NEURONS

# Silent Hypothesis

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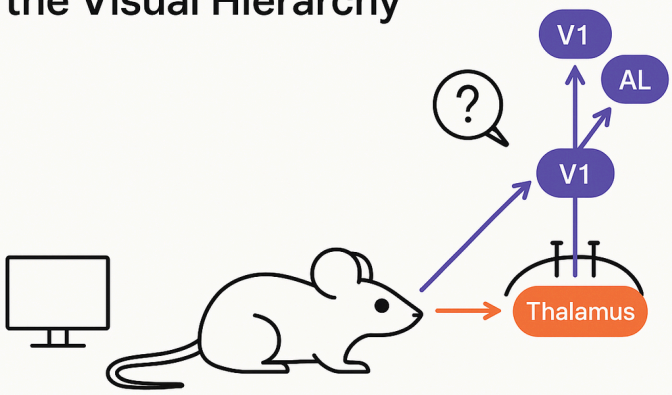
## Introduction and Research Overview

# NEURONS

We are using IBL dataset and trying to find patterns in intra region communication flow and information decoding during a Visually-Guided Decision-Making Task

## Investigating Communication Flow in the Visual Hierarchy




Simultaneous recordings across thalamocortical visual areas during a decision-making task

02 Dataset Information

# IBL- Experiment Setup for Data Collection

SUBJECTS: 115 MICE (80 MALES, 35 FEMALES)

TASK: VISUOMOTOR DECISION-MAKING USING A ROTATING WHEEL.

BEHAVIOURAL CUES: VISUAL STIMULUS, CHOICE, FEEDBACK (REWARD/NOISE), AND REACTION TIME.

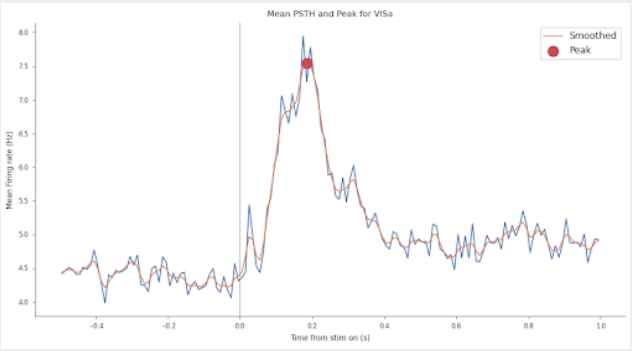
GOAL: IDENTIFY BRAIN-WIDE NEURONAL CORRELATES OF SENSORY, MOTOR, AND COGNITIVE VARIABLES.

# 03 Modelling Techniques

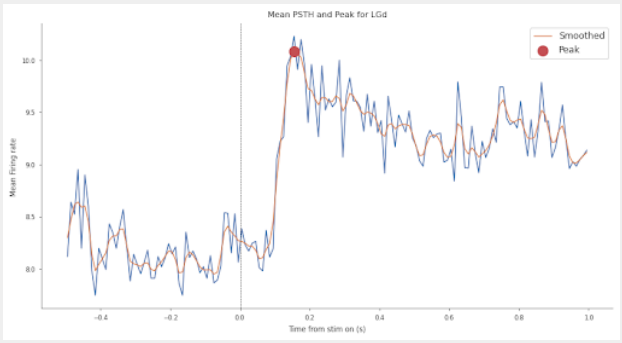
# Latency Analysis

**AREA OF INTEREST : VISa and LGd**

VISa Latency(time of peak) = 0.185 s




LGd Latency(time of peak) = 0155 s

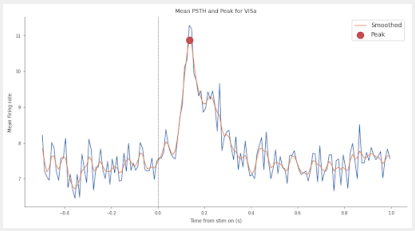


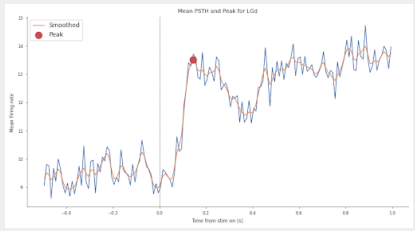

| | LGd | VISa |
|---|---|---|
| S1 | 31 | 20 |
| S2 | 20 | 35 |
| S3 | 14 | 22 |
| S4 | 20 | 15 |

## OBSERVATIONS

1. Time lag exists in 1 probe of 30 ms.
2. Inconsistent over sessions

LGd : 145 ms
VISa : 135 ms



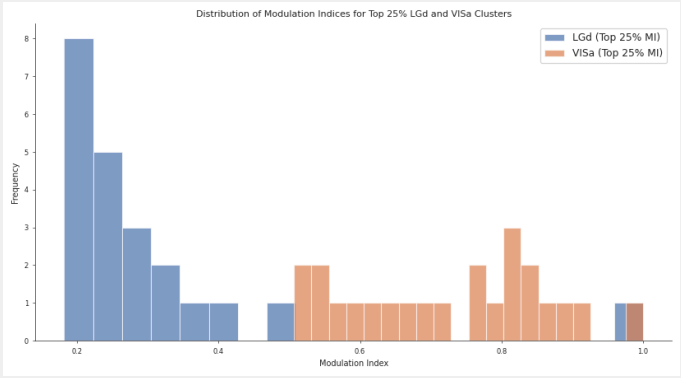



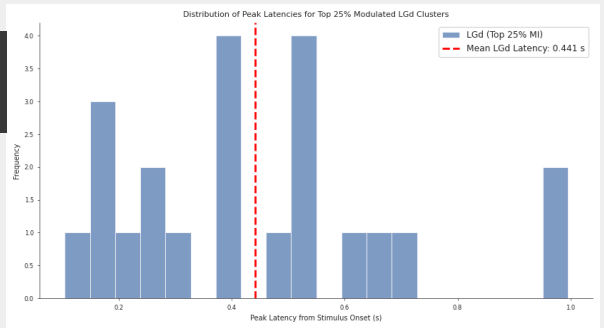

# Latency Analysis

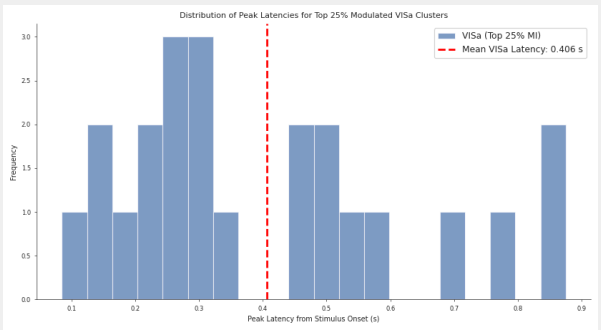
**AREA OF INTEREST : VISa and LGd**

**modulation index (MI)**. The formula is:

$$MI = \frac{|\text{pre} - \text{post}|}{|\text{pre} + \text{post}|}$$



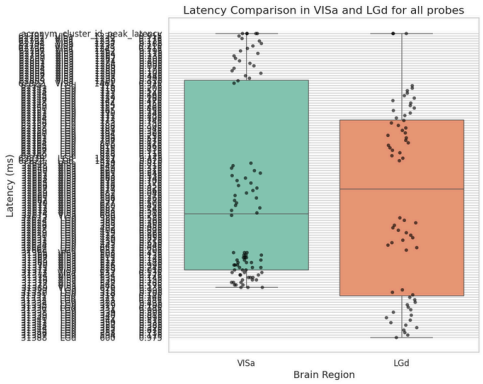




## POINTS TO PONDER

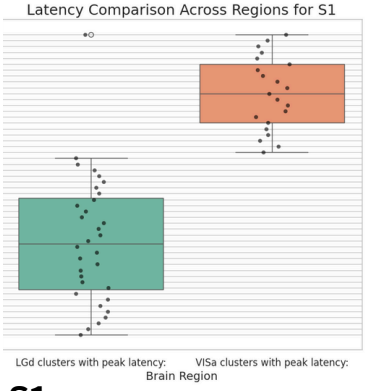
1. LGd has a high baseline activity on its own. The activation need not be a peak or region is involved in different pathways
2. Between Visual regions VISam and VISpm, we observed no lag (1 session ) but not reliable based on latency histogram

LGd mean latency : 441 ms
VISa mean latency : 406 ms

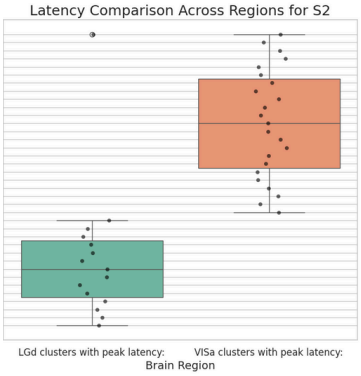



# Timing Hierarchy in LGd & VISa

- LGd responds faster than VISa in all four sessions
- VISa shows greater variability
- Boxplots show clear separation in latency distributions between regions




S1

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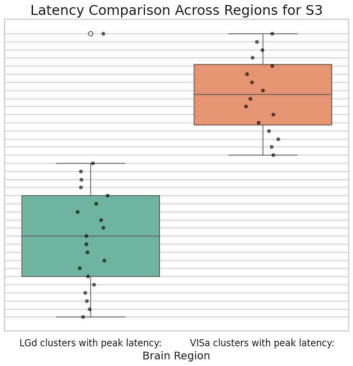
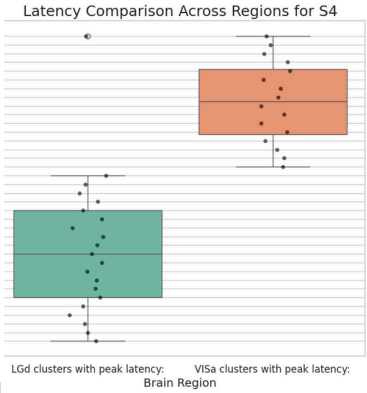



S3




S4

# Cross Correlation

Analyze timing between thalamic (LGd) and cortical (VISa) visual regions

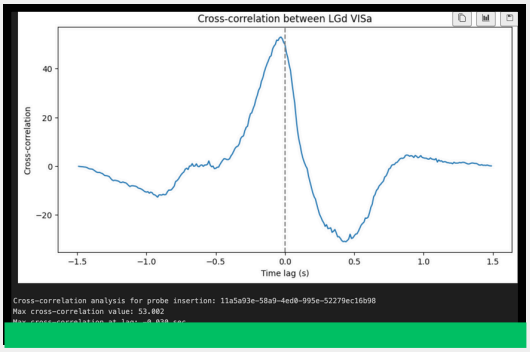
## Independent session results

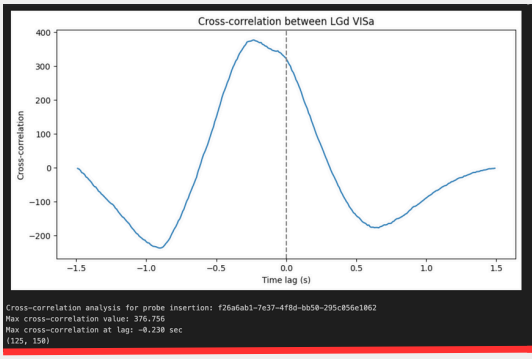
- Some sessions show LGd leads VISa (expected)
- Others are inconsistent → likely due to variability in neuron sampling

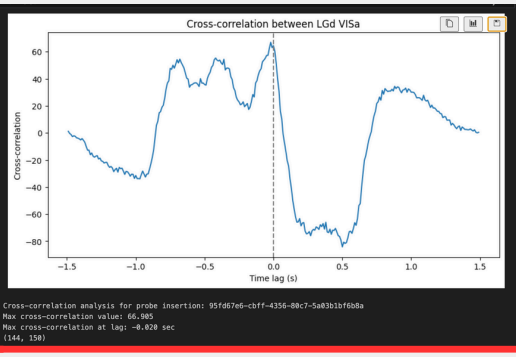
## Across session analysis

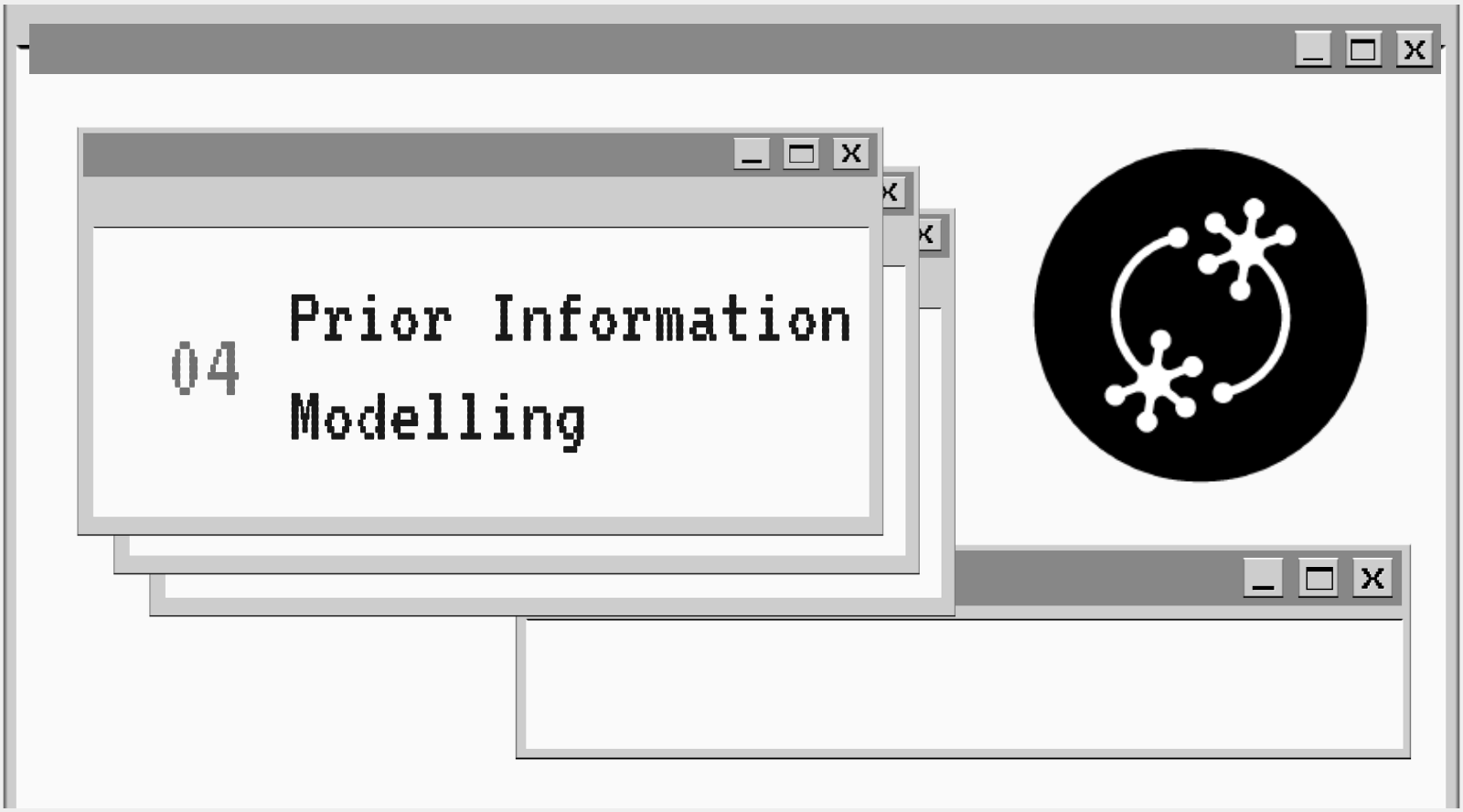
- LGd leads VISa by ~56 ms on average
- Not statistically significant ($p = 0.1811$) – small number of sessions

- Suggests directional thalamocortical flow
- Effect may be real, but underpowered






# What about the 0 contrast trials?

## Hypothesis

During zero contrast trials, the mouse relies solely on prior expectations - specifically, its internal prediction of the block bias (i.e. `probabilityLeft`) - to make a decision.

## Pipeline

Step 1: Is the block bias estimated reliably by the mouse?

→ Predict block bias from pre-stimulus neural activity.

| Model | Input Variable | Trial Type | Predicted Output | Accuracy | p-value |
|---|---|---|---|---|---|
| Block Bias (All trials) | Pre-stimulus firing (−0.5 to 0 s) | All contrast levels | Block Bias (0.2/0.5/0.8) | 57.7% | < 0.001 |
| Block Bias (Strong bias only) | Pre-stimulus firing (−0.5 to 0 s) | Only 0.2 & 0.8 blocks | Block Bias (0.2 vs 0.8) | 58.5% | < 0.001 |

✅ Significant accuracy → Mouse encodes the block structure internally.

Step 2: Does this internal bias drive choice?

→ Decode choice from the same pre-stimulus activity.

| | | | | | |
|---|---|---|---|---|---|
| Choice (All trials) | Pre-stimulus firing (−0.5 to 0s) | All contrast levels | Mouse Choice (L/R) | 51.5% | 0.220 |
| Choice (0% contrast only) | Pre-stimulus firing (−0.5 to 0s) | Only 0% contrast trials | Mouse Choice (L/R) | 59.4% | 0.180 |

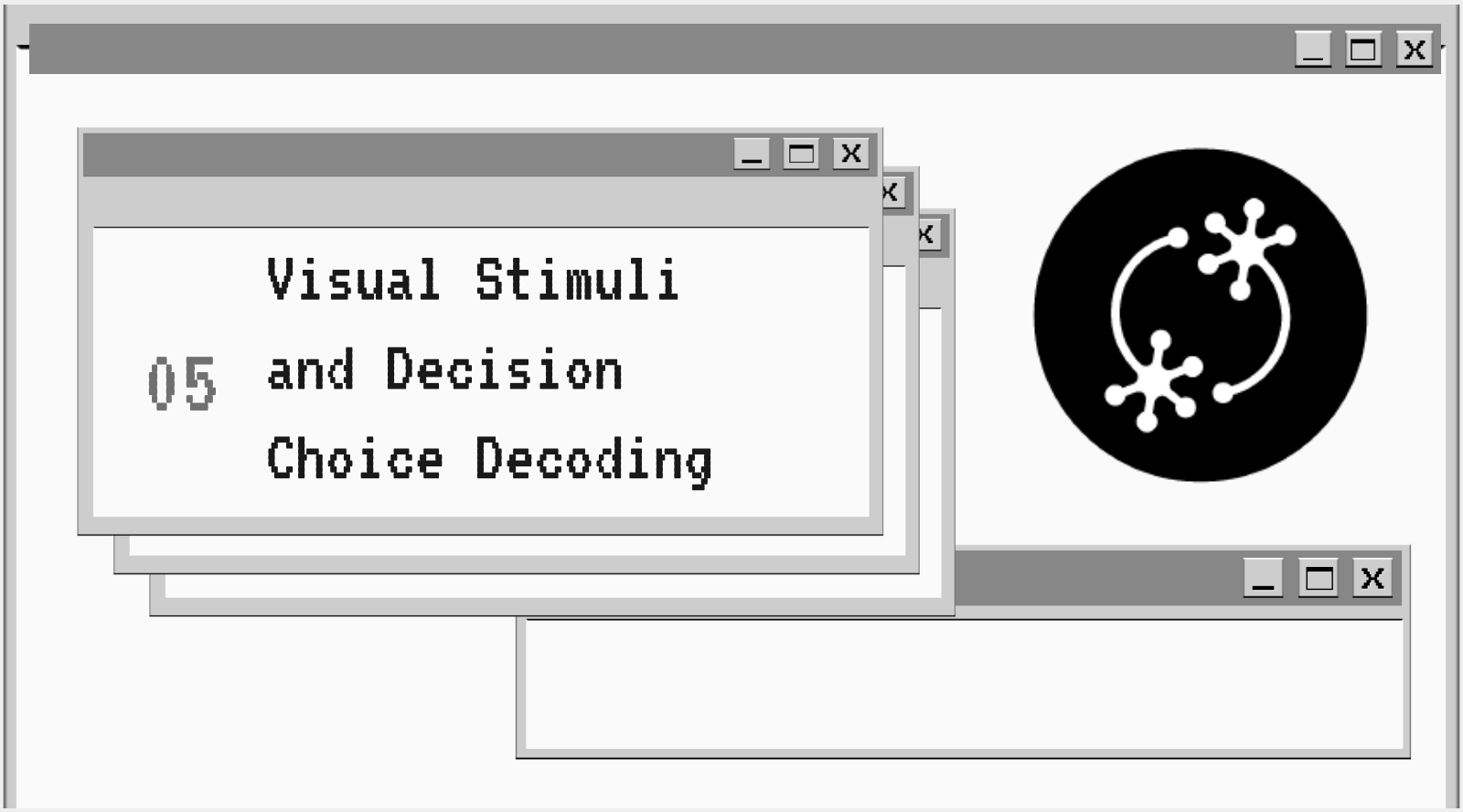
✅ Higher accuracy in 0% contrast trials → Prior guides decisions under uncertainty.

## Interpretation

- These results show that the mouse brain reliably encodes the block bias setup by the experiment.
- Choice decoding improves in zero contrast trials
- Suggests that internally stored priors guide decision-making when no visual input is available

## Limitations

- This analysis is done on a single session tagged with MOs. More region- and session-wise decoding is needed for generalization.



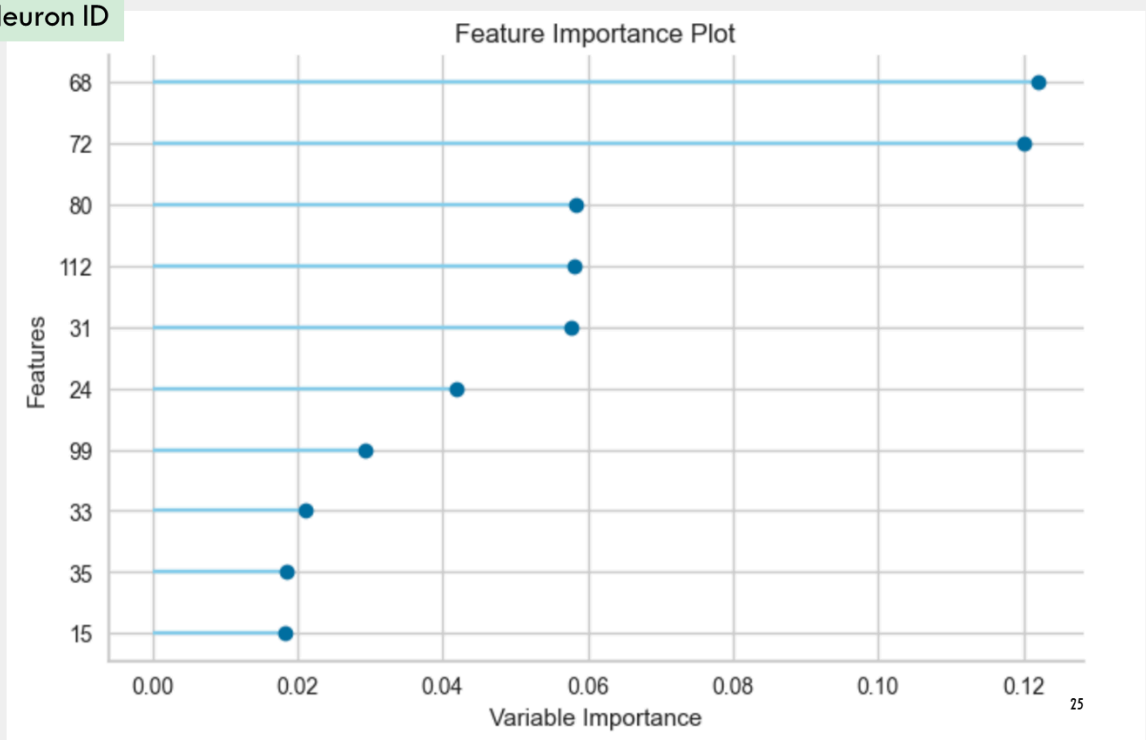
# PSTHS CONDITIONED ON CHOICE





# FEATURE IMPORTANCE

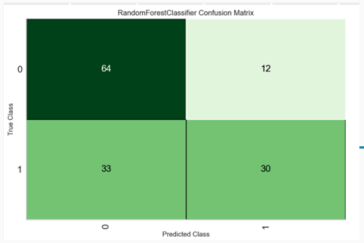
| Brain Region | Neuron ID |
|---|---|
| VISPm | 68 |
| VISPm | 72 |
| VISPm | 80 |
| VISPm | 112 |
| APN | 31 |
| APN | 24 |
| VISam | 99 |
| APN | 33 |
| root | 35 |
| APN | 15 |

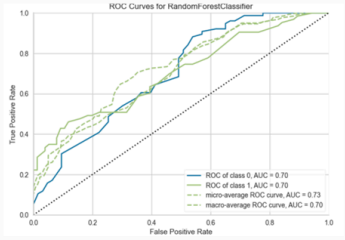


# MODELS FOR DECODING VISUAL STIMULI -MRN, APN, Root, DG, CA1, VISpm, VISam

## Full Dataset

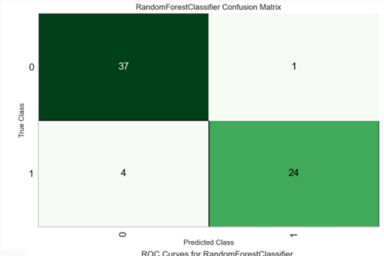
| MODEL | ACCURACY | AUC | RECALL | PREC. | F1 | KAPPA | MCC |
|---|---|---|---|---|---|---|---|
| Random Forest Classifier | 0.7223 | 0.7745 | 0.7223 | 0.745 | 0.7096 | 0.4237 | 0.4533 |
| Gradient Boosting Classifier | 0.6977 | 0.7748 | 0.6977 | 0.701 | 0.6927 | 0.3842 | 0.390 |

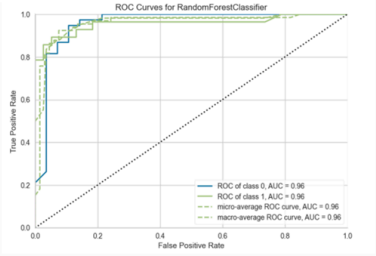



## High Contrast Dataset

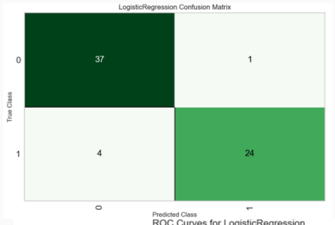
| MODEL | ACCURACY | AUC | RECALL | PREC. | F1 | KAPPA | MCC |
|---|---|---|---|---|---|---|---|
| Random Forest Classifier | 0.9017 | 0.958 | 0.901 | 0.912 | 0.900 | 0.797 | 0.808 |
| Extra Trees Classifier | 0.8950 | 0.961 | 0.895 | 0.903 | 0.894 | 0.784 | 0.793 |

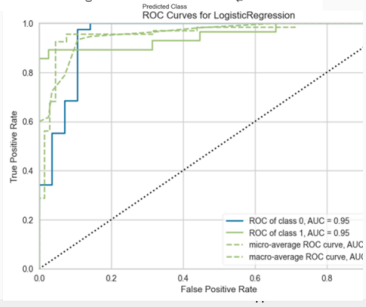



## PCA

| Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|---|---|---|---|---|---|---|---|
| Logistic Regression | 0.8817 | 0.9455 | 0.8817 | 0.8934 | 0.8813 | 0.7583 | 0.7687 |
| SVM - Linear Kernel | 0.8483 | 0.9098 | 0.8483 | 0.8551 | 0.8477 | 0.6873 | 0.6935 |

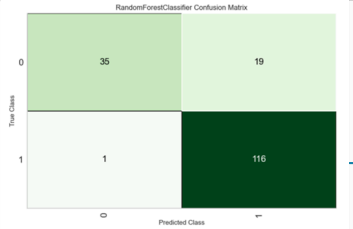


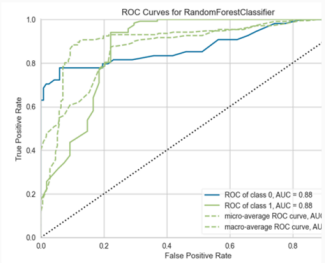




# MODELS FOR DECODING DECISION CHOICE -PO, LD, CA3, CA2, CA1, Root, SSp-tr

## Full Dataset

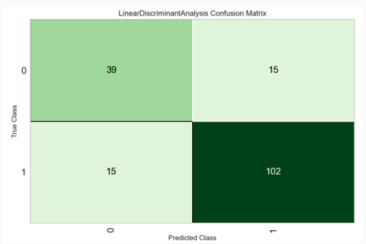
| Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|---|---|---|---|---|---|---|---|
| Random Forest Classifier | 0.8619 | 0.8776 | 0.8619 | 0.8707 | 0.8529 | 0.6514 | 0.6752 |
| Light Gradient Boosting Machine | 0.8617 | 0.8815 | 0.8617 | 0.8612 | 0.8586 | 0.6690 | 0.6743 |

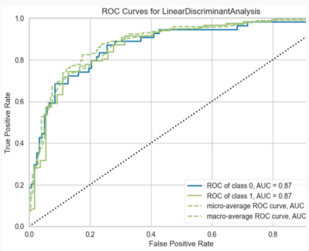


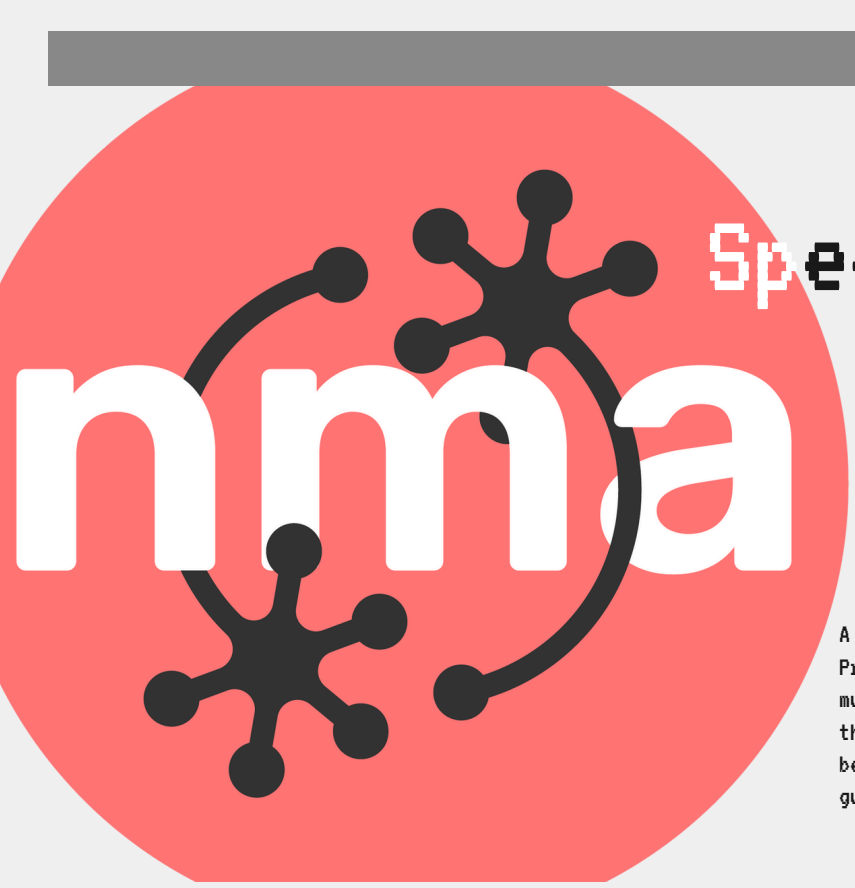

## PCA

| Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|---|---|---|---|---|---|---|---|
| Linear Discriminant Analysis | 0.8718 | 0.9060 | 0.8718 | 0.8728 | 0.8704 | 0.6999 | 0.7037 |
| Ridge Classifier | 0.8692 | 0.9066 | 0.8692 | 0.8697 | 0.8677 | 0.6932 | 0.6967 |



# 07 Acknowledgments



## Special Thanks

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