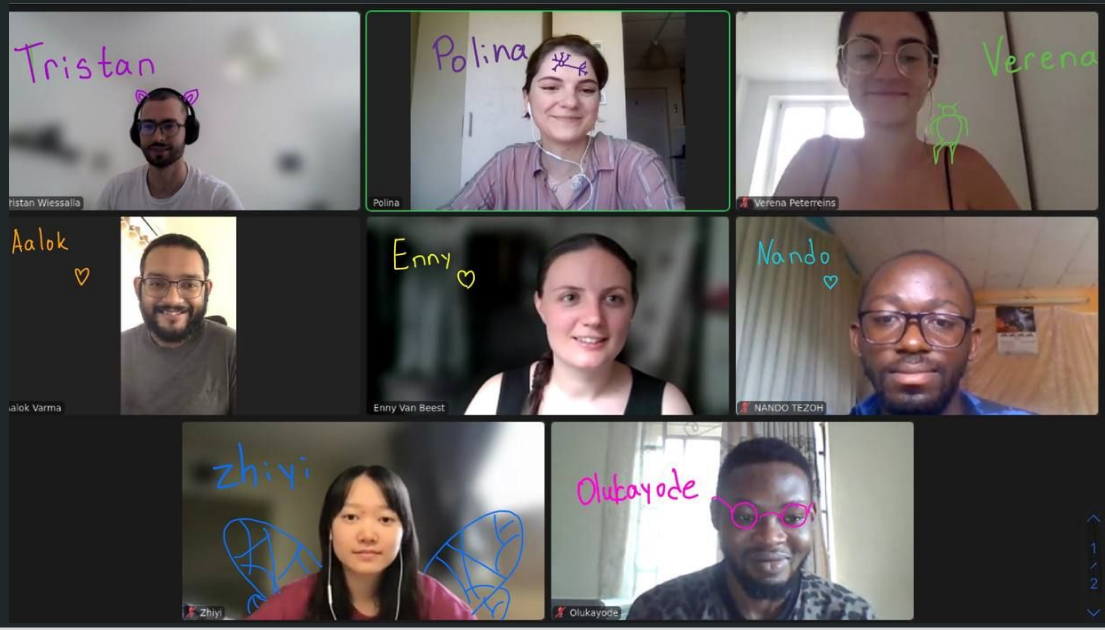
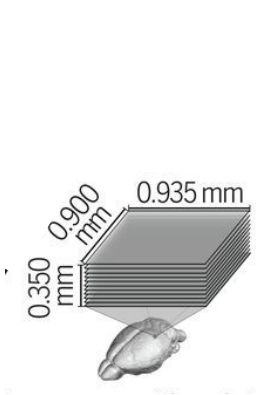
Decoding motion from visual cortex



By: Olukayode, Polina, Tristan, Verena, Yang, Zhiyi
Compsognathus_Belly / Hypertuned

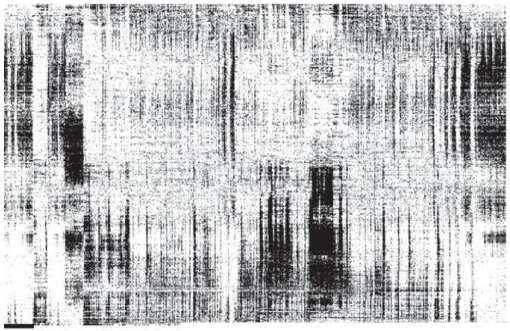
neuromatch academy

Are different motor behaviors encoded by overlapping populations in V1

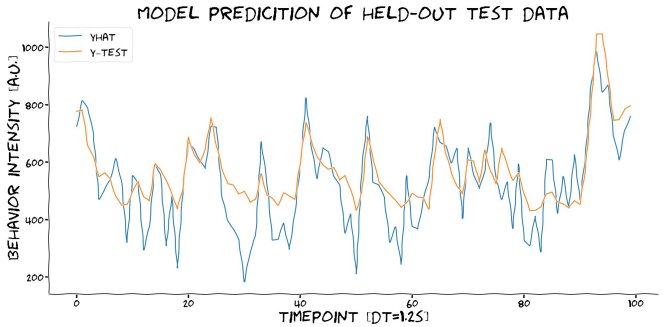


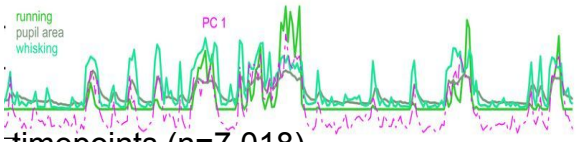
timepoints (n=7,018)

neurons (n=11,293)



predict behavior





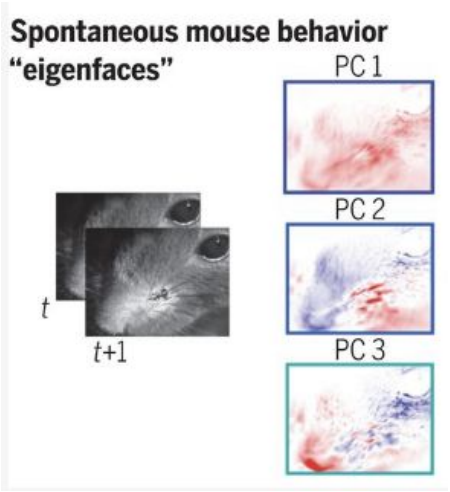
timepoints (n=7,018)

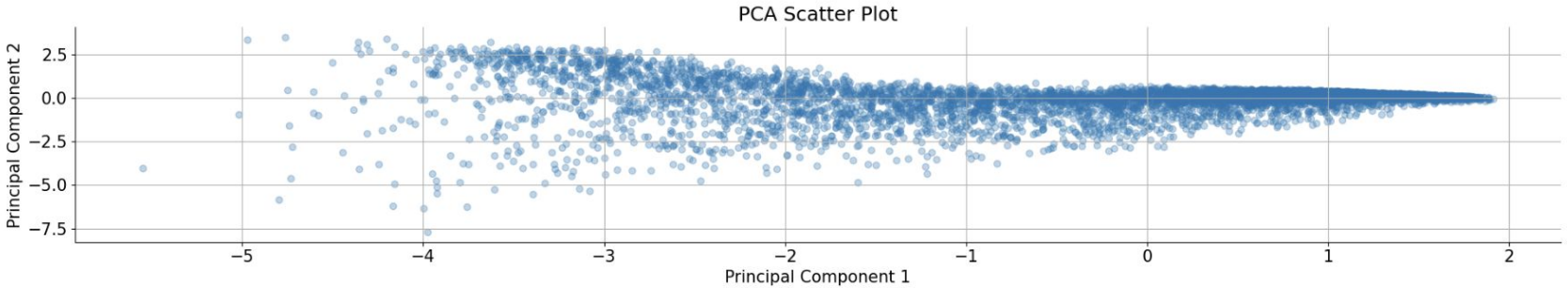
check model fit

PCA analysis on behavioral data

Behavioral data: pupil diameter, eye speed, running speed, eigenfaces

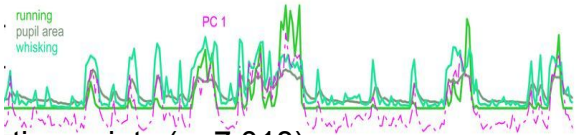
Main conclusion: PC1 and PC2 explains 84% of variance of behavioral data => Different behavioral datasets is highly correlated





L2 - regularized linear model

y



timepoints (n=7,018)

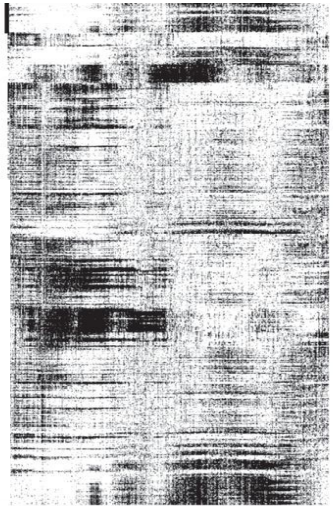
=

weights (n=11,293)

θ *

X

neurons (n=11,293)

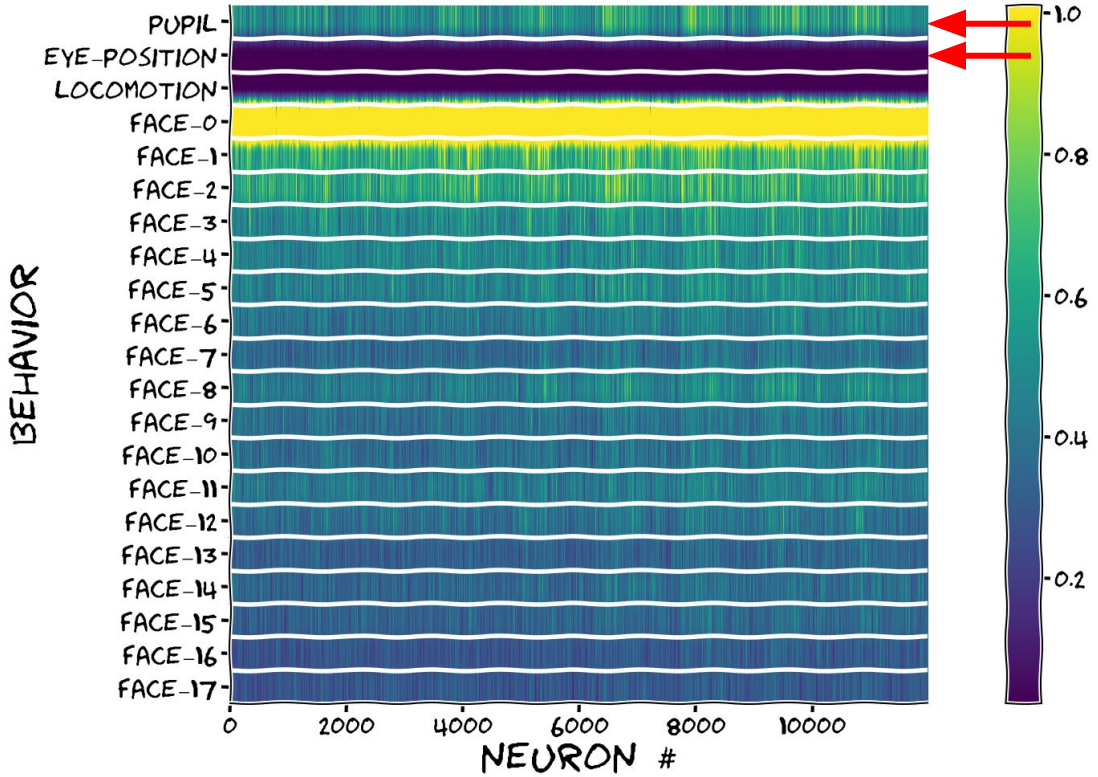


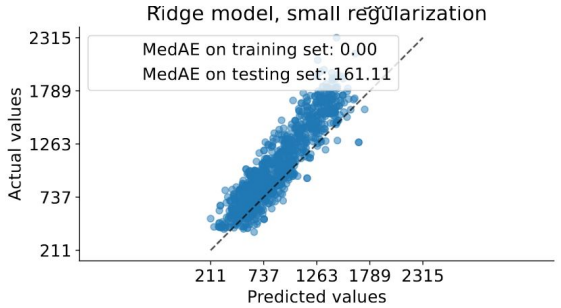
timepoints (n=7,018)

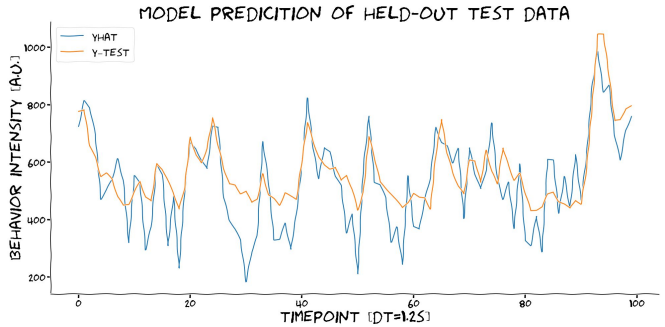
$$-\log \mathcal{L}'(\theta|X,y) = -\log \mathcal{L}(\theta|X,y) + \frac{\beta}{2}\sum_i \theta_i^2$$

1. optimize for **β**
2. solve for **θ**

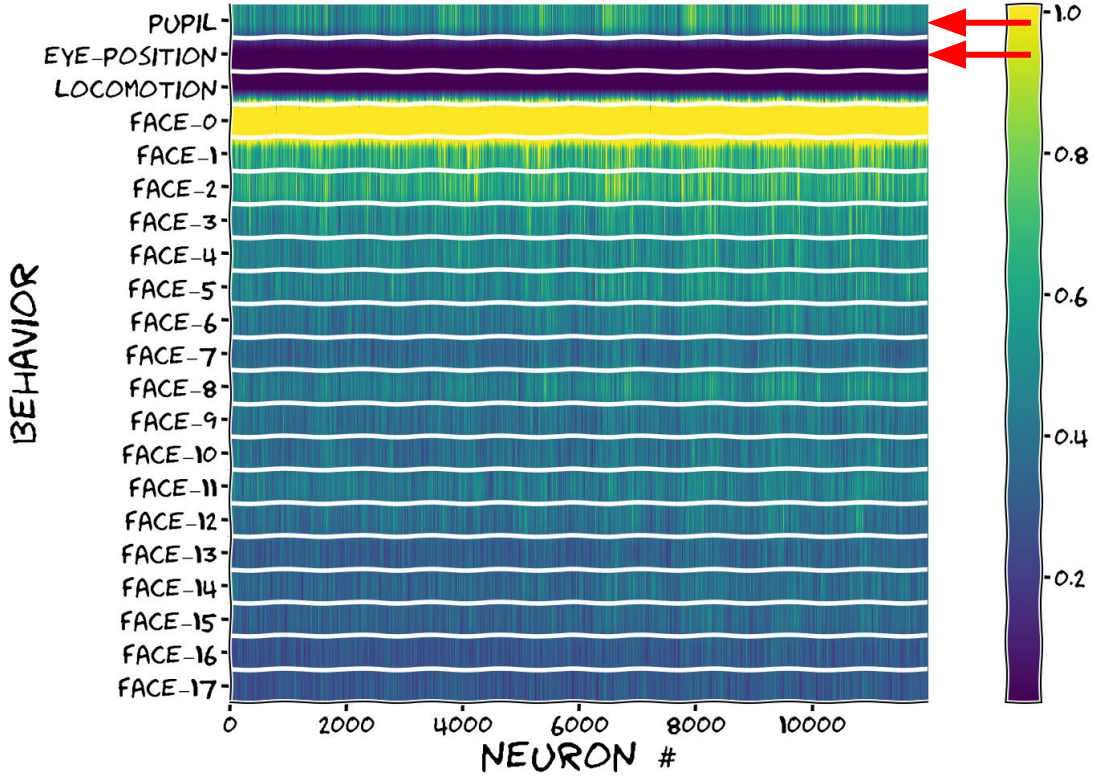
Overlapping populations encode different behaviors

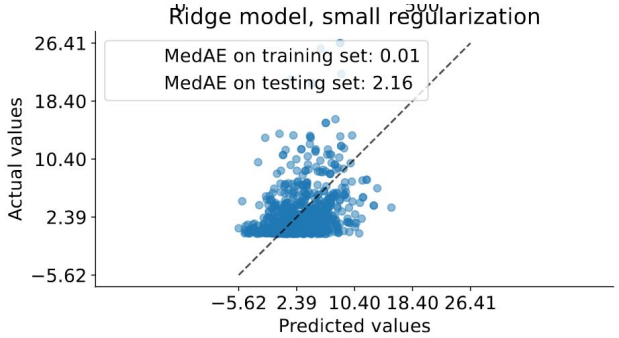


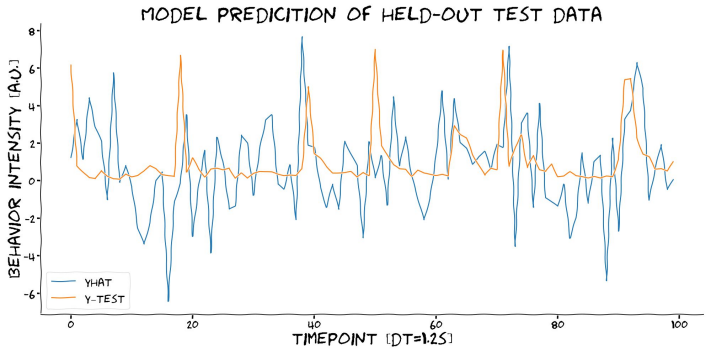




Overlapping populations encode different behaviors

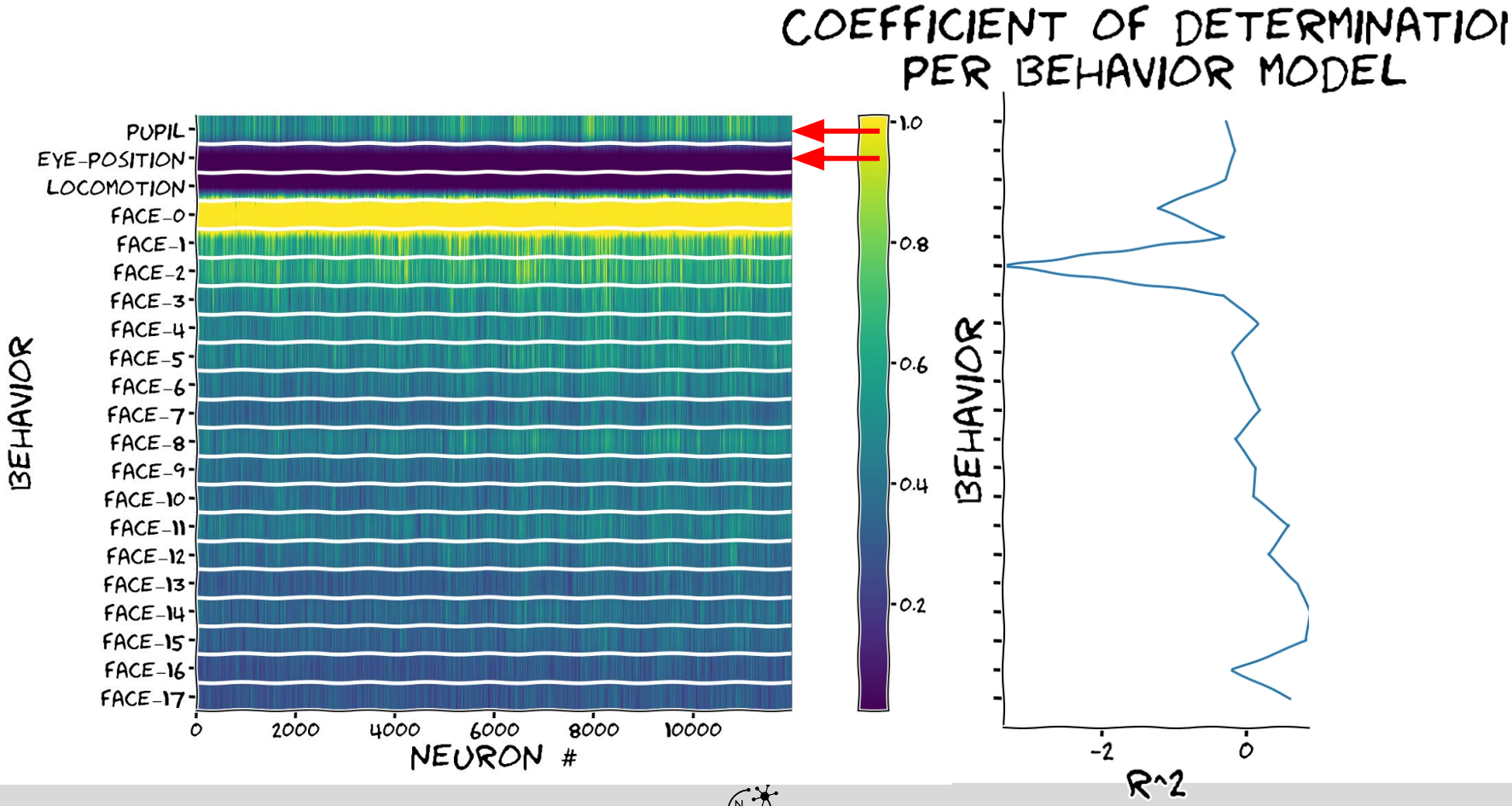






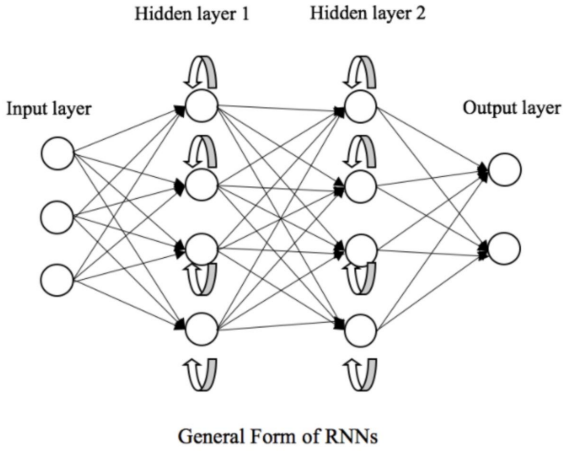
Population encoding of motor activity in V1

Hypertuned


COEFFICIENT OF DETERMINATIOI
PER BEHAVIOR MODEL
PUPIL
EYE-POSITION
LOCOMOTION
FACE-0
FACE-1
FACE-2
FACE-3
FACE-4
FACE-5
FACE-6
FACE-7
FACE-8
FACE-9
FACE-10
FACE-11
FACE-12
FACE-13
FACE-14
FACE-15
FACE-16
FACE-17
BEHAVIOR
0
2000
4000
6000
8000
10000
NEURON #
1.0
0.8
0.6
0.4
0.2
BEHAVIOR
-2
0
R^2

RNN

Input:
subset of neurons and timepoints

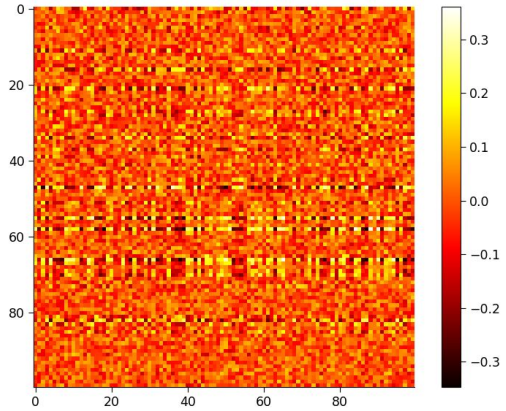


General Form of RNNs

Output:
prediction of pupil size per timepoint based on neural activity

Weight matrix layer1
(100 hidden units):

Training → learn weights between units
(How strongly units are connected and contribute to the prediction of pupil size)



Future:

- optimize model parameters
- evaluate model performance
- train model for further behaviors (running speed, whisking), … & compare models
- Prediction: if different motor behaviors are encoded by overlapping V1 populations, model performance should be similar

Discussion

- Different behavioral datasets (pupil diameter, eye speed, running speed, eigenfaces) is highly correlated
- Overlapping V1 populations most likely encode this shared behavior dimension, not precise motor output

What we tried:

- UMAP on neuronal data -> gives us fixed values, but we want to predict varying data -> not suitable
- GLM from scratch -> to understand the math
- L1 regularisation model on pupil diameter, running speed and pupil position
- RNN

Thank you for your attention!

Many thanks to our mentors -
Nando, Aalok, Enny ❤️

Happy to answer your questions

code