Hidden State Dynamics in visual cortex and motor cortex

Pod name: Mesfouf Pod mentor: Pietro Verzelli

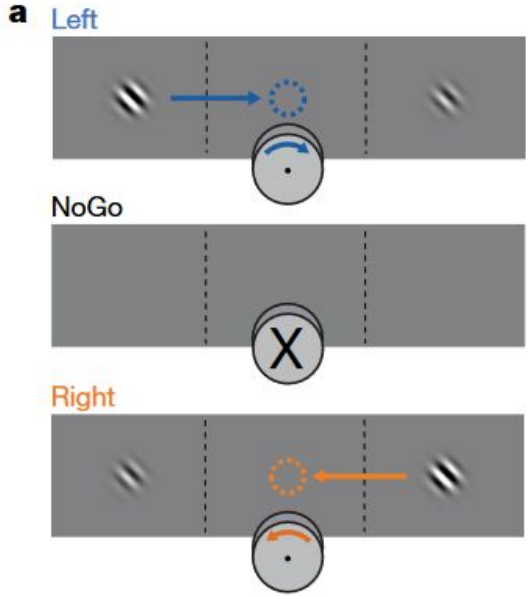
Project TA: Sinem Serap Project mentor: Benjamin Gagl

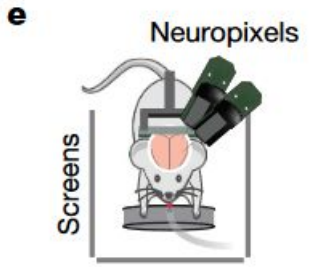
Group: Chao(s)fan

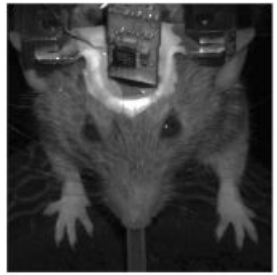
Jing, Peng, Ula, Yuyang, Farnaz, Yidan

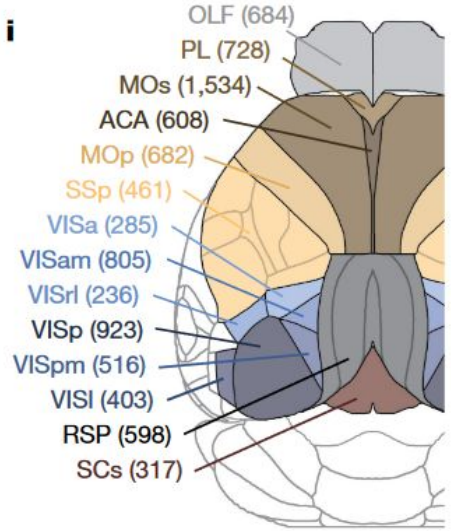
Introduction

- In **Steinmetz dataset**, mice perform a decision making task, involving processing different visual stimuli, selecting actions and getting the feedback.
- **Scientific question:** How does information transform from the visual cortex to the motor cortex?





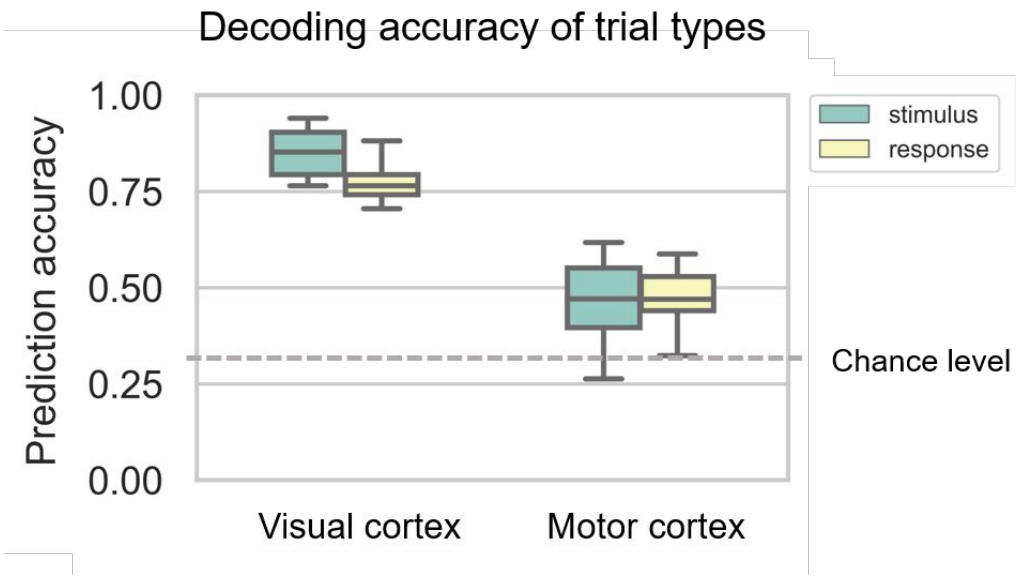




Steinmetz, N.A., Zatka-Haas, P., Carandini, M. *et al.* (2019).

Decoding trials information from neurons firing rates

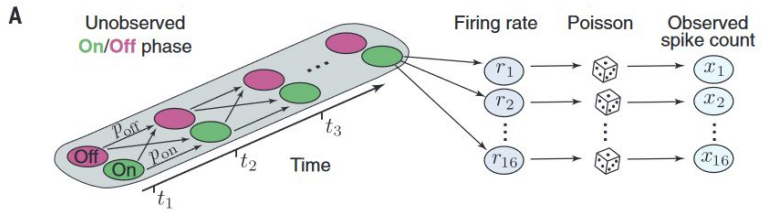
- The firing rate of neurons in visual cortex and motor cortex both contain trial information of stimulus and response.(Shuler & Bear, 2006)
- The firing rate of neurons in visual cortex better predicted stimulus type than response type.
- The firing rate of neurons in motor cortex had almost the same decoding accuracy in predicting stimulus types and response types.



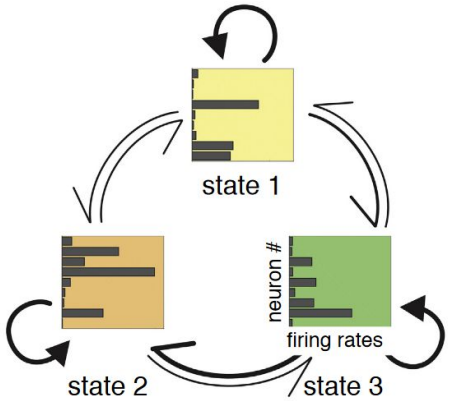
(Supportive vector classifier with 10-fold cross validation)

Selecting the best number of states for Hidden Markov Model

Poisson HMM

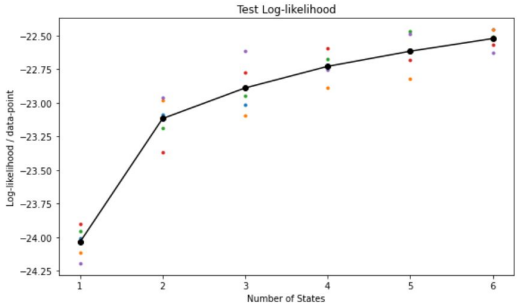


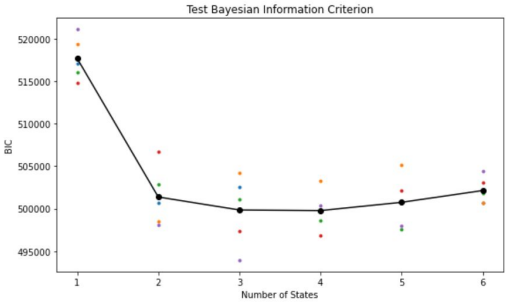
(Engel et al., 2016)



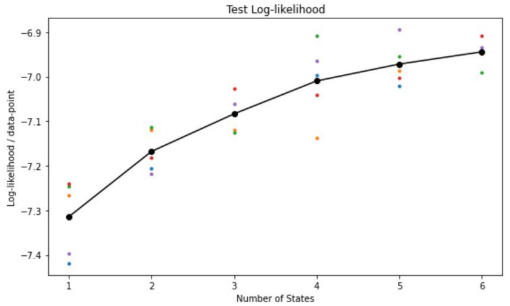
(Mazzucato et al., 2019)

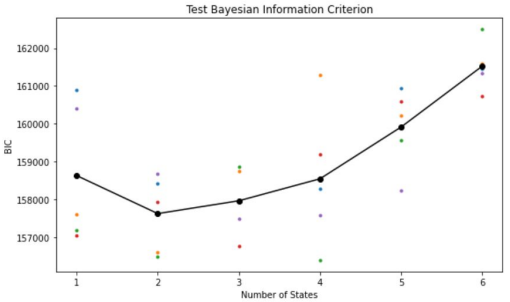
Visual cortex





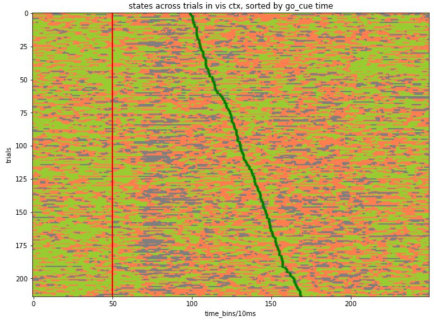
Motor cortex

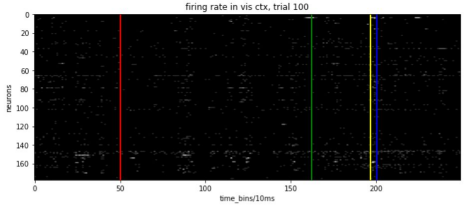


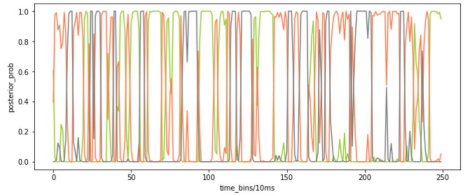


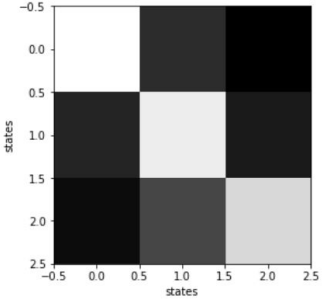
Hidden states in visual cortex and motor cortex using Hidden Markov Model

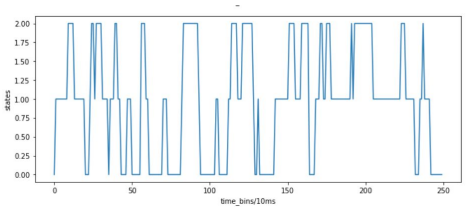
Visual cortex



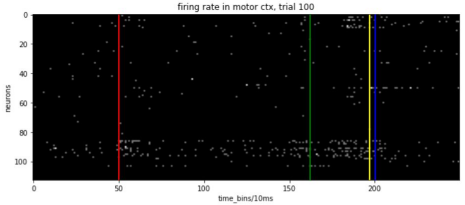


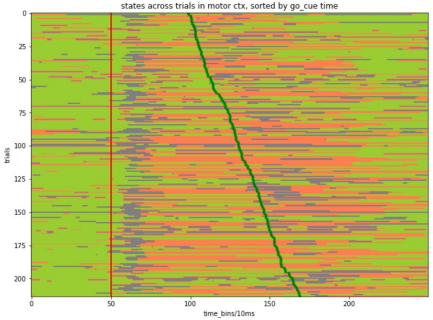


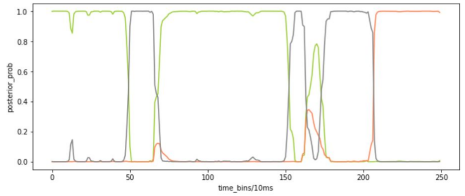


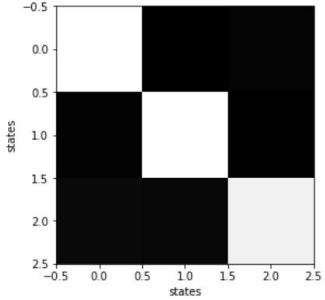


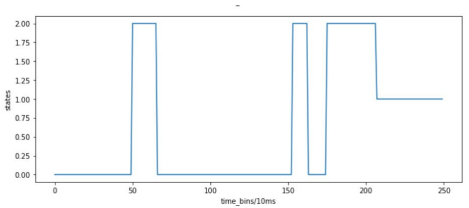
Motor cortex











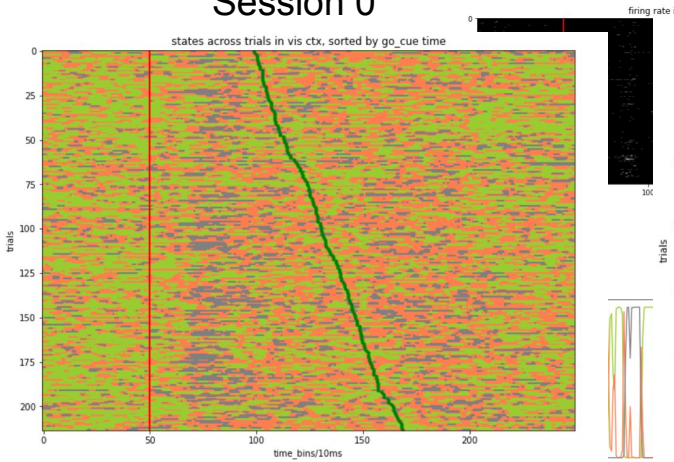
Hidden states in visual cortex and motor cortex using Hidden Markov Model

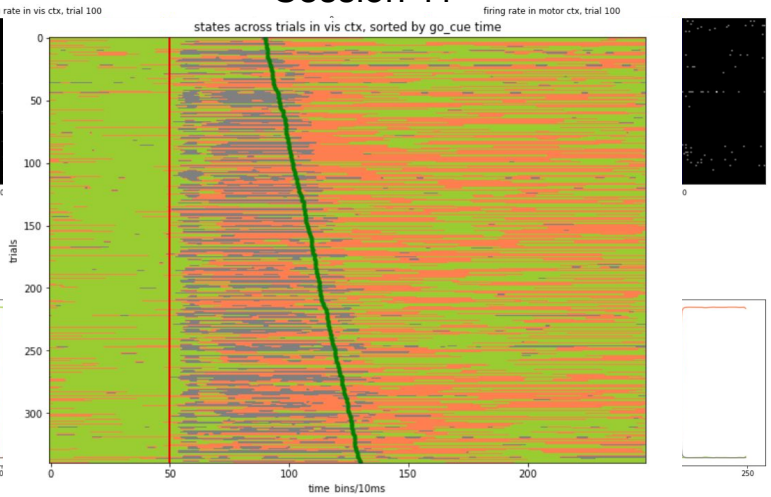
Visual cortex

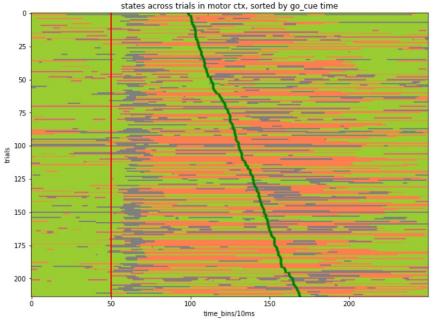
Motor cortex

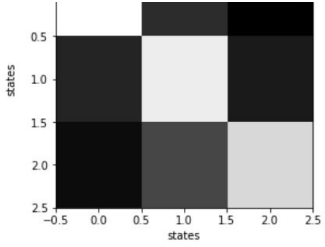
Session 0

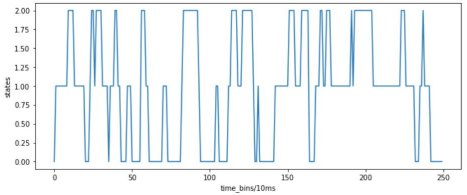
Session 11

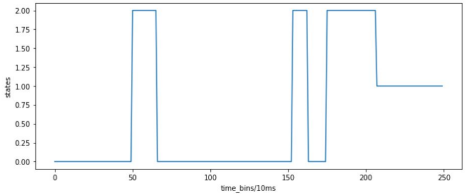


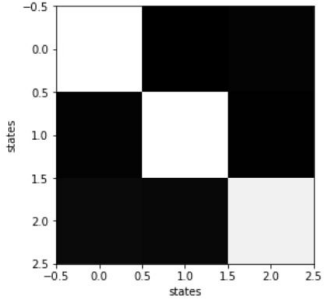






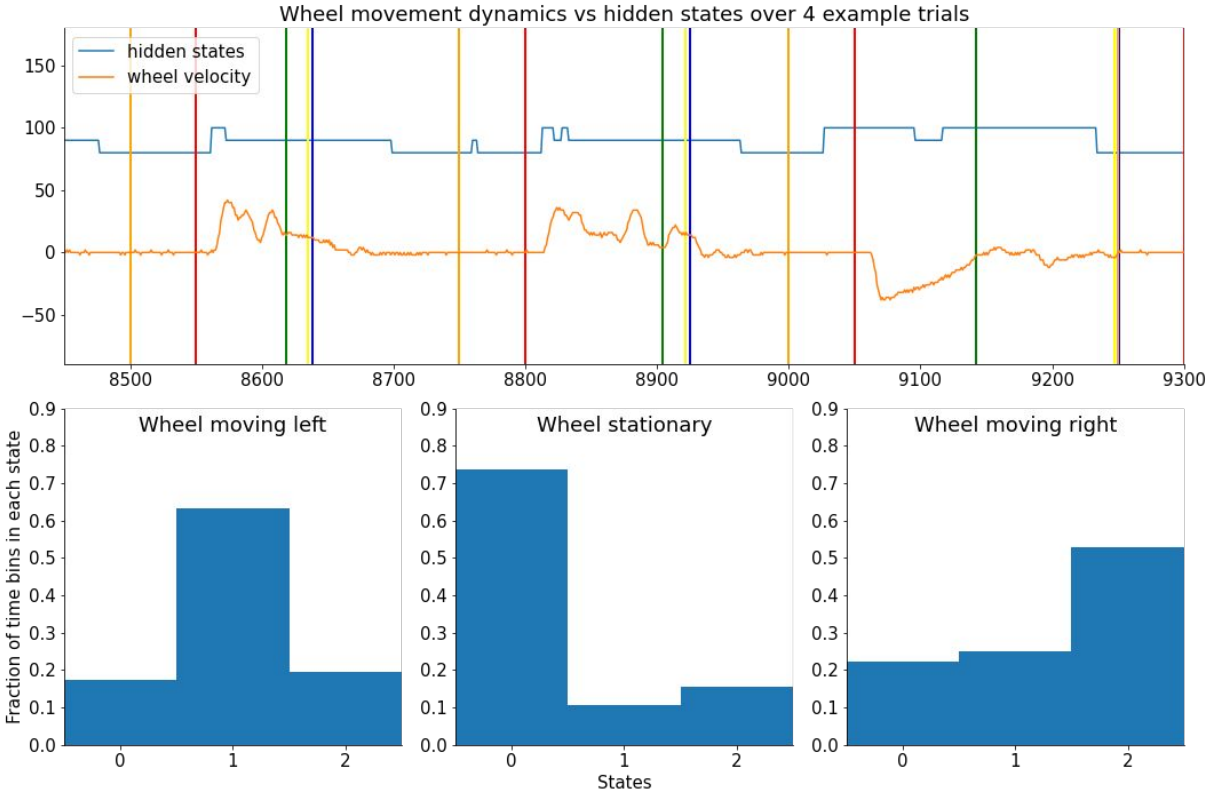






States in motor cortex reflect the direction of wheel motion

- Wheel motion direction is predicted quite well by the HMM fit
- The accuracy of prediction is the lowest for moving in **the ipsilateral direction**



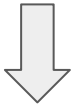
Statistical features of different hidden states

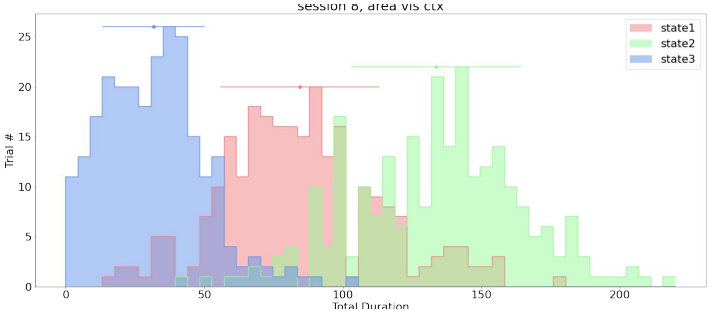
Visual cortex

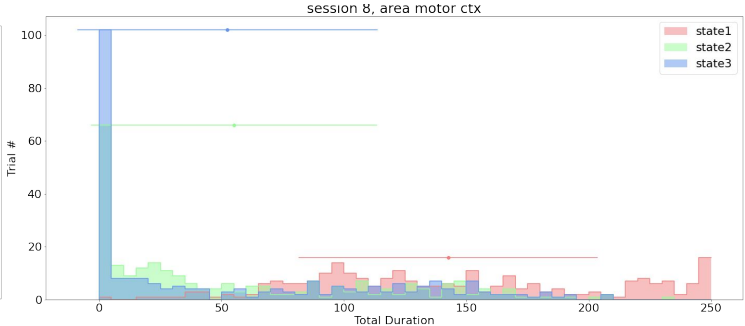
Motor cortex

State duration time

Different direction of movement

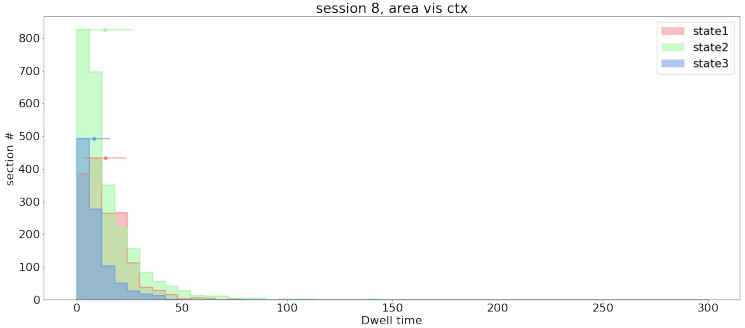


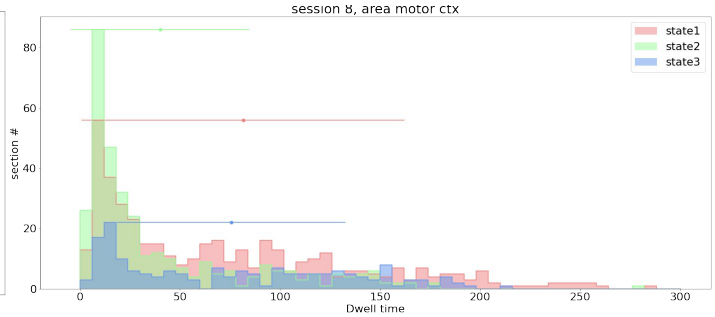




Different brain activity

Dwell time



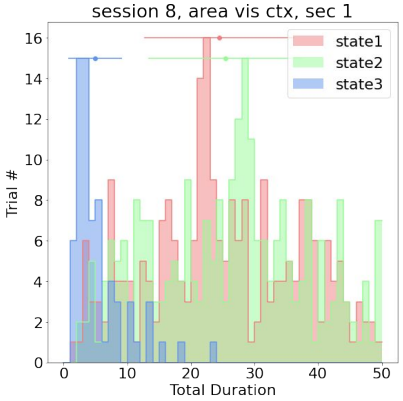


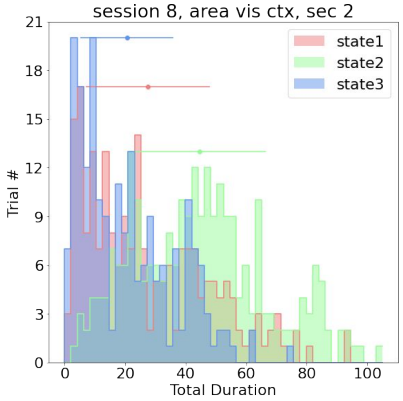
High standard deviation

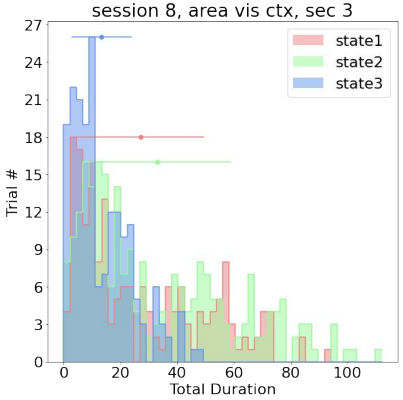
Non-Poisson

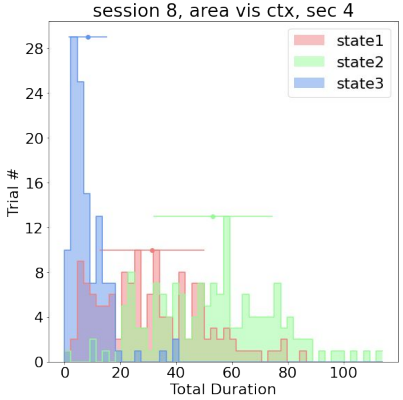
Duration of states within different sections

Visual cortex

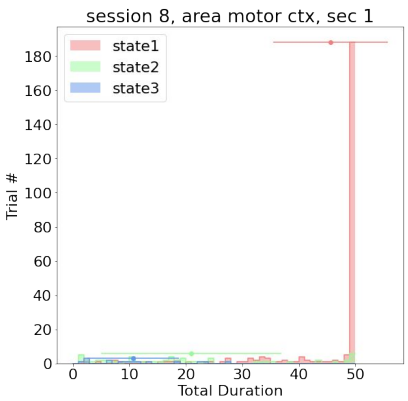


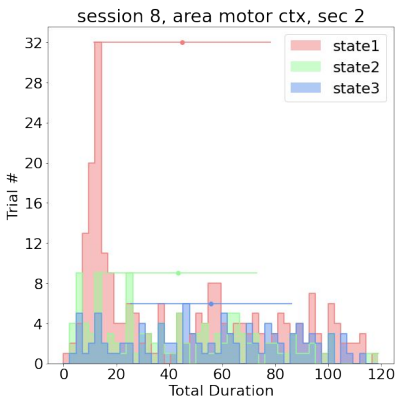


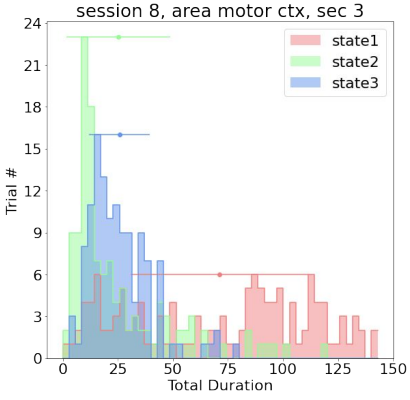


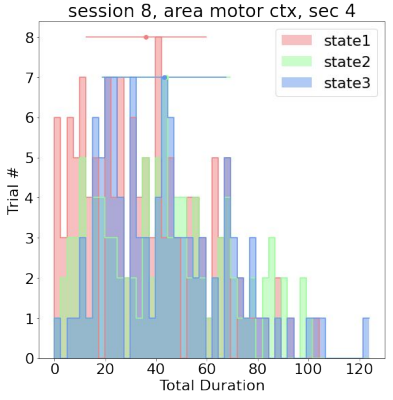


Motor cortex

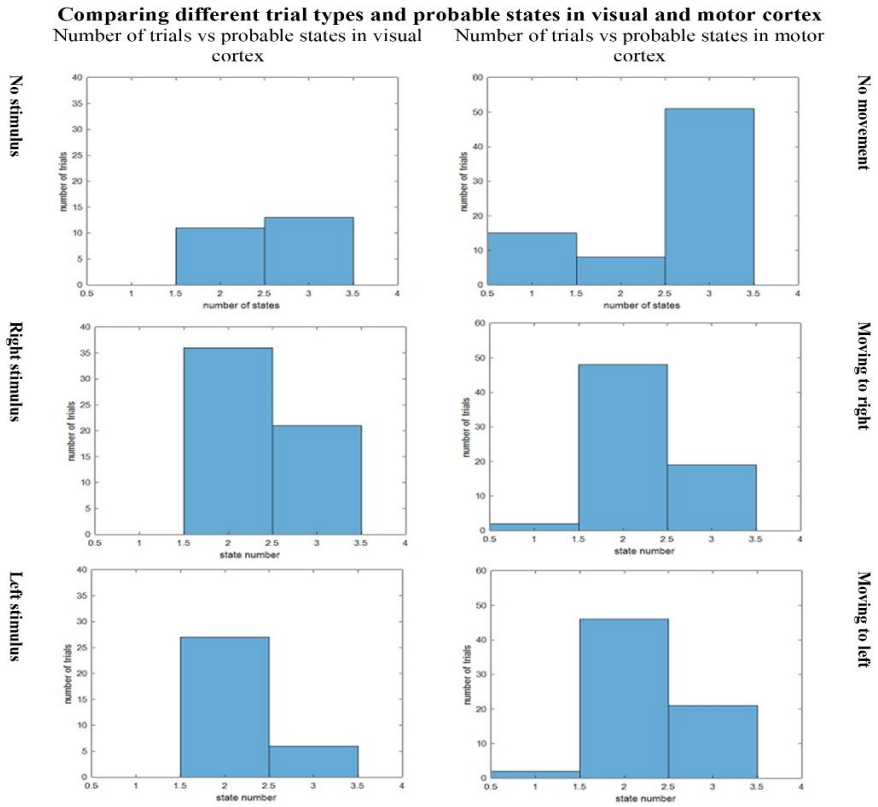


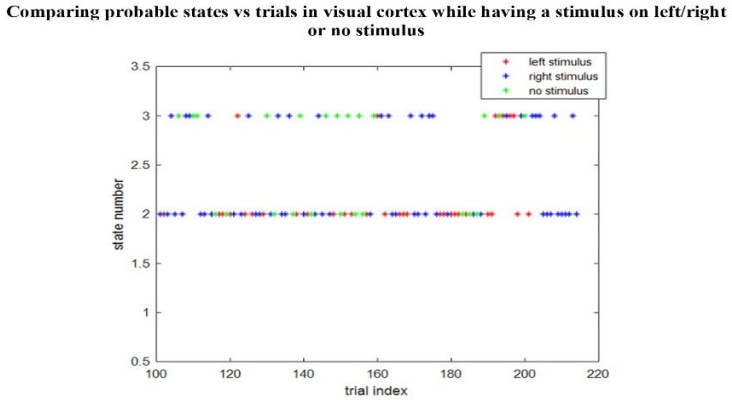


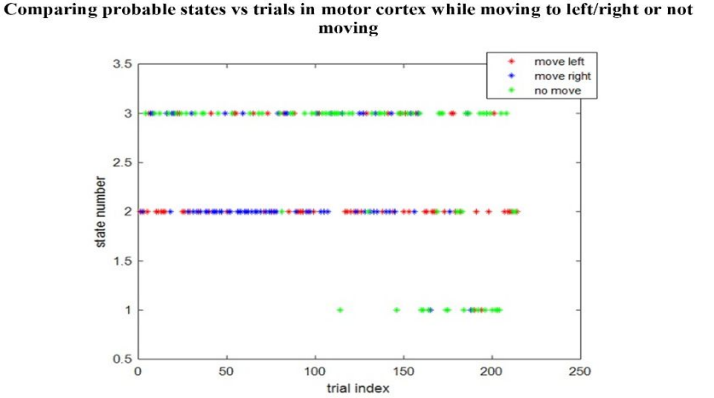




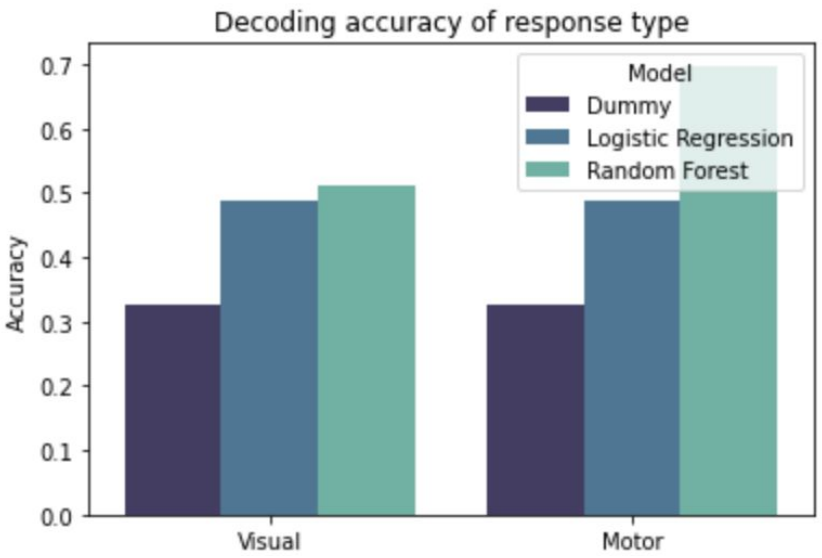
Comparing different stimulus/movement types in visual and motor cortex

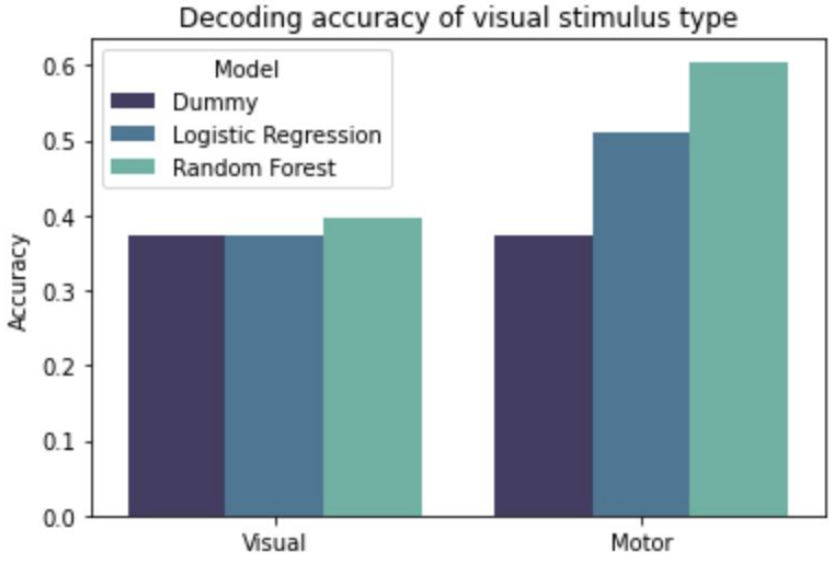






Decoding trial information from HMM posterior in visual cortex & motor cortex





Discussion

- Hidden states under visual cortex correlate to the visual stimuli type, and have more frequent transitions

- Hidden states under motor cortex correlate to movement direction, and the transitions are more stable

- Information encoded is different in different areas during this visual discrimation task.
  - visual cortex encodes more visual stimuli related information
  - motor cortex encodes more movement related information

- Results will change across different sessions
  - eg. hidden states under visual cortex have more stable transition pattern.

- Unfinished: **how** does information transform from the visual cortex to the motor cortex, we just figure out the difference of neural dynamics in visual cortex and the motor cortex.

Thank you!