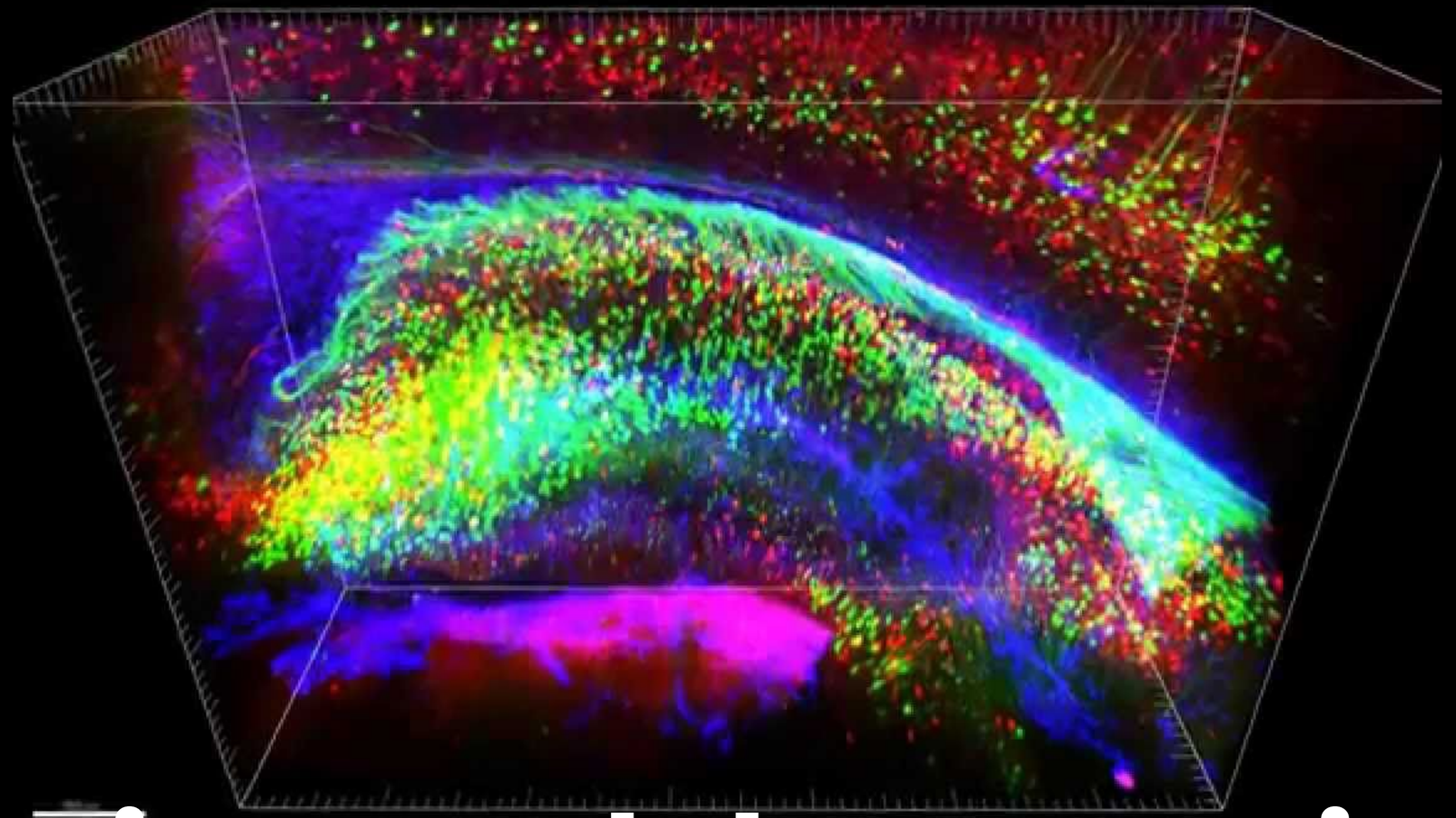
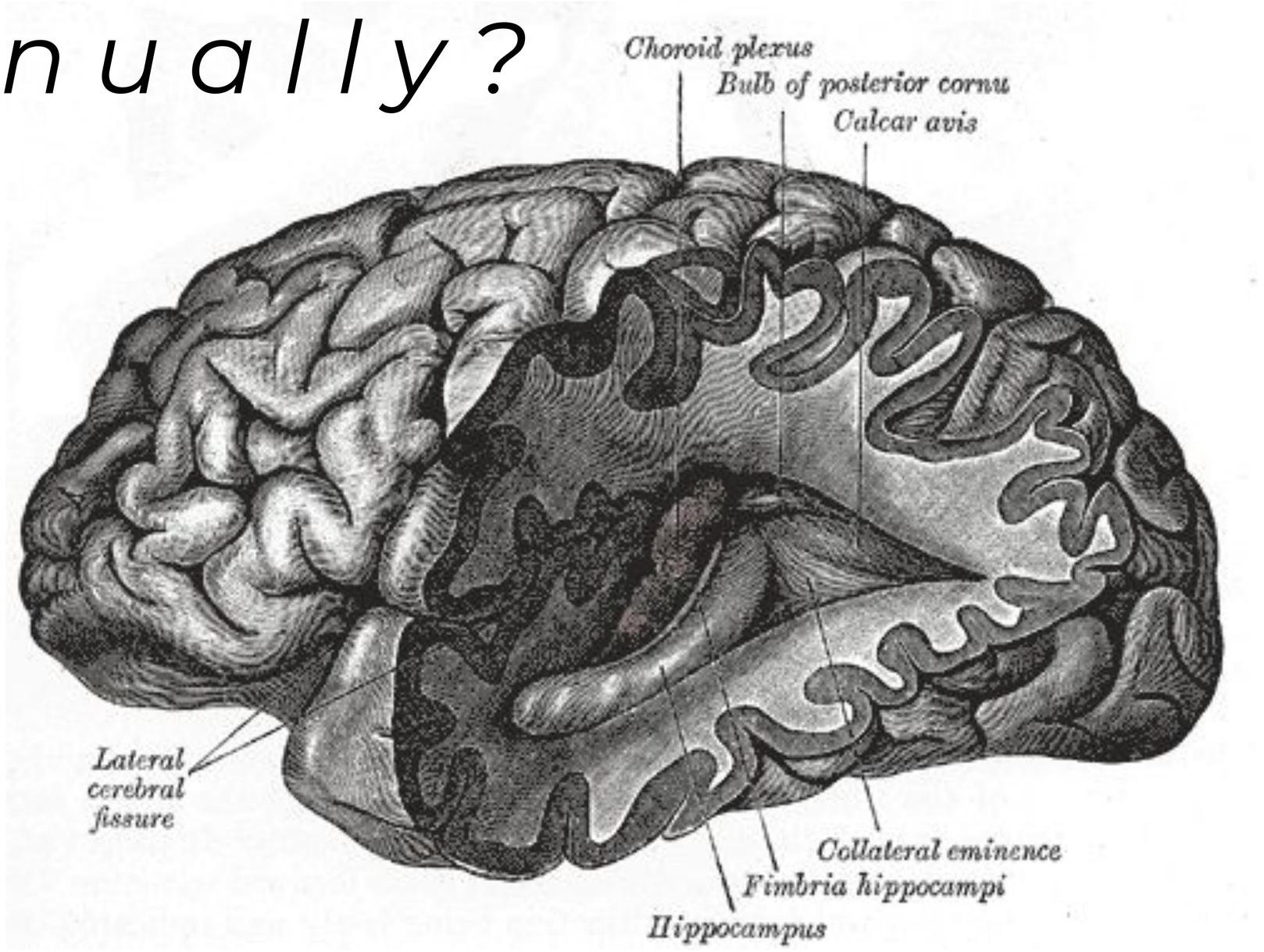
Keiland Cooper | kwcooper.xyz | University of California, Irvine | Continual AI | 200326



continual learning:
Neuroscience + AI

How does the brain learn *continually?*



Figures from Gray 1858

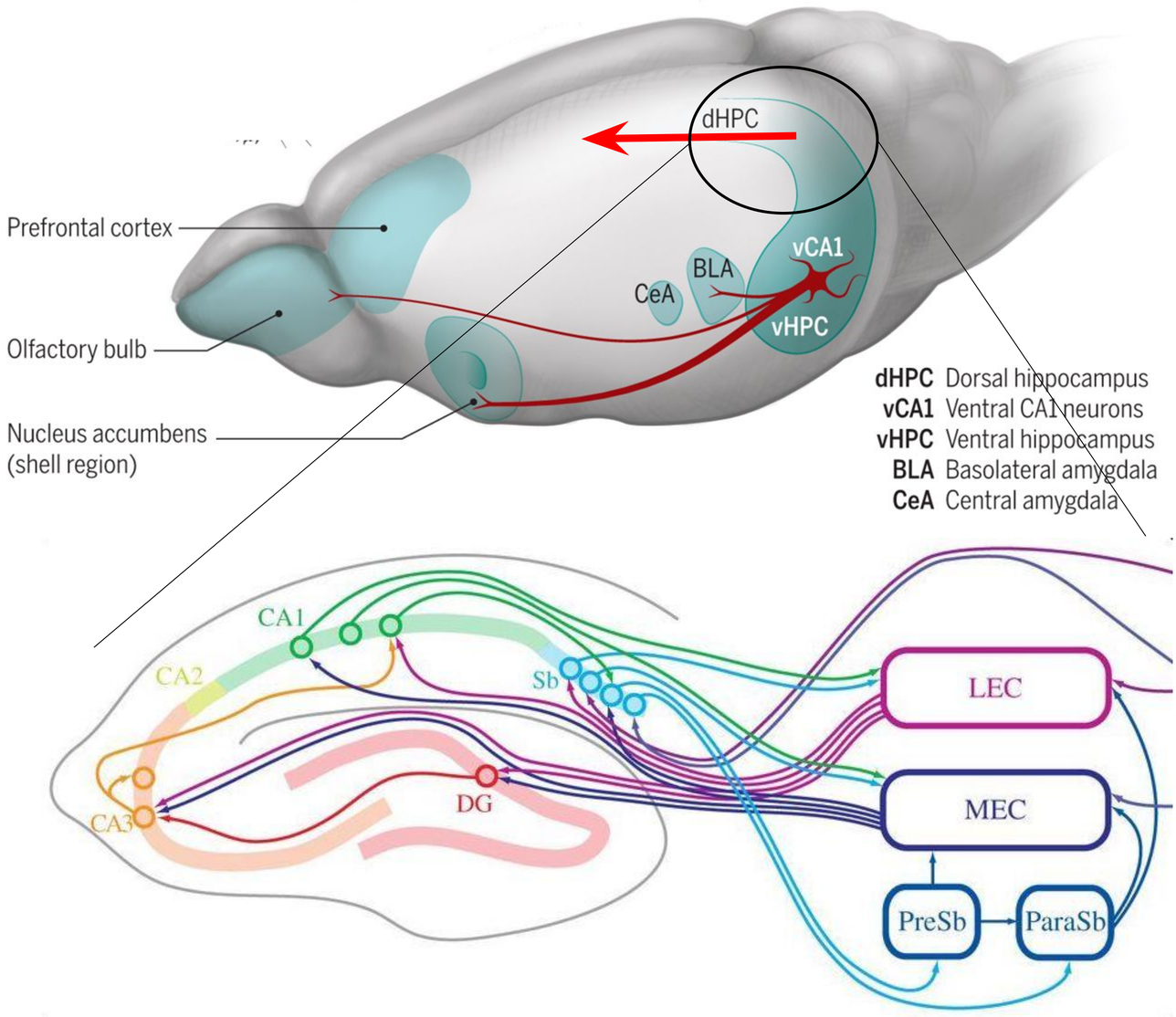
Hippocampal Contributions

Hippocampal circuits are well defined

Circuit plasticity defined by Hebbian rules

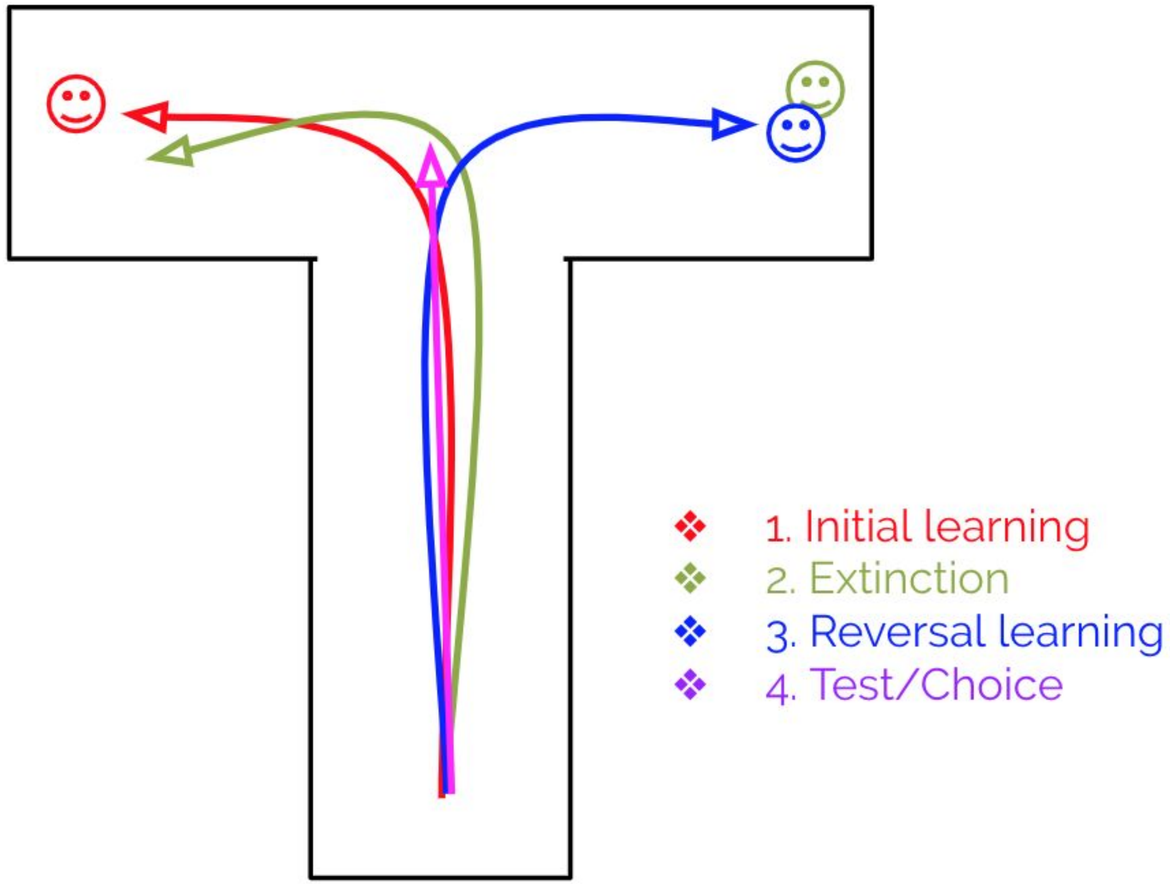
Neuronal activity timed (theta rhythm (6-12 Hz))

Chemicial modulation (acetylcholine)



Figures from Saxena 2016; Hartley 2014

Hippocampal Mode switching

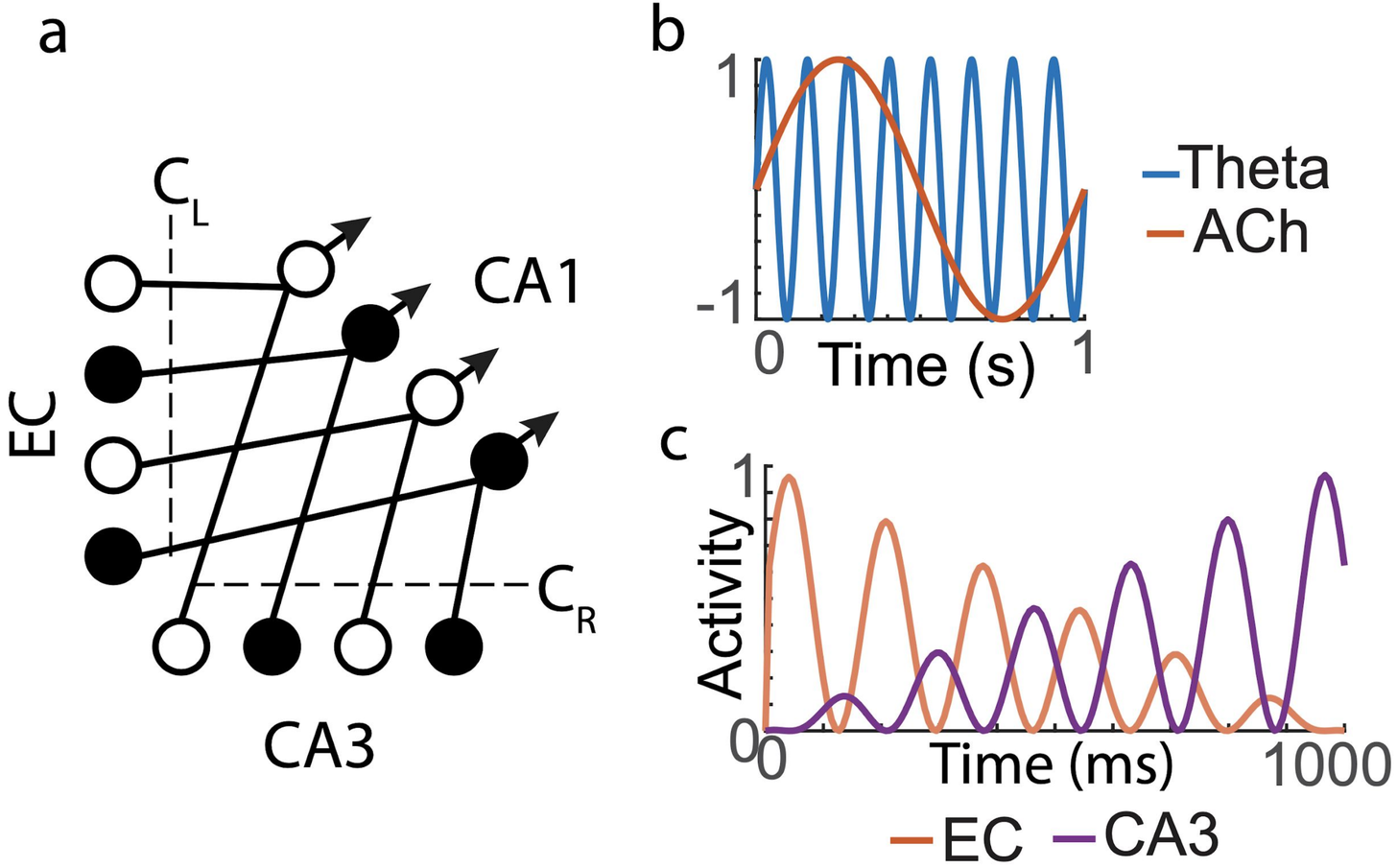


T - maze alternation task

Animal must prevent the association of the past reward interfering with the new location

Tabular Q learning methods cannot account for this?

Hippocampal Mode switching



A. Network model of EC, HPC, and cholinergic modulation

B. Varying timescales of theta and cholinergic activity

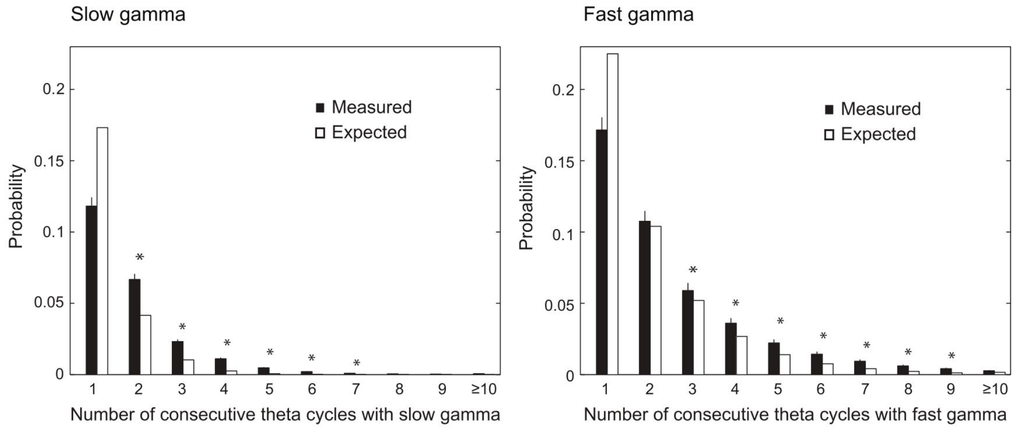
C. Scaling EC and CA3 activity across multiple mode timescales

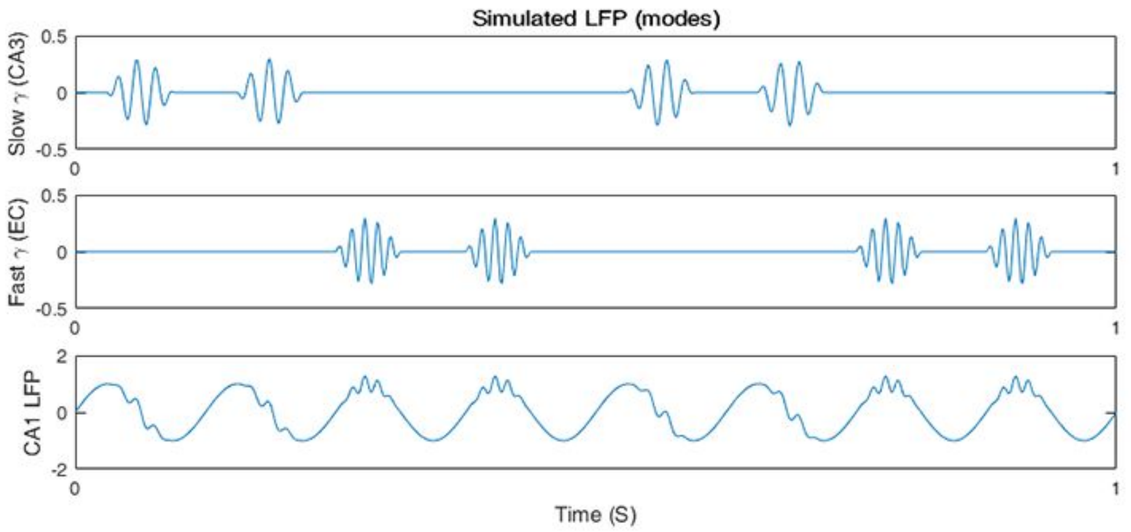
Hippocampal Mode switching

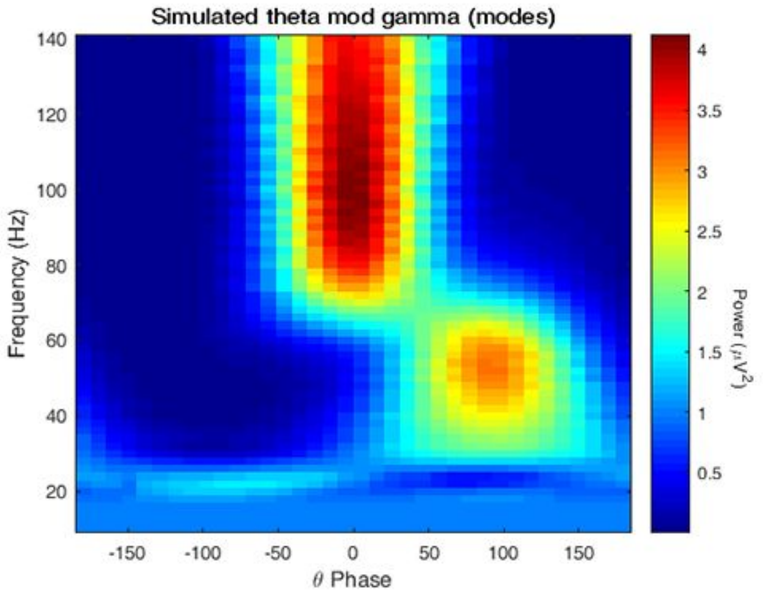
Top figure from Colgin 2009: Fast and slow gamma are offset.

Below: output from the model, demonstrating modes of EC and CA3 activity.

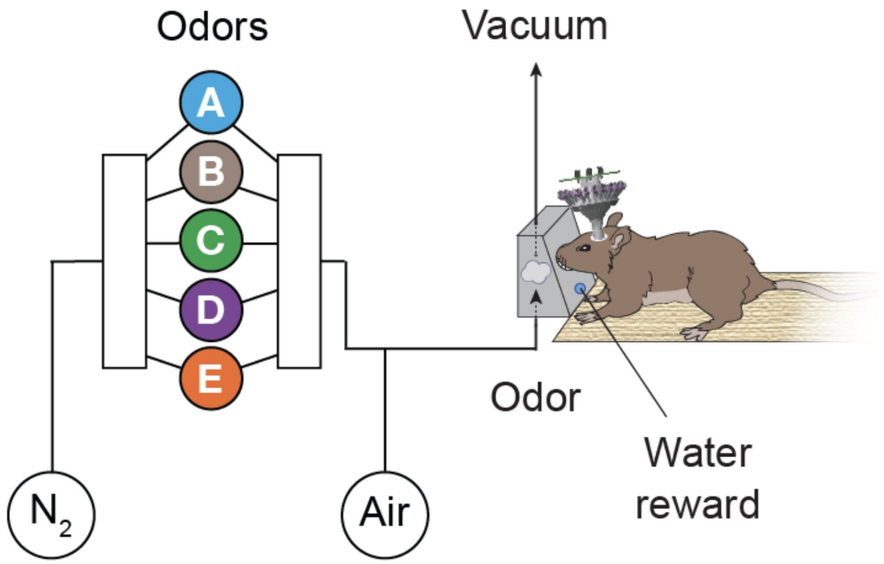
EC: Fast gamma, CA3: Slow gamma







Sequence decoding

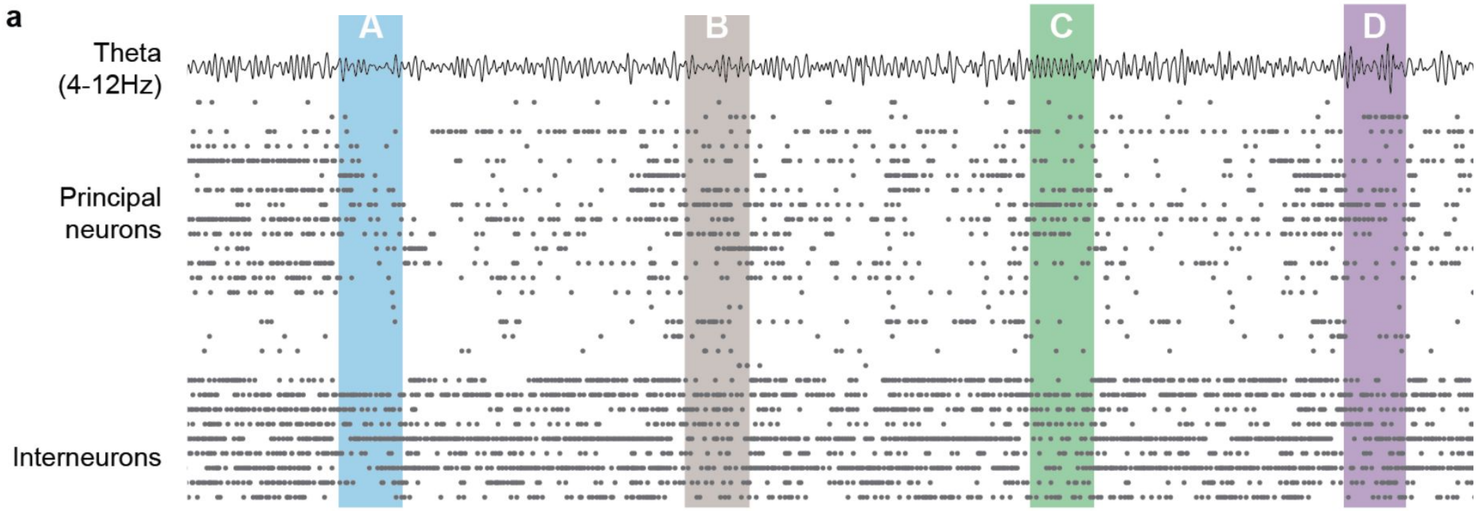


presented a sequence of odors.

Rewarded for “correct sequences”

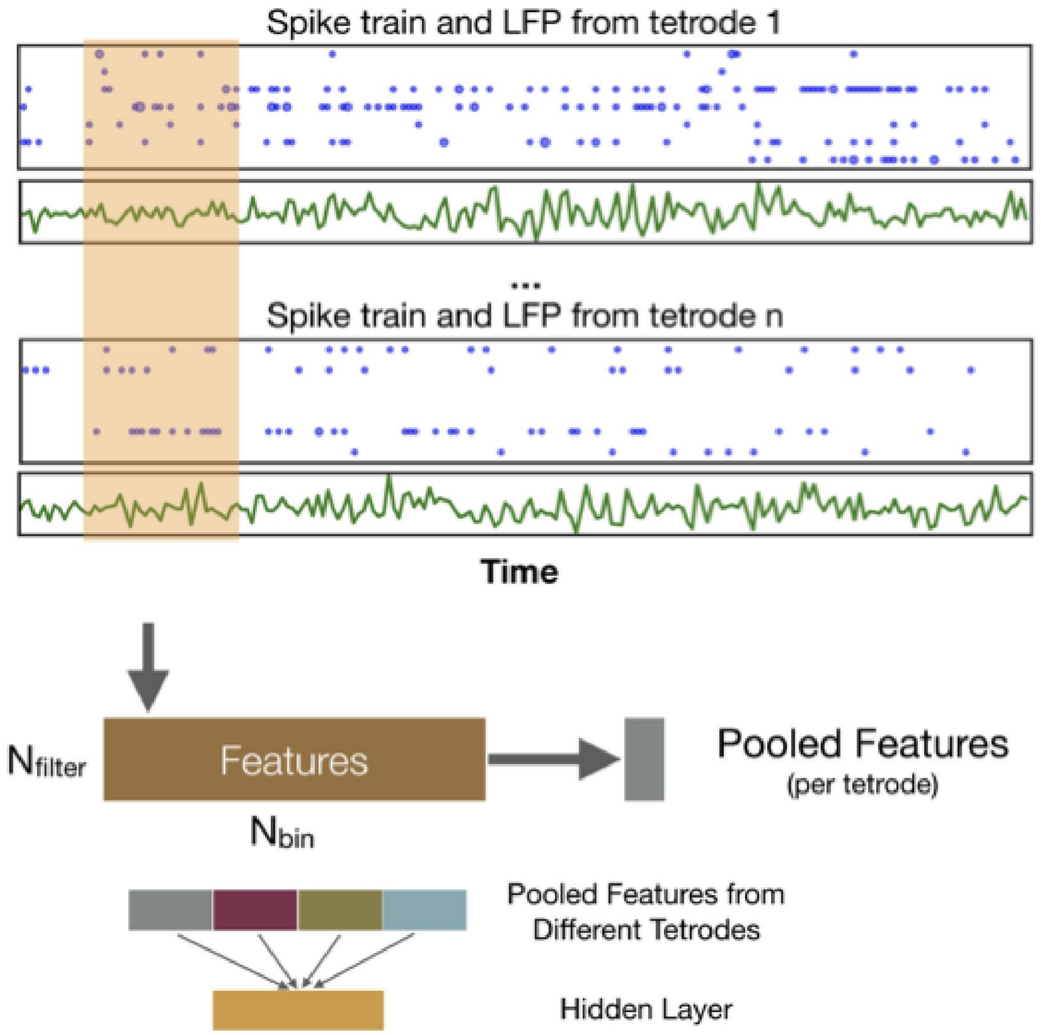
if incorrect, animal must leave port

CA1 tetrode recordings



Shahbaba 2020; Fortin lab

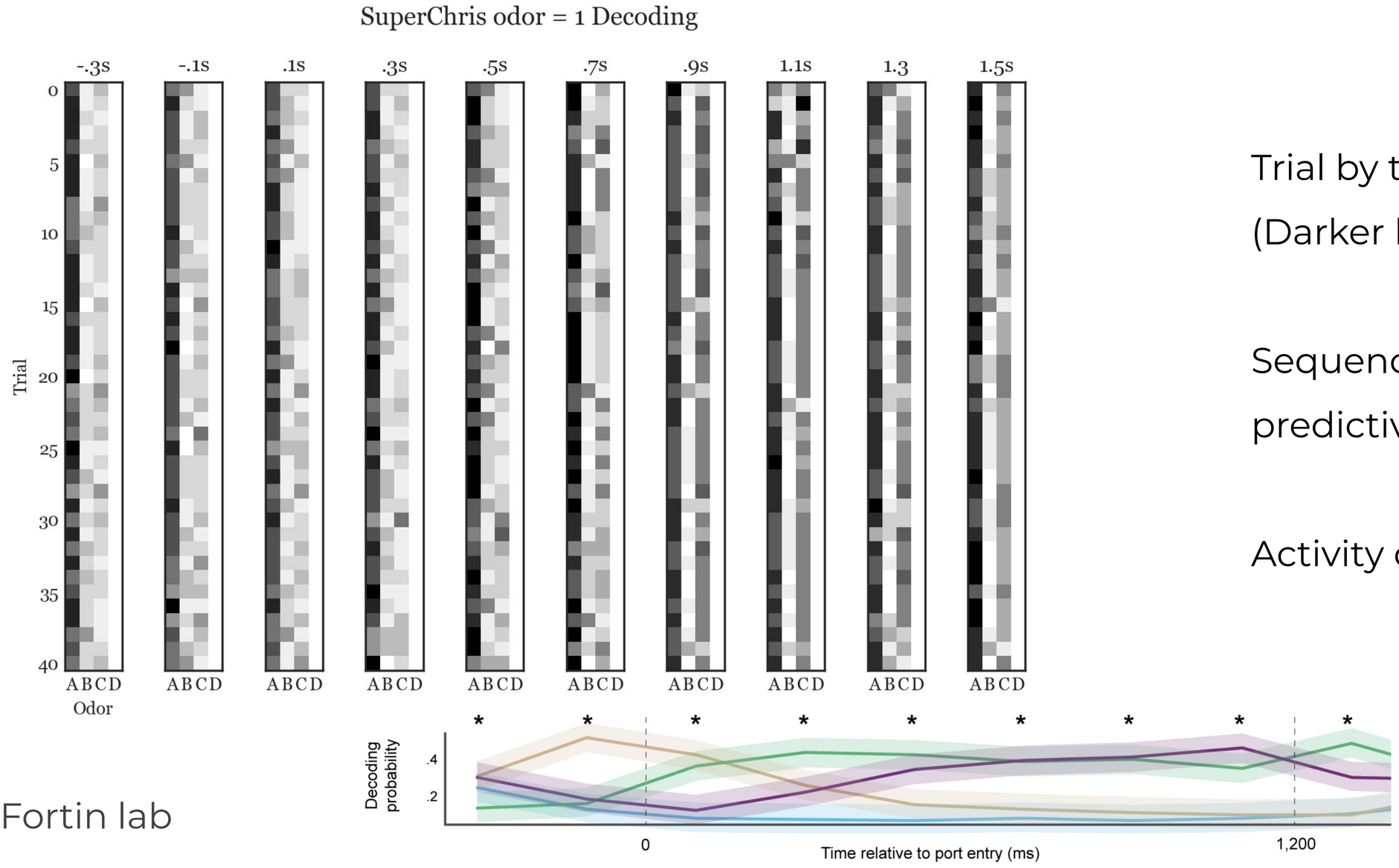
Sequence decoding



CNN using LFP & spike as input features

output: probability of odor

Sequence decoding



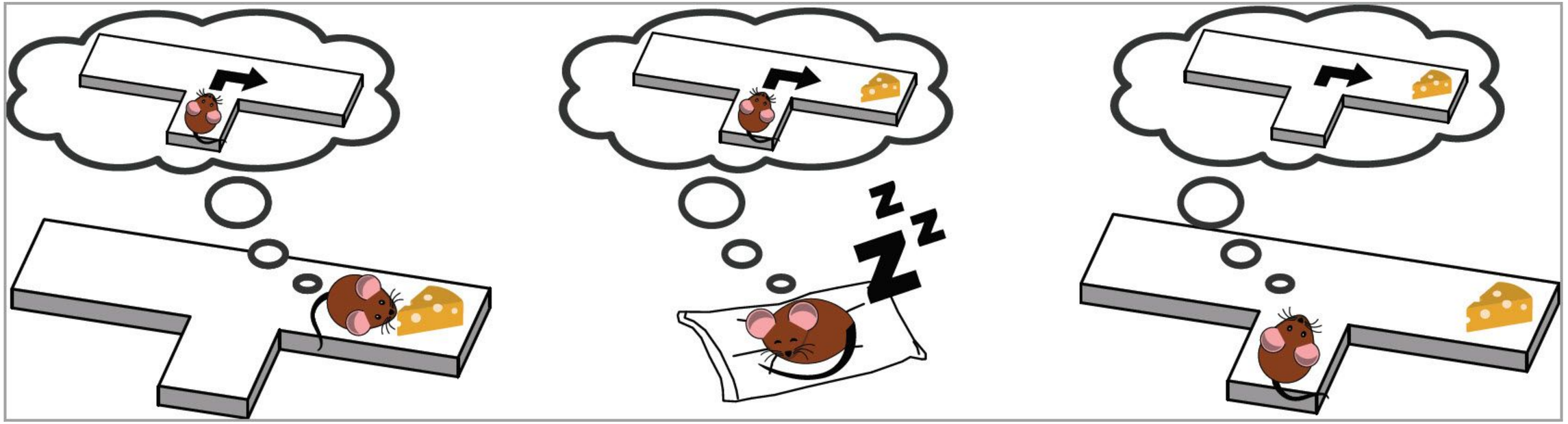
Trial by trial odor decoding (Darker higher probability)

Sequences display a sort of predictive coding

Activity of next item increases

Fortin lab

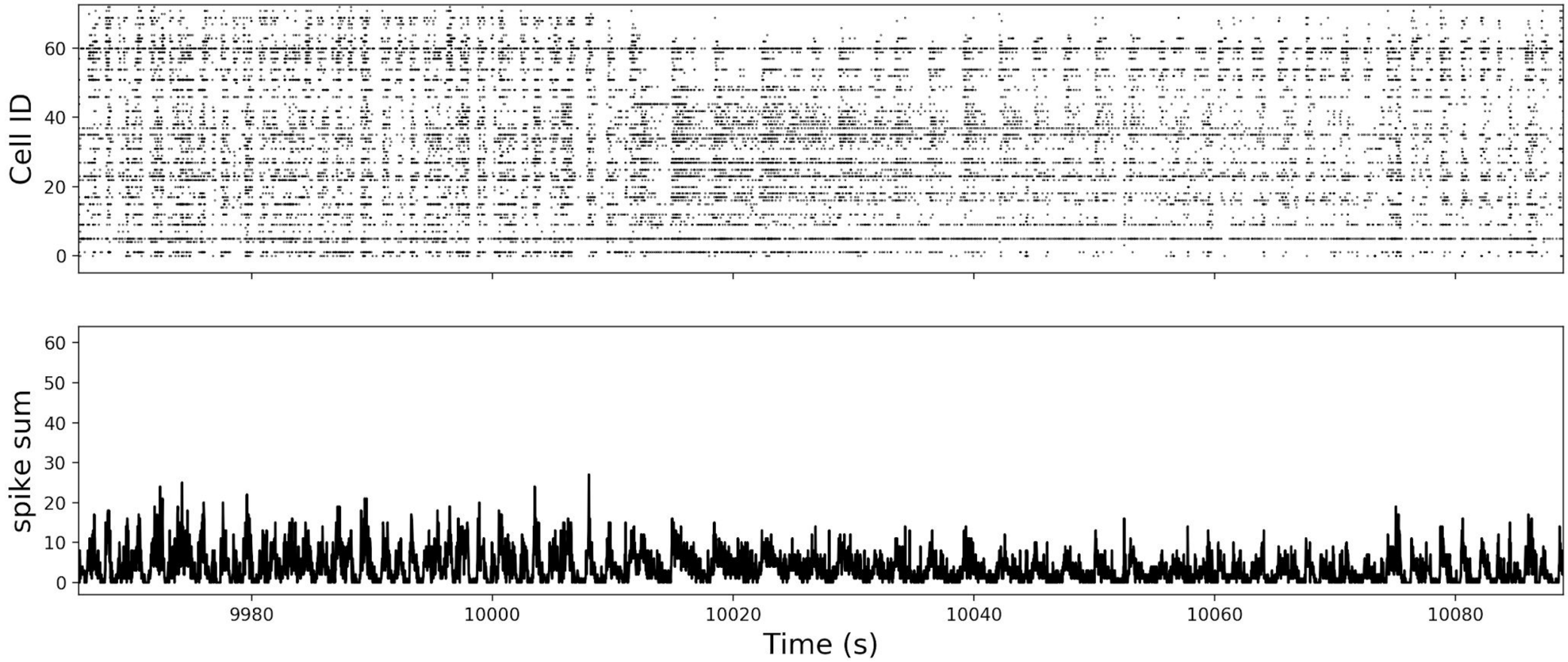
Sleep Replay



Replay, a common technique to overcome CF

Figures from Mattar 2018

Sleep Replay



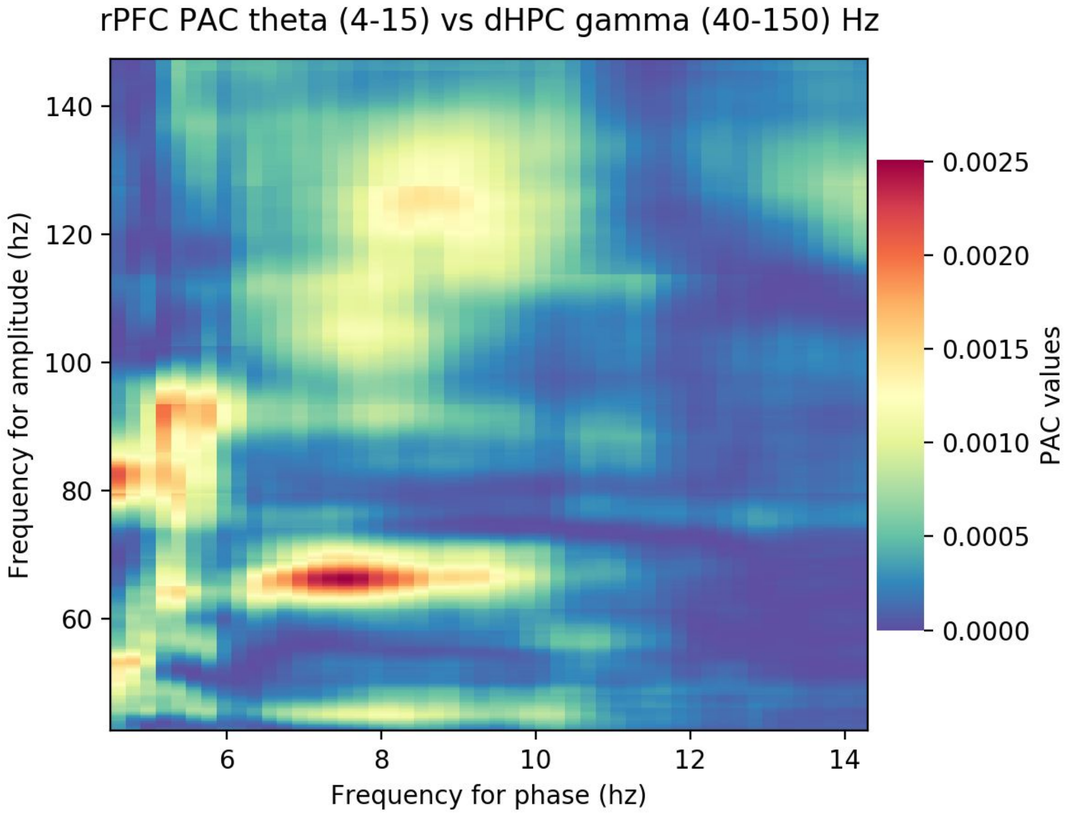
Cortex spiking data during waking and sleep

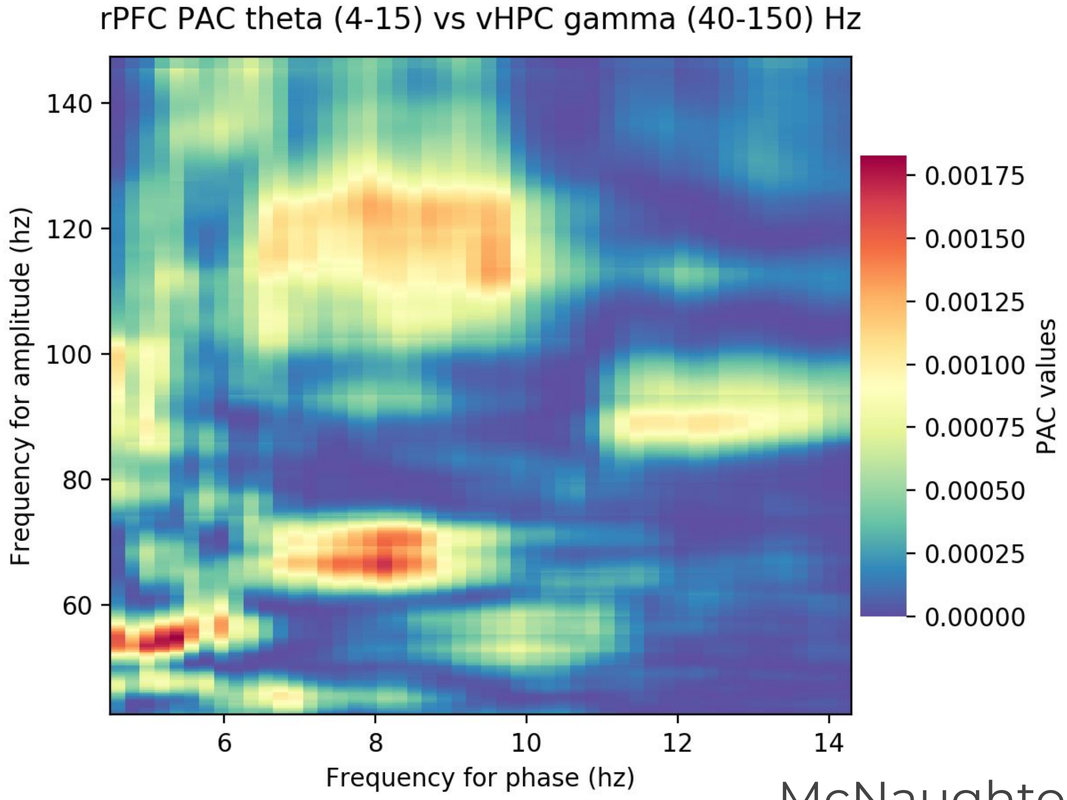
McNaughton Lab

HPC / CTX PAC

Phase amplitude coupling has also been shown to display information exchange and directionality similar to granger causality (Nandi et al 2019)

One example of this is dvHPC vs right PFC coupling:





INP | Interdepartmental Neuroscience Program

Keiland Cooper | kwcooper.xyz

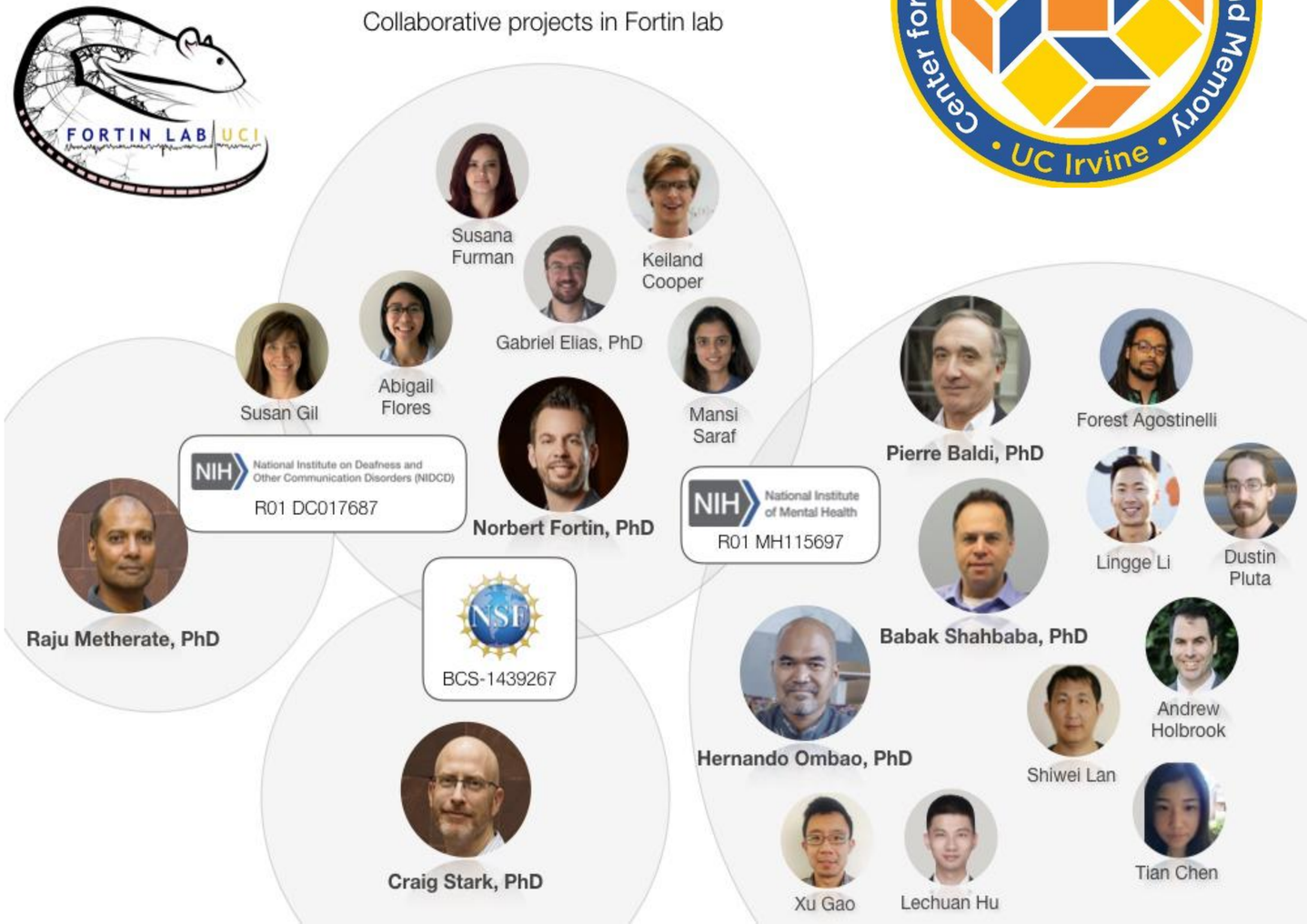
Newman Lab: Ehren Newman (IU)

Fortin Lab: Norbert Fortin (UCI)

McNaughton Lab: Bruce McNaughton (UCI)

Ivan Skelin

Rajat Saxena

Scott Kilianski

Justin Shobe