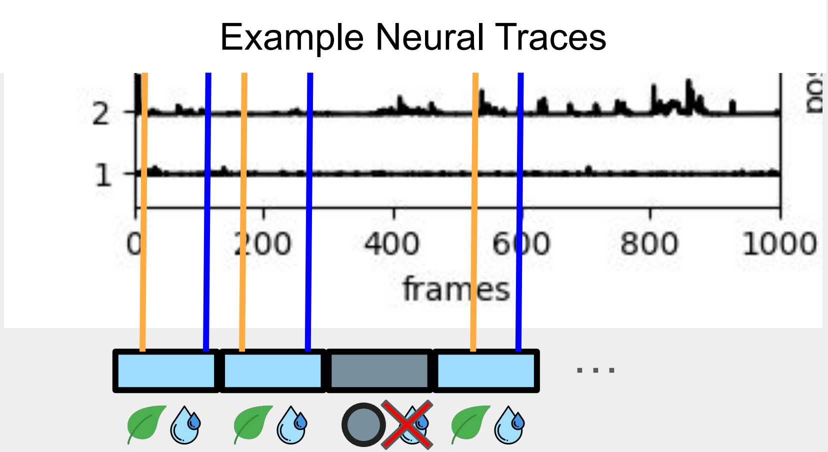
If sensory regions like the visual cortex encode these goal-directed vs free-exploratory internal states, this suggests that cognitive states can influence sensory representations.

Dataset:

- Zhong et al., 2025 – in vivo calcium imaging of the visual cortex.
- ~80,000 recorded neurons per animal → rich population data for studying state encoding.
- Includes supervised and unsupervised behavioral conditions, enabling state-specific comparisons.

Task Design and Cortical Recording Regions

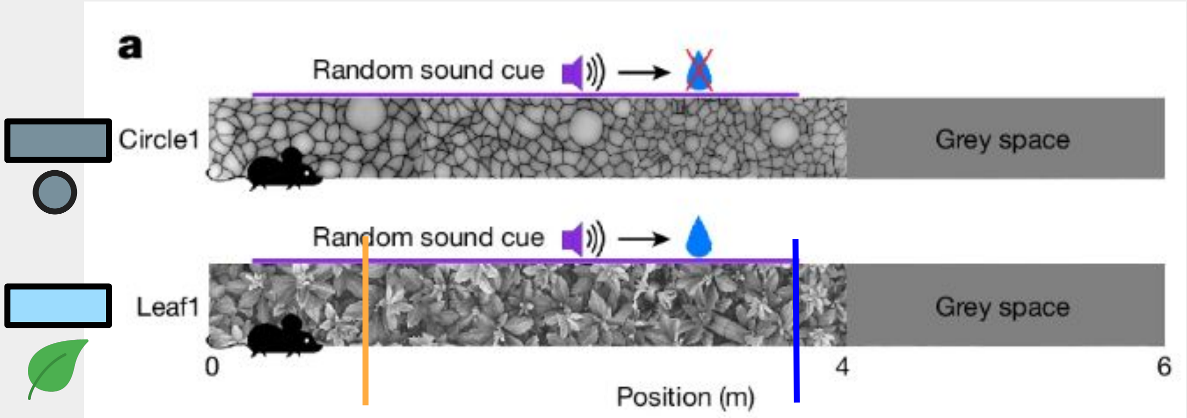


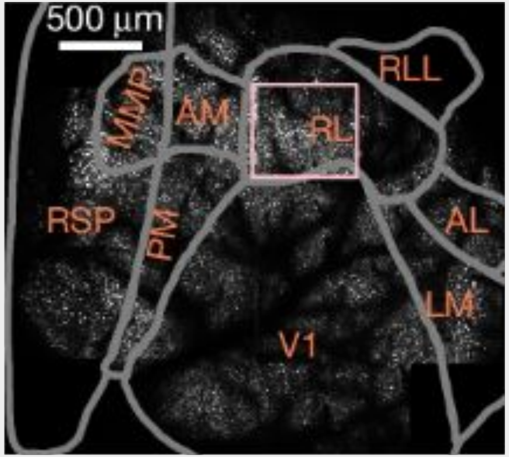


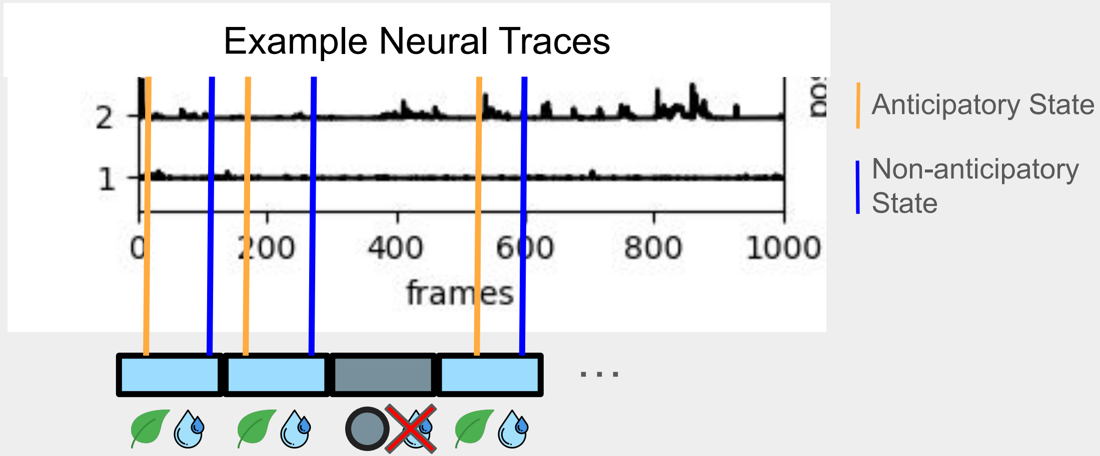
Anticipatory State

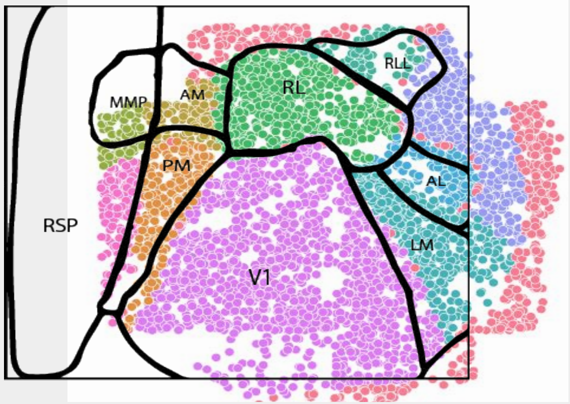
Non-anticipatory State

Task Design and Cortical Recording Regions









Analysis Pipeline

1) Data preparation

- Extract behavioural and neural data from dataset
- Align neural data with behavioural data

2) Encoding on a neuronal level

- Quantify anticipatory neurons via cohen's d
- Visualize distribution of high |d'| neurons

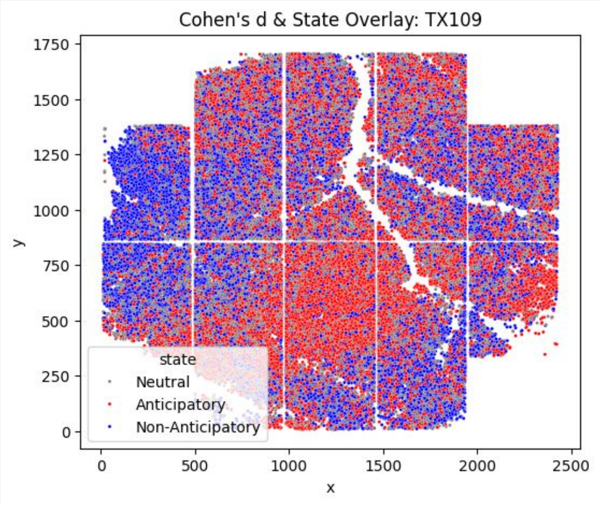
3) Control comparisons

- (1) Behavioural controls (speed)
- (2) Comparison with unrewarded stimulus
- (3) Comparison with unrewarded animals

4) Population encoding/decoding

- Encoding: PCA, tSNE
- Decoding: Linear regression model from PCA

Single-Animal Analysis of Neuronal Selectivity & Activity During Anticipatory States (TX109)

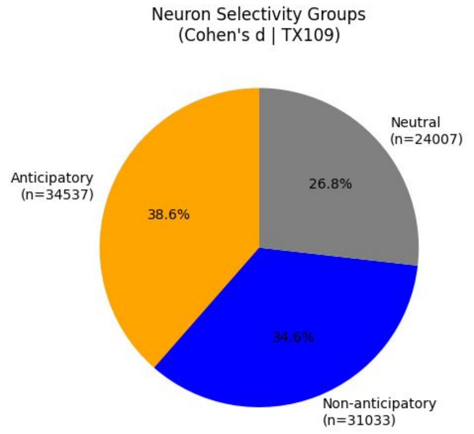


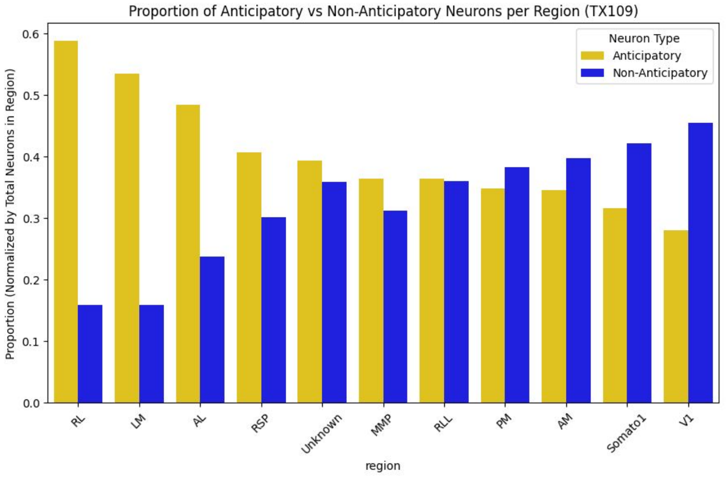
Cohen’s d used to classify neurons as anticipatory, non-anticipatory, or neutral.

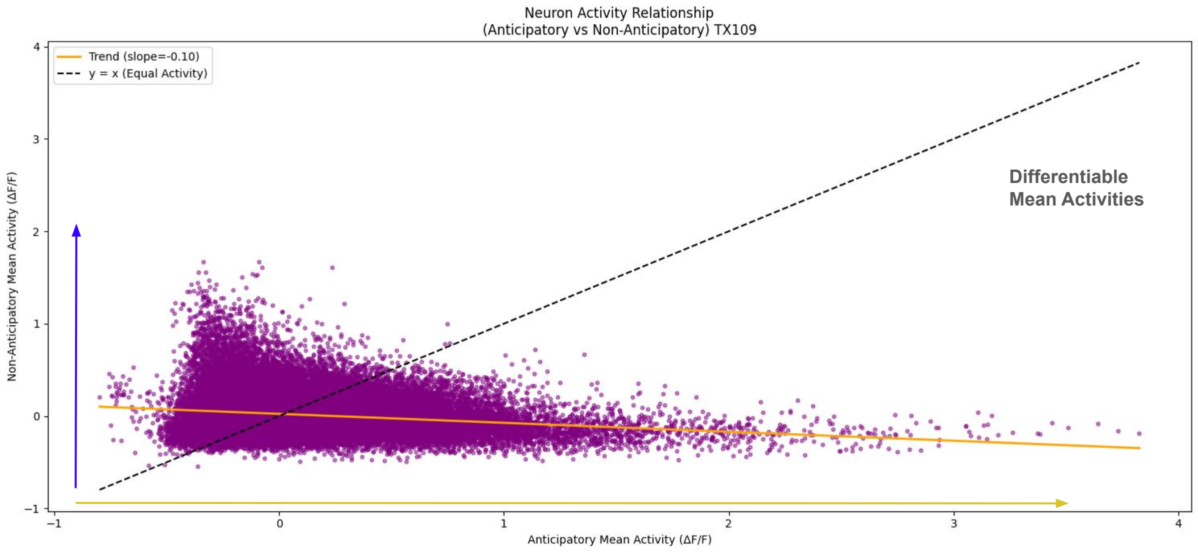
2)

Quantify anticipatory neurons via cohen’s d

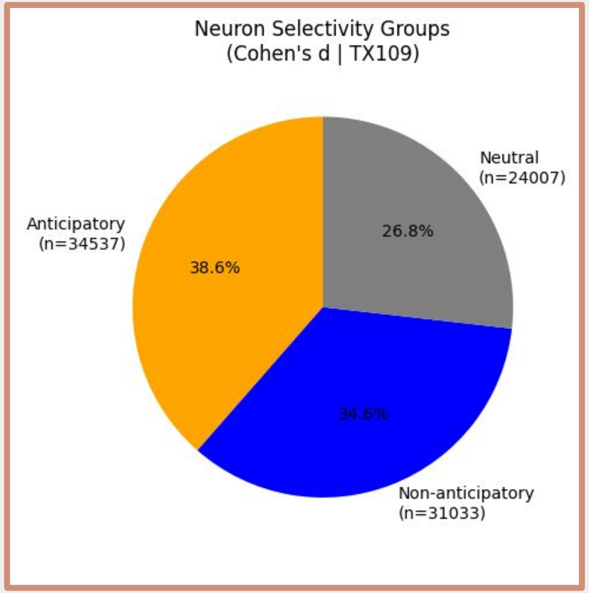
Visualize distribution of high |d’| neurons

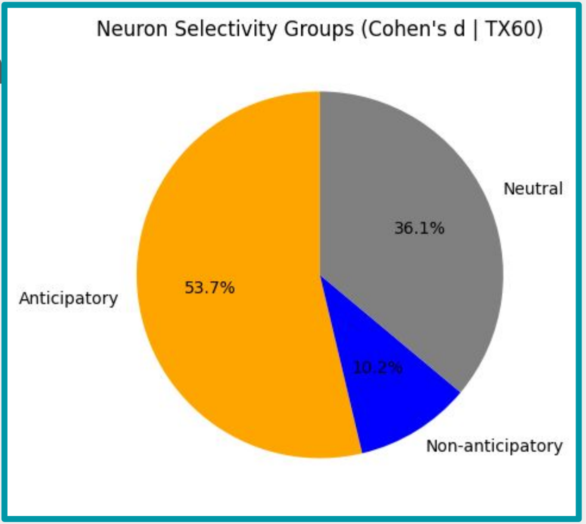


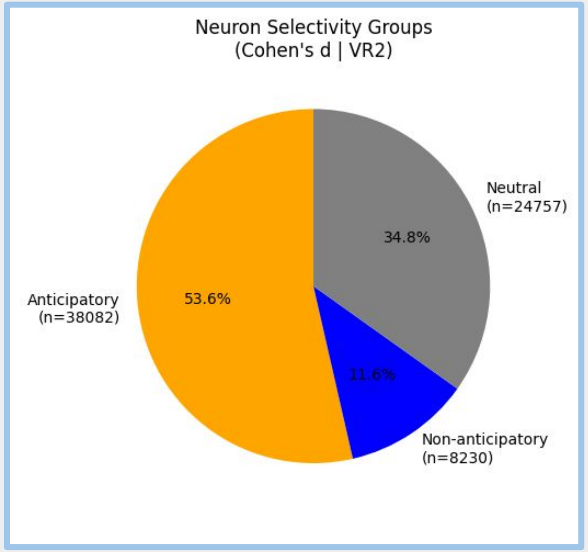


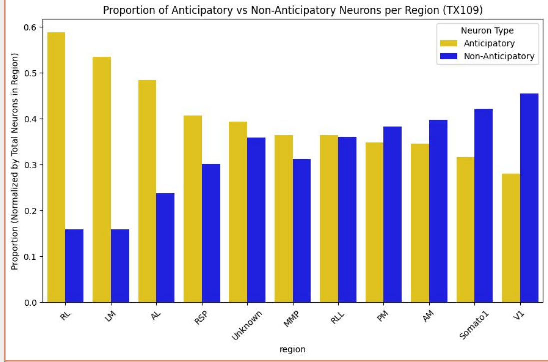


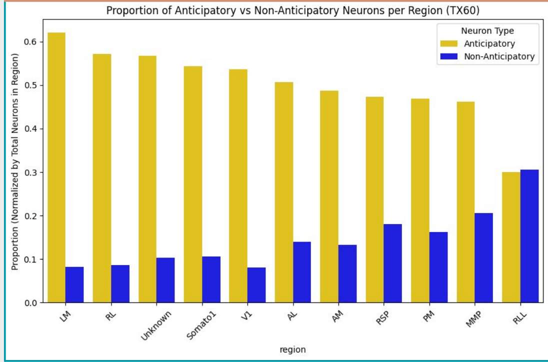
Across-Animal Comparison of Neuronal Selectivity Proportions During Anticipation

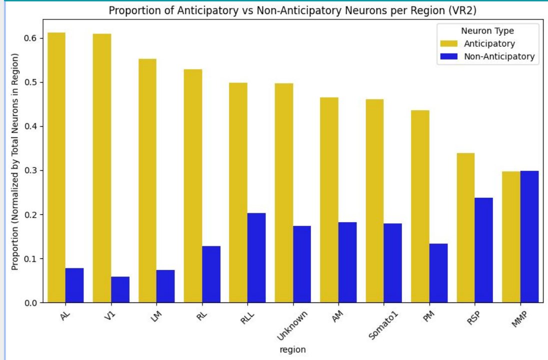




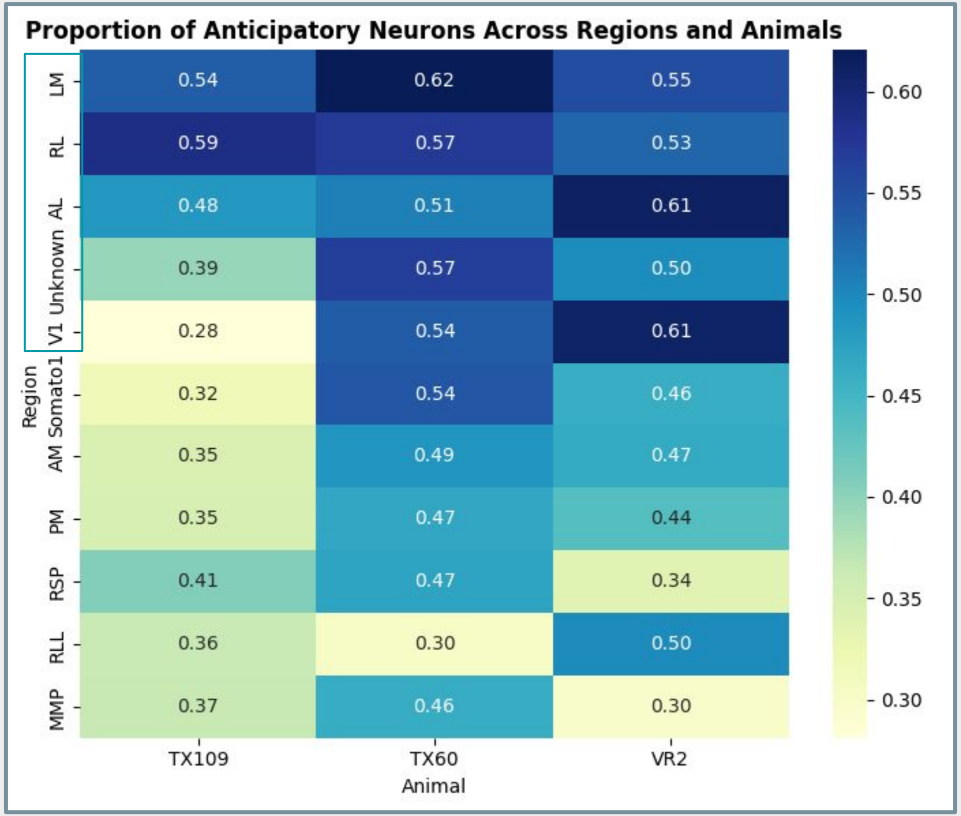






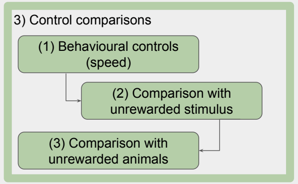


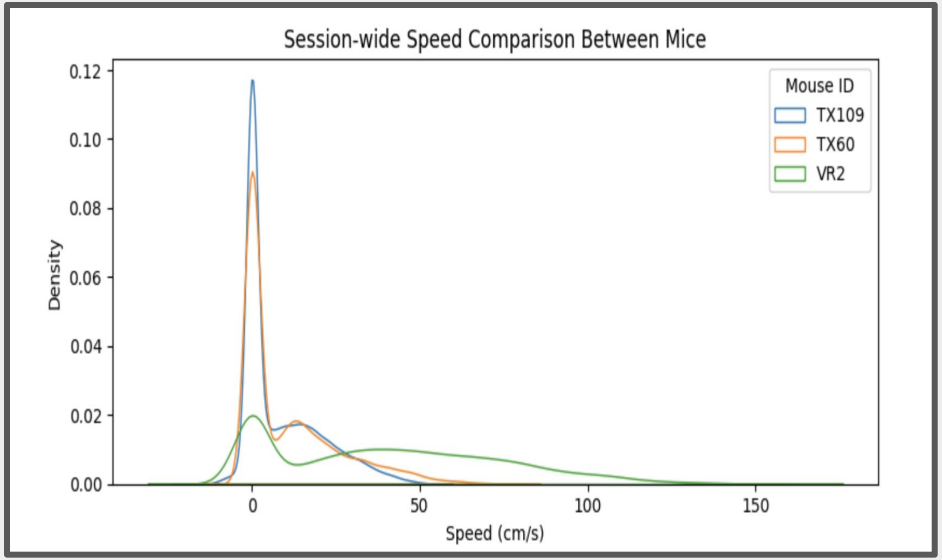
Sensory Regions (LM, RL, V1) Show High Anticipatory Neuron Proportions Across Animals

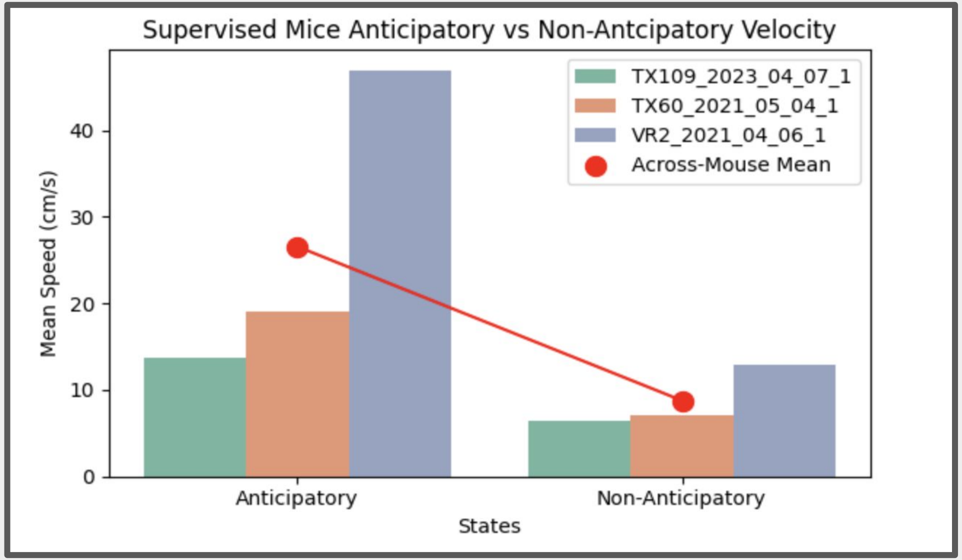


To rule out potential confounds, we tested whether differences in anticipatory vs non-anticipatory neural activity could be explained by differences in velocity.

Are Anticipatory and Non-Anticipatory Neural Differences Explained by Speed?







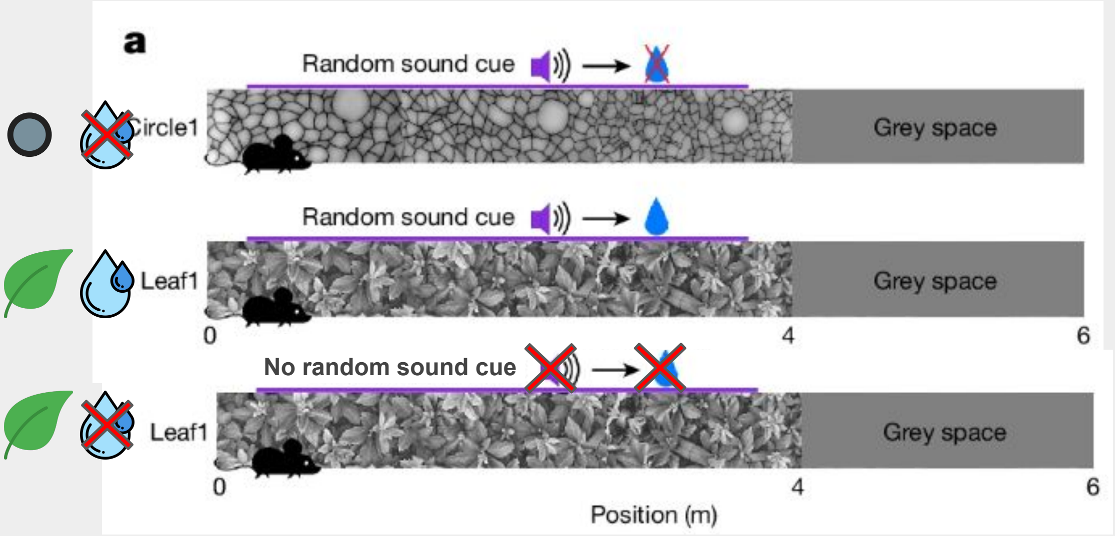
- Mice accelerate toward the reward and decelerated after the reward.
- Each mouse showed distinct running speeds. On average, some paused more often and others sprinted faster.
- It is possible that the observed neural differences in both states simply reflect changes in running speed (processing different visual motion).

Disentangling Anticipation From Visual and Temporal Representations

Control groups

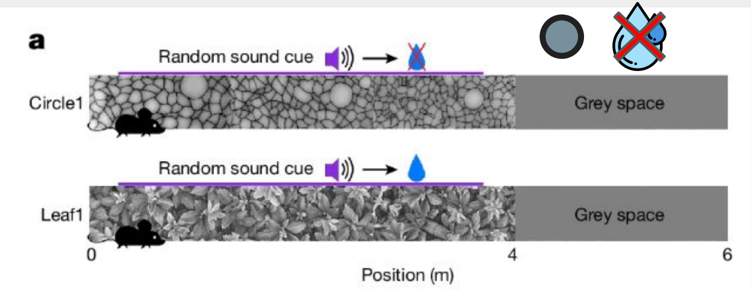
1) Same subjects, unrewarded stimulus (tests temporal representation)

2) Different subjects, same visual stimulus without reward (controls visual representation)

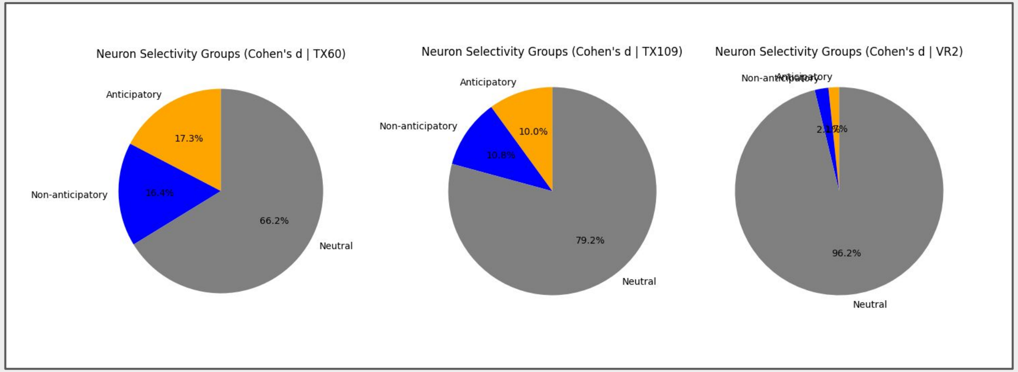


Are These Neural Responses Specific to Anticipation?

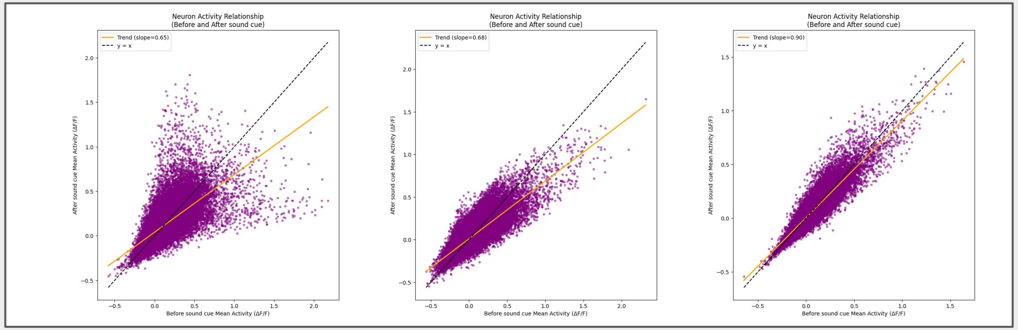
Neurons do not show anticipatory encoding during unrewarded stimulus.



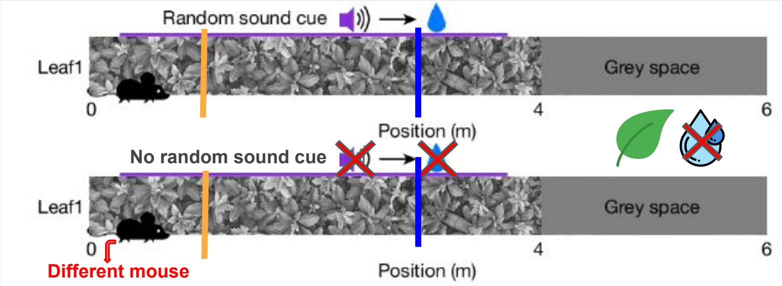
Mouse	Trials with no licks	Trials with licks	Number of neurons
TX60	118	37	57368
TX109	104	50	89577
VR2	194	42	71069



Comparing activity of cells to the first vs last lick



Unrewarded (unsupervised) controls with same stimulus show reduced neuronal selectivity



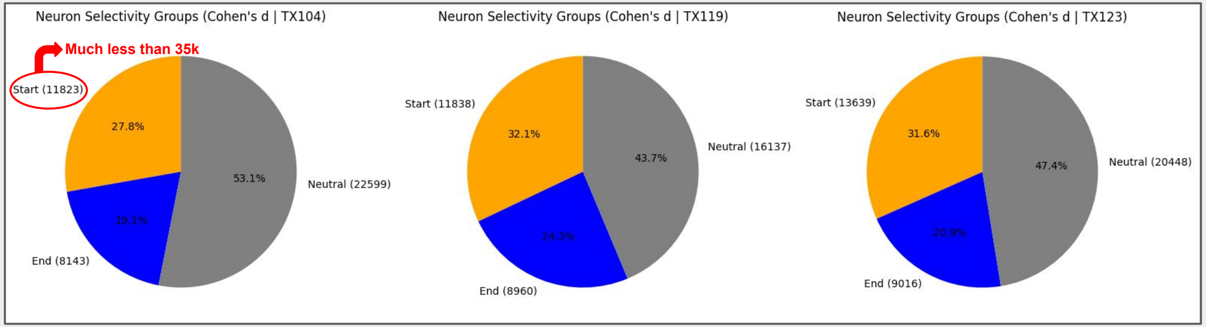
First lick - Anticipatory

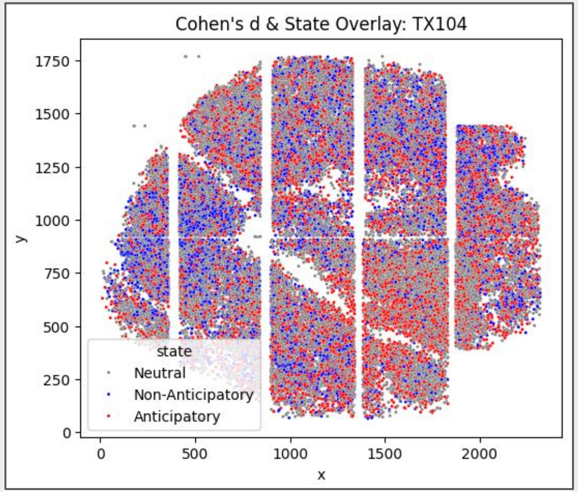
Last lick - Non anticipatory

20% trial after start frame

39% trial before end frame

Mouse	No. of Neurons
TX104	42565
TX119	36935
TX123	43103





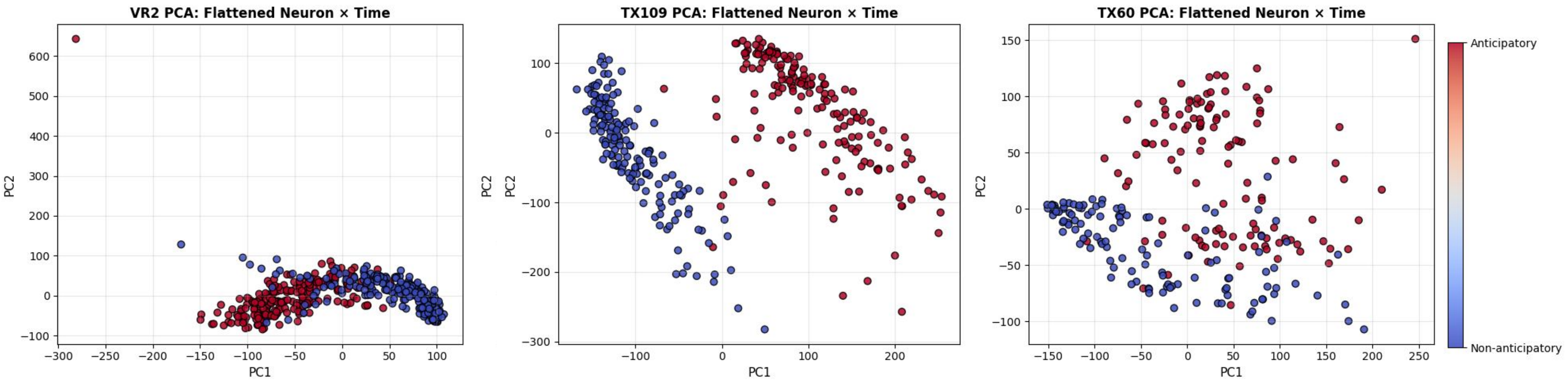
Differences most likely because of anticipation!

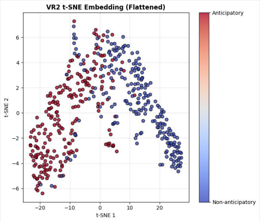
4) Population encoding/decoding

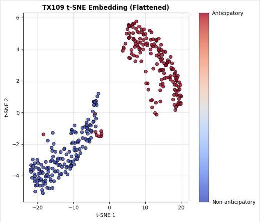
Encoding: PCA, tSNE

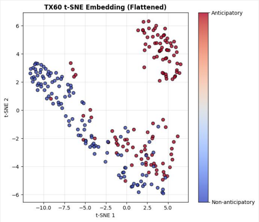
Decoding: Linear regression model from PCA

PCA Reveals Separation of Anticipatory and Non-Anticipatory Neural Activity in Supervised Mice









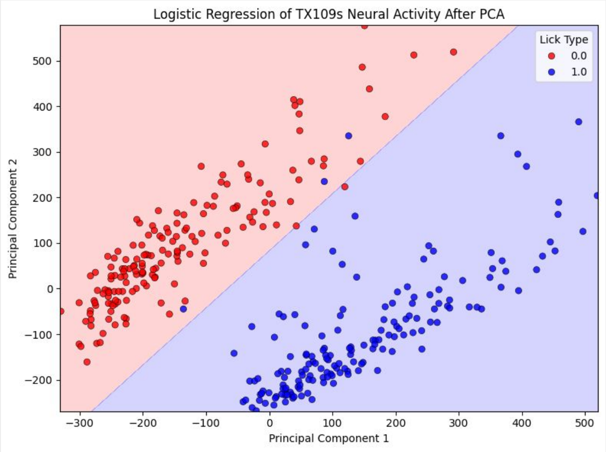
Decoding Anticipatory State From Population Activity

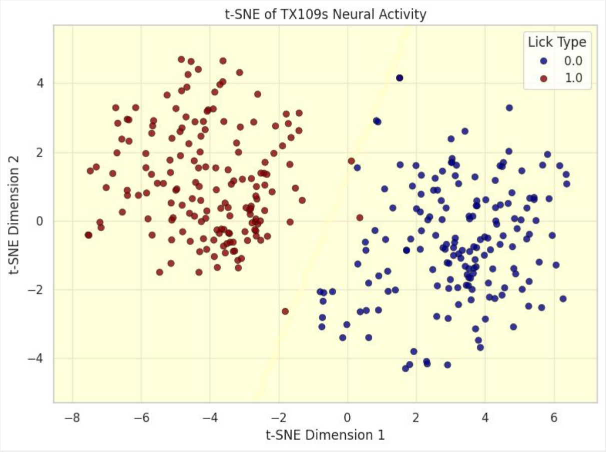
PCA -> Top 100 Features
Logistic Regression
1 = ant. state; 0 = non-ant. state

TX109

98% cross-val accuracy

Clear State Separation

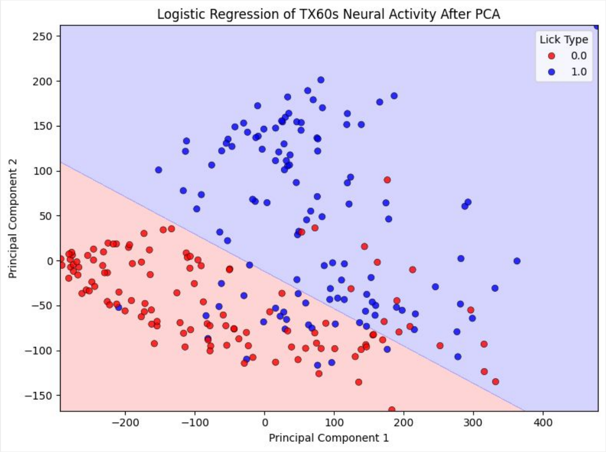


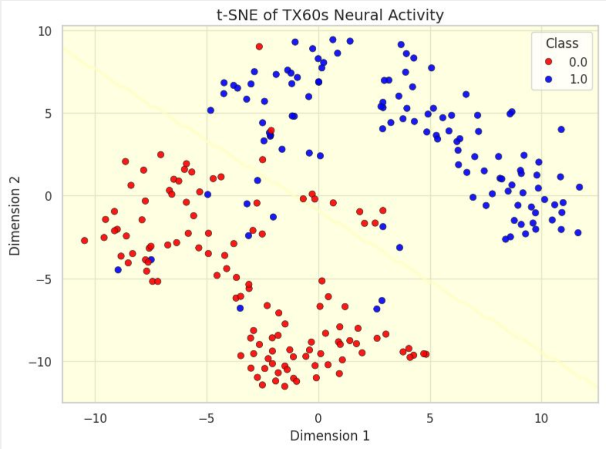


TX60

90% cross-val accuracy

-> 94% accuracy via LR hyperparameter optimisation





Conclusion

In this project, we tested whether anticipatory states are <u>encoded</u> in the mouse visual cortex and whether these states can be <u>decoded</u> from the neuronal activity.

- Cohen's d quantified the **effect size** of anticipatory vs non-anticipatory **neural activity**, allowing us to classify neurons into selective groups.

- **Population analyses** and **dimensionality reduction** (PCA & t-SNE) revealed components that separate anticipatory and non-anticipatory states in supervised mice.

- Overall, these findings support the idea that se**nsory cortices** participate in **encoding cognitive states**, such as reward **anticipation**