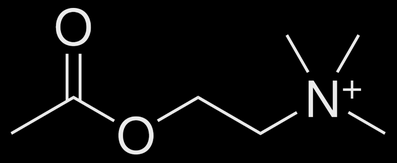
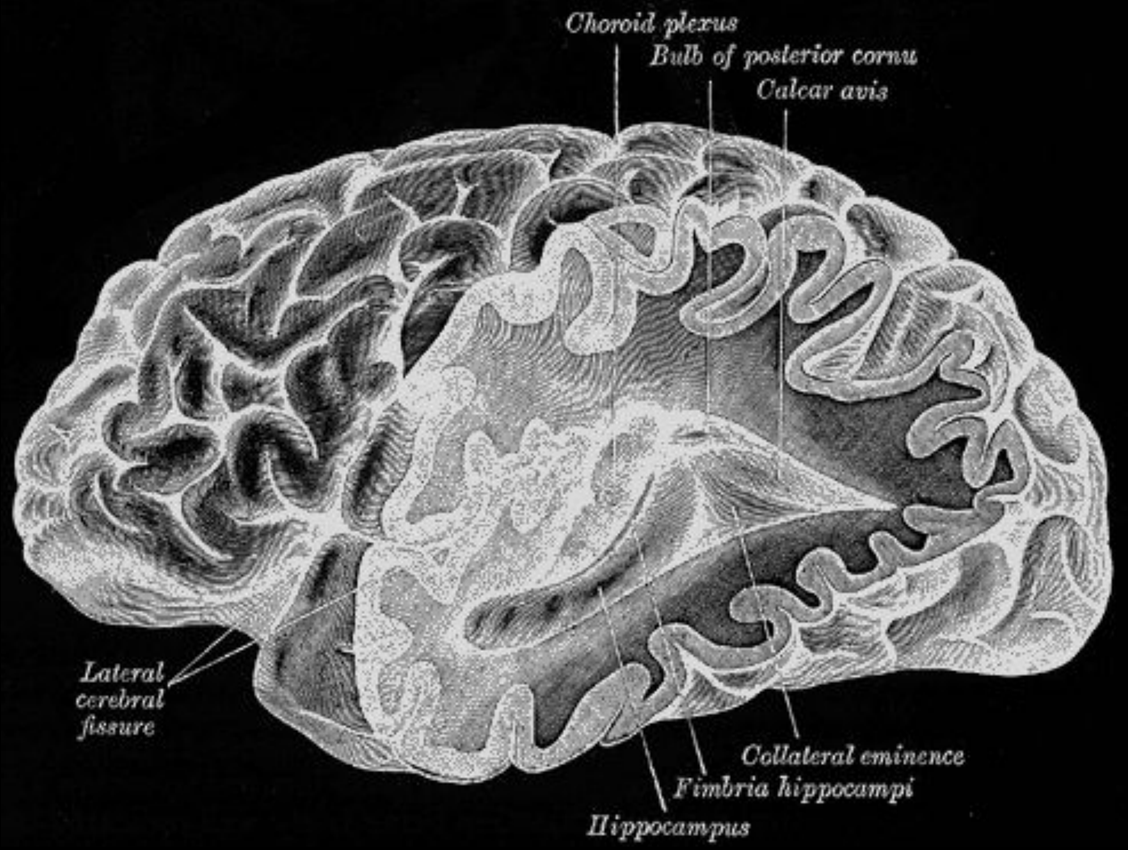
Keiland Cooper | kwcooper.xyz | University of California, Irvine | Neuromatch | 200326

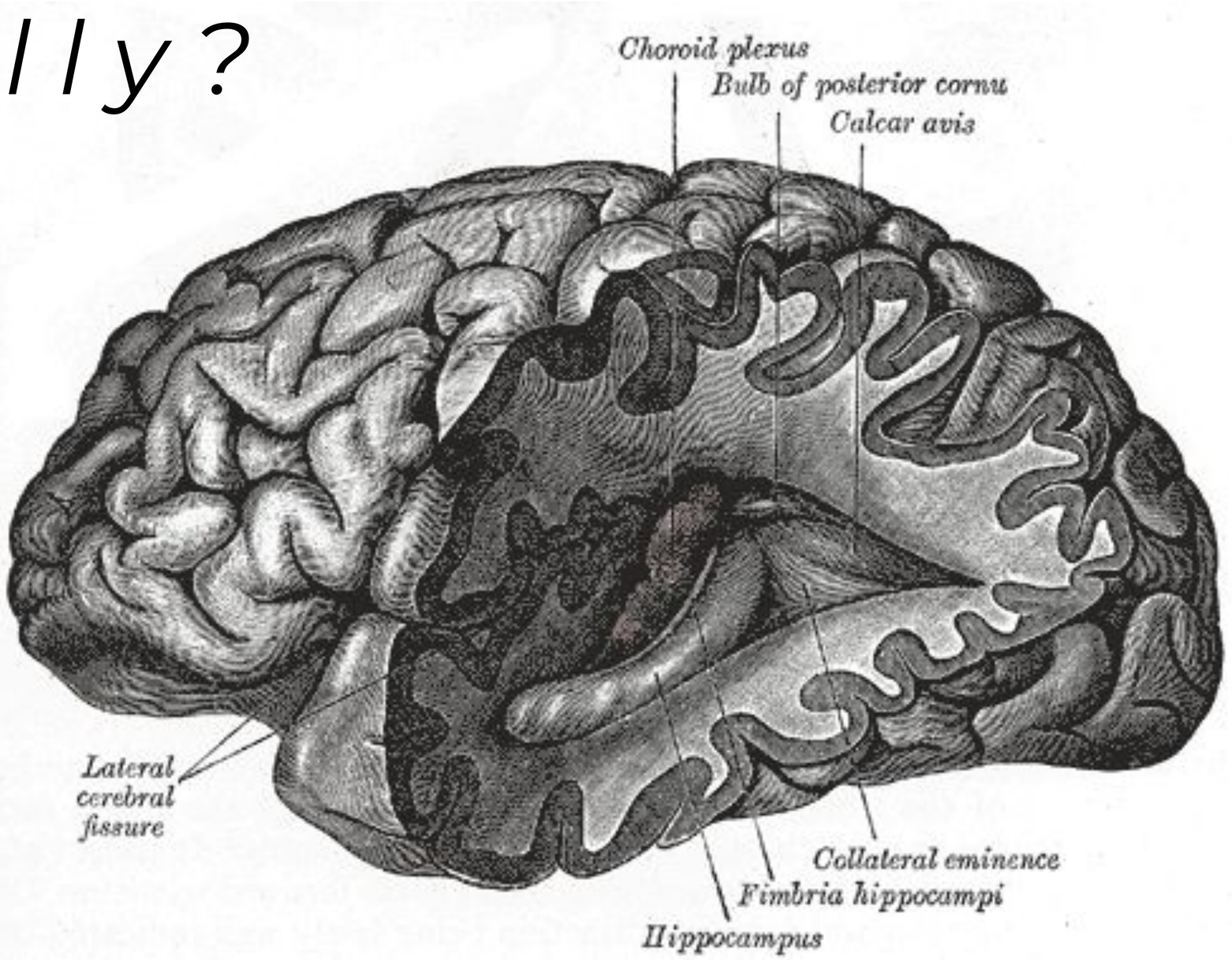




Dual processes of hippocampal mode switching

How does the brain learn

continually?



ContinualAI

www.continualai.org

Figures from Gray 1858

Hippocampal Contributions

Hippocampal circuits are well defined

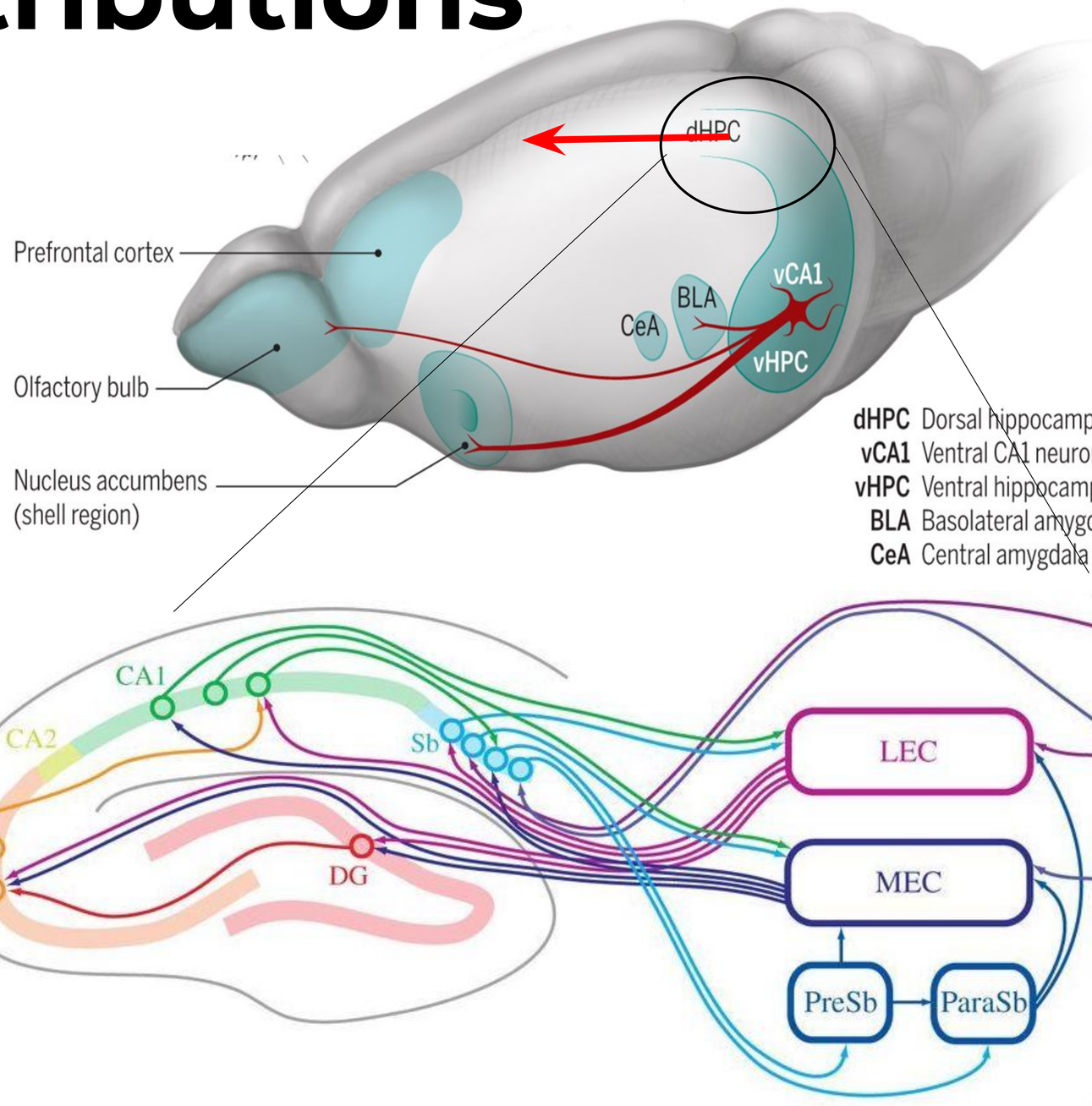
Circuit plasticity defined by Hebbian rules

Neuronal activity timed

ie. theta (~6-12 Hz); gamma (~30 - 120 Hz)

Chemicial modulation

ie. acetylcholine



Figures from Saxena 2016; Hartley 2014

Hippocampal Modes

Networks must serve 2 memory functions:

encoding and retrieval

Hasselmo 2002; Honey 2017

EC as encoding

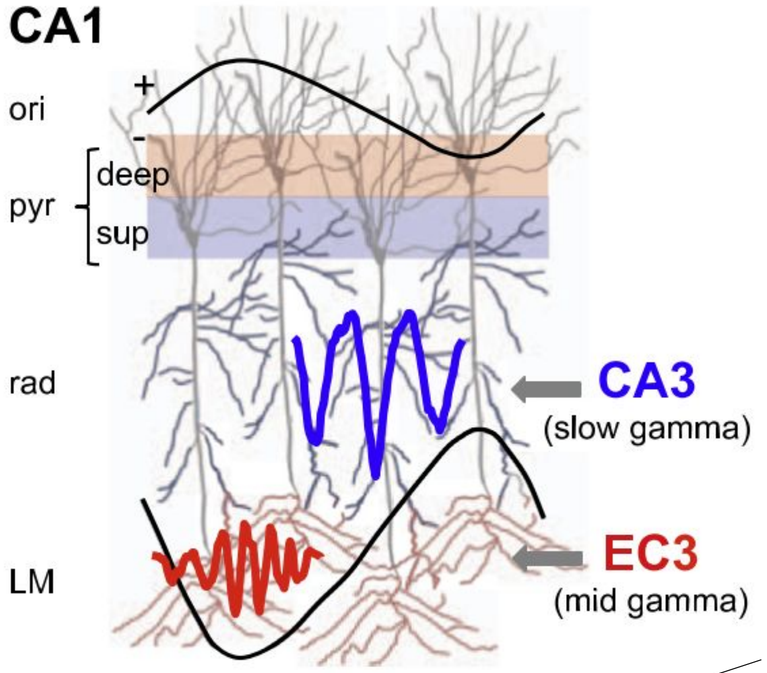
CA1 representents local information during EC drive

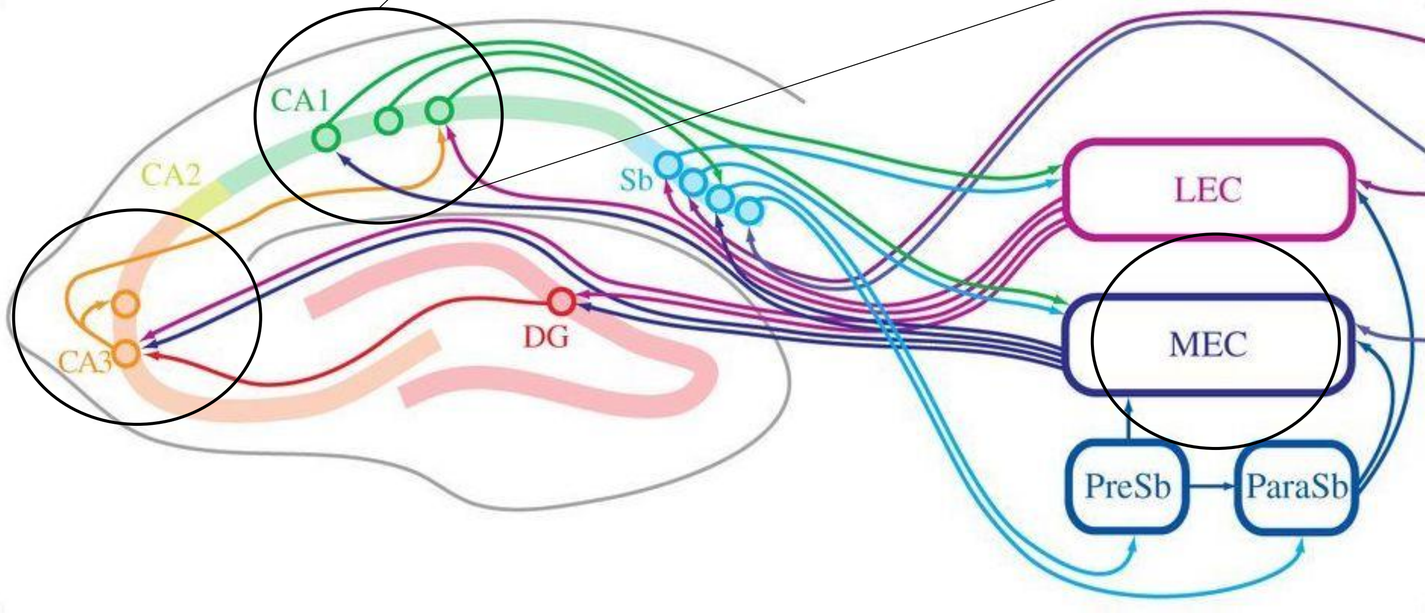
Fernández-Ruiz et al., 2017; Itskov, Pastalkova, Mizuseki, Buzsáki, & Harris, 2008; O'Keefe & Recce, 1993

CA3 as retrieval

Recurrent dynamics

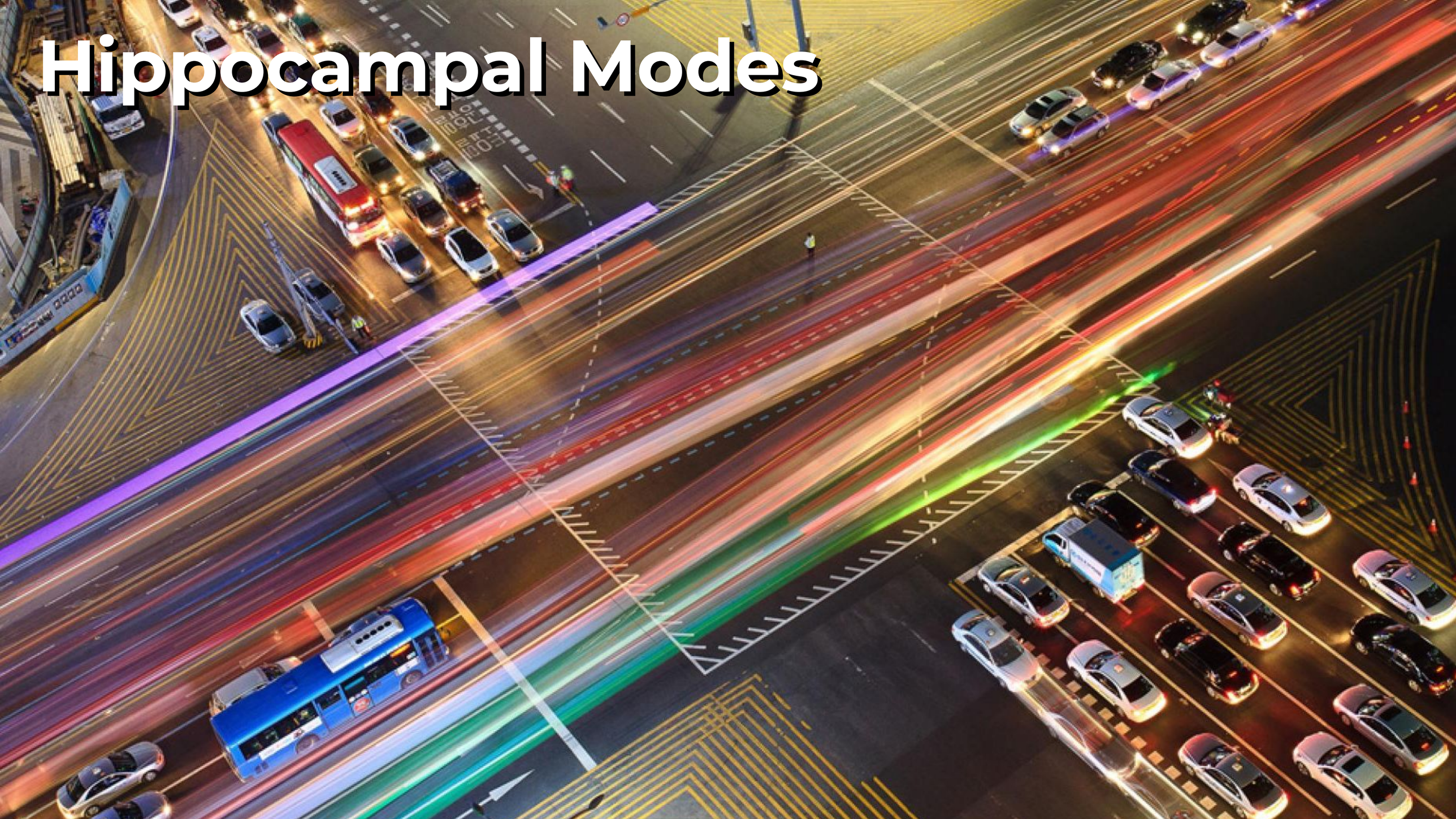
Marr 1972; Hopfield 1982; Itskov, Pastalkova, Mizuseki, Buzsáki, & Harris, 2008; O'Keefe & Recce, 1993





Figures from Hartley 2014; Fernández-Ruiz et al., 2017

Hippocampal Modes



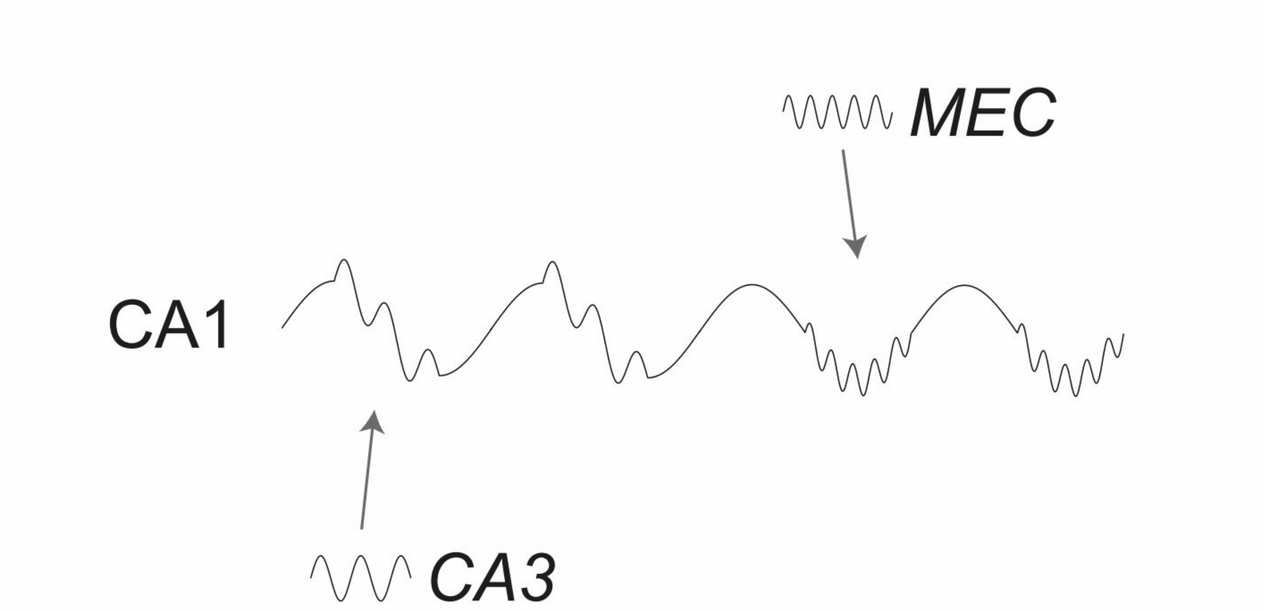
Hippocampal Modes

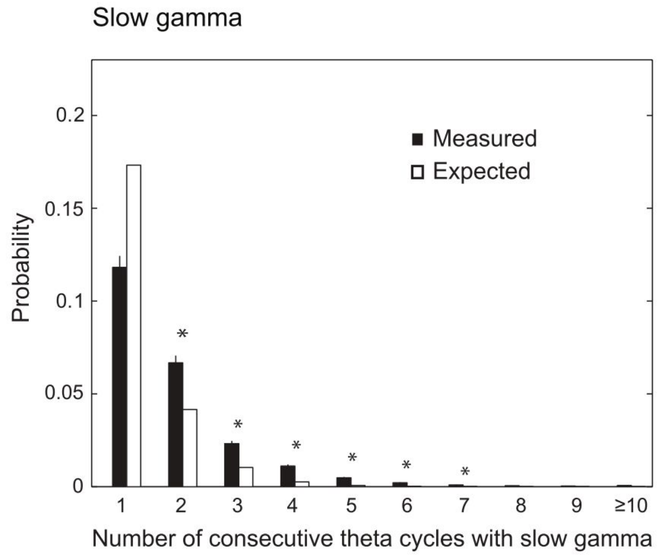
Hippocampal Mode switching

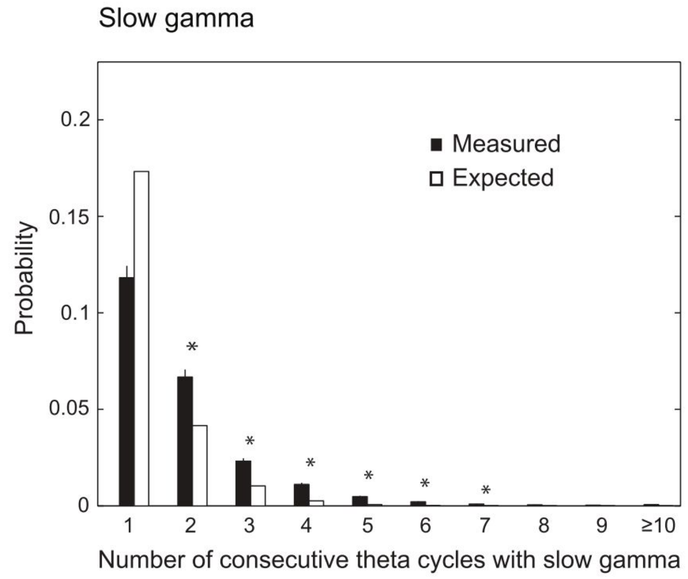
From Colgin 2009:

Gamma epochs are offset by cycle however, multiple cycles apart.

EC: Fast gamma, CA3: Slow gamma







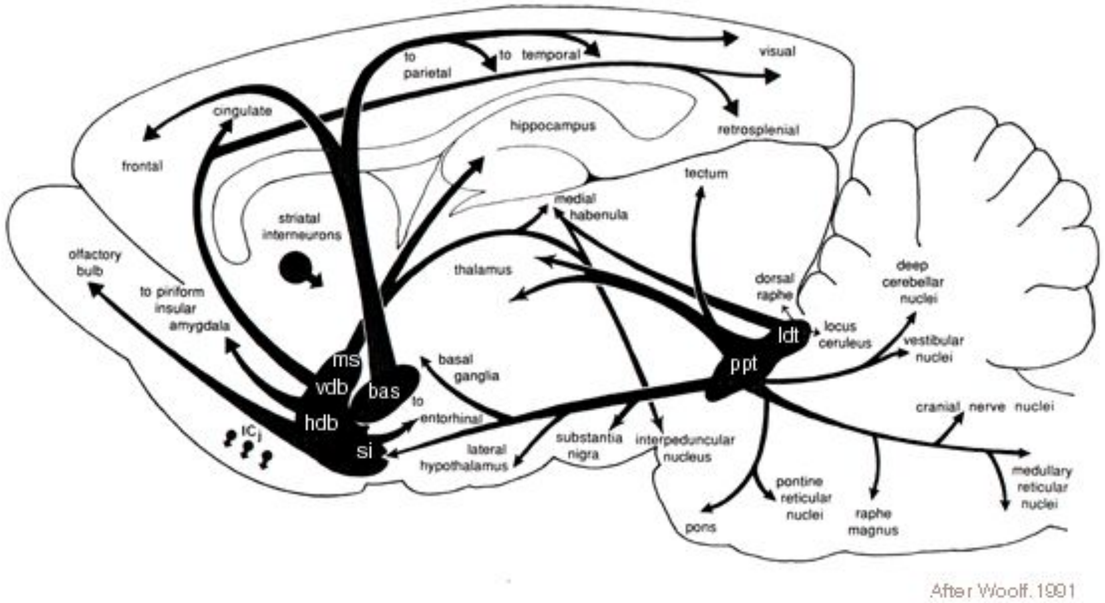
Cholinergic mode switching

Hypothesis:

Cholanergic modulation may explain

Differential modulation of EC and CA3

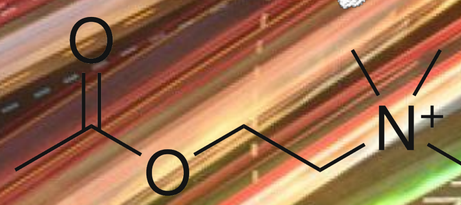
Hasselmo 2006; Honey 2017



Figures from Woolf 1991; Allen Connectivity Atlas

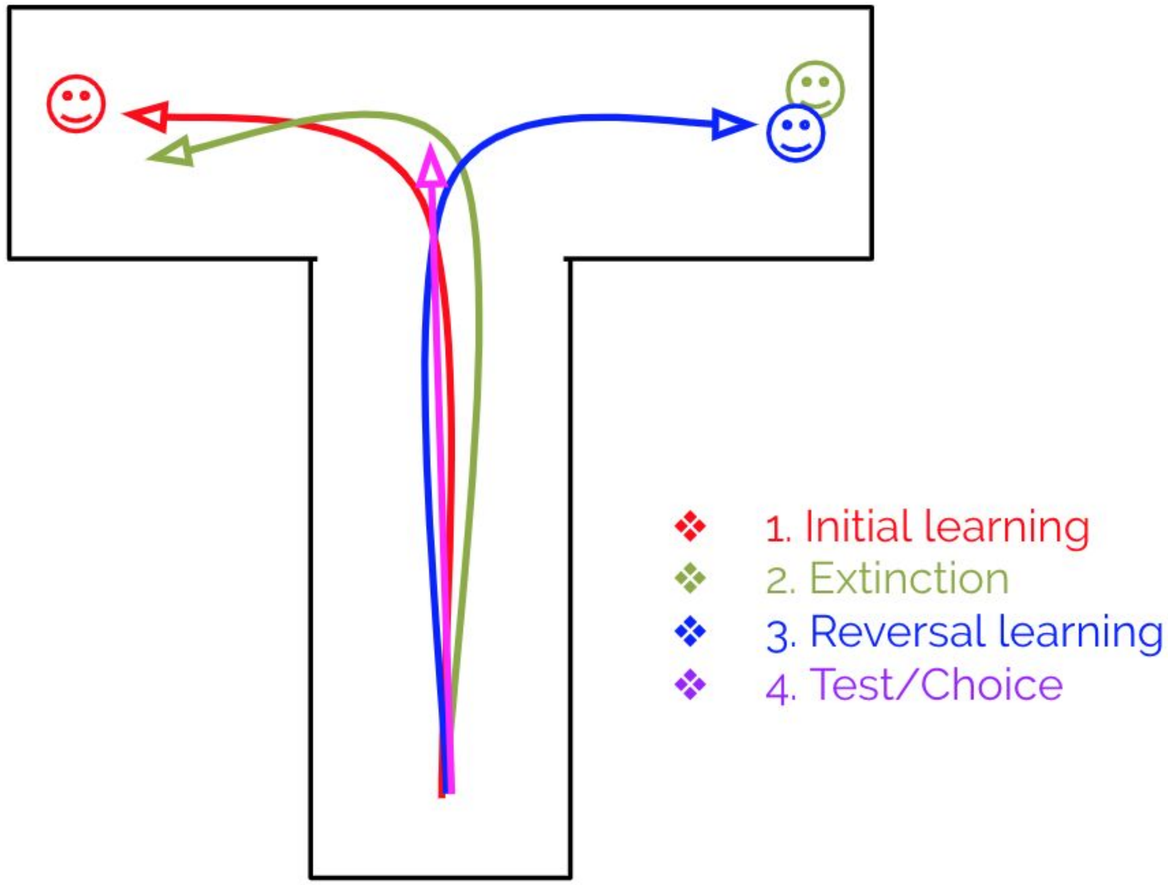
Hippocampal Modes

EC



CA3

Task



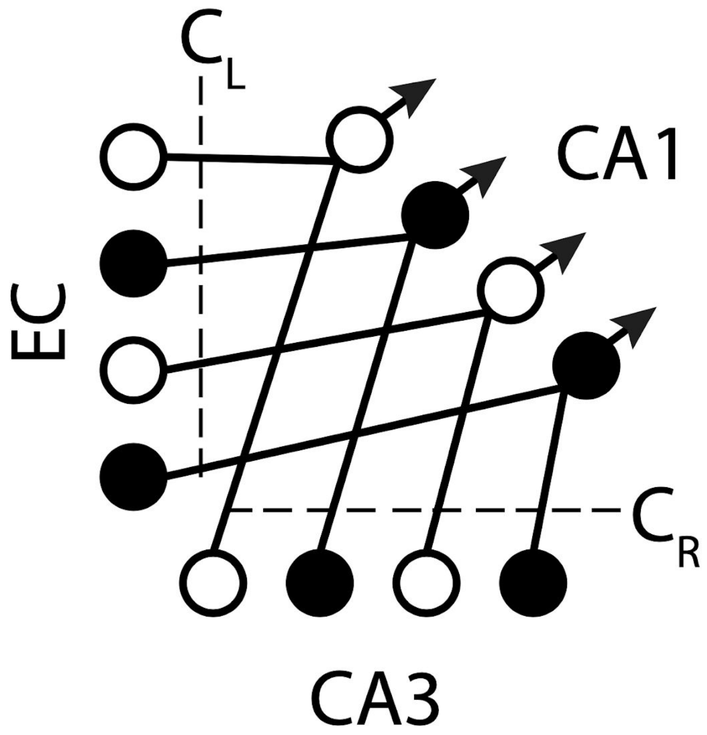
T - maze alternation task

Hasselmo 2002

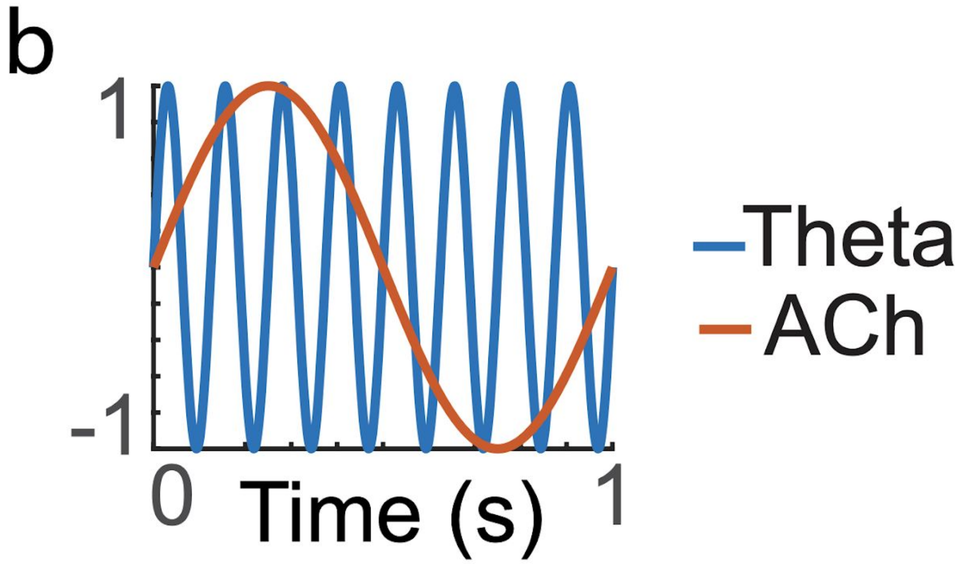
Animal must prevent the association of the past reward interfering with the new location

Model

a



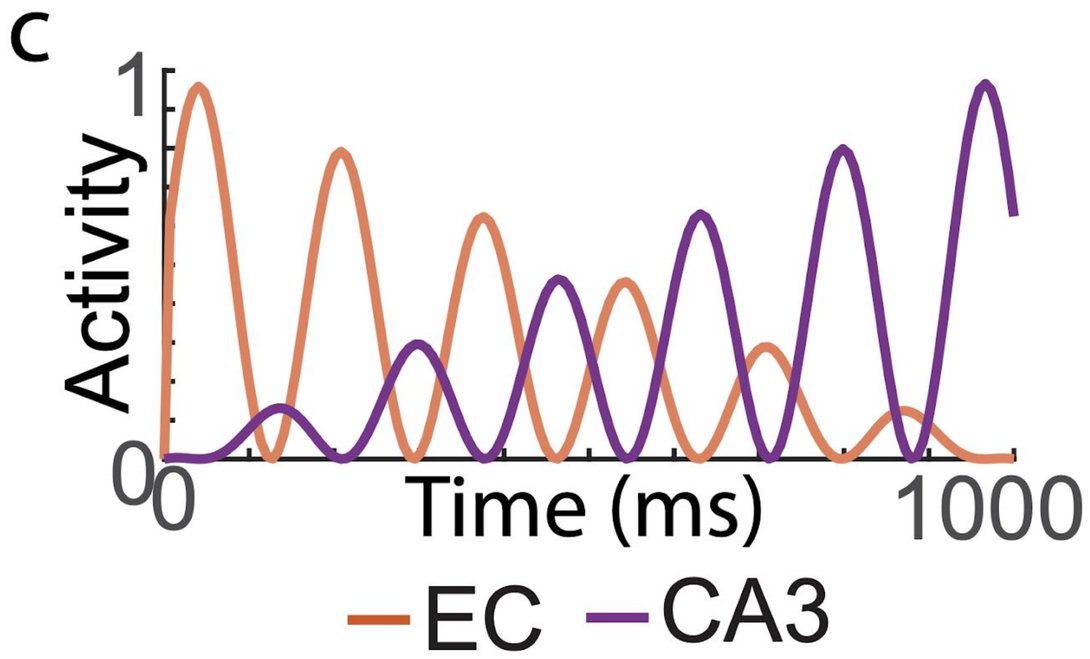
b



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

B. Varying timescales of theta and cholinergic activity
   Modulates LTP in each sub region

Model

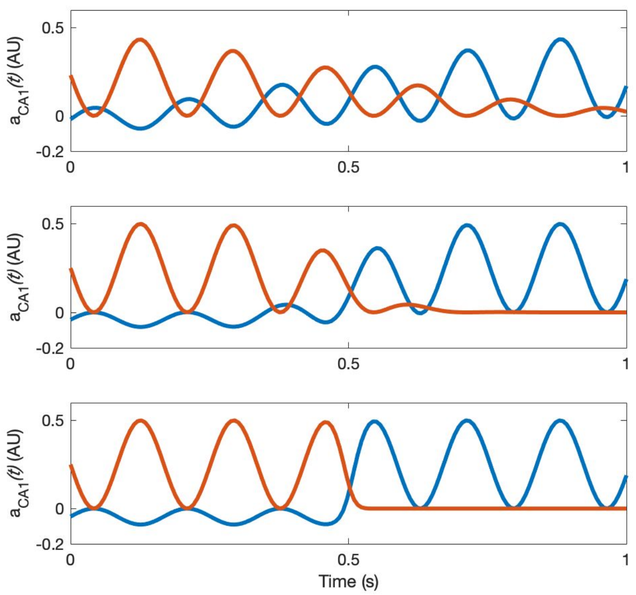


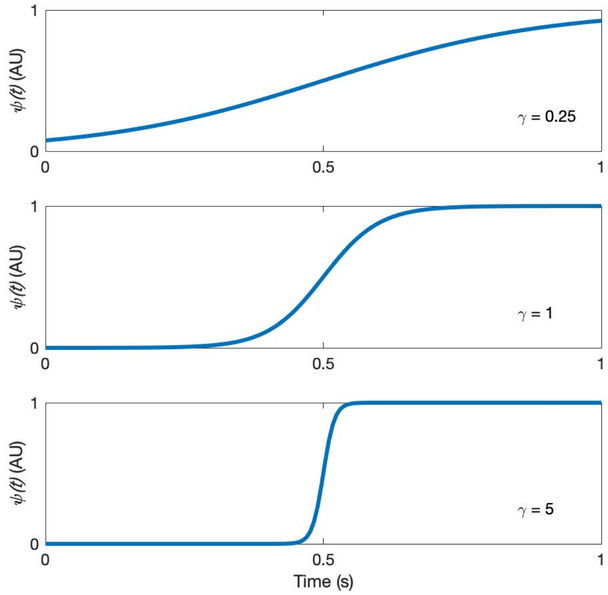
C. Scaling EC and CA3 activity across multiple mode timescales

Cholanergic modulates longer durations

theta rhythm modulates shorter durations

ACh governs global mode





Model does produce expected outcome

Altering ACh levels alters mode switching

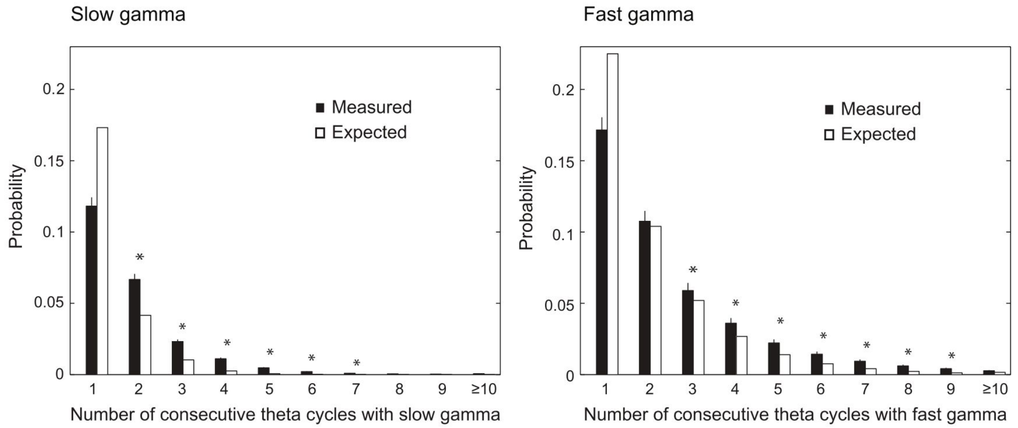
Prediction: Can we see this *in vivo*?

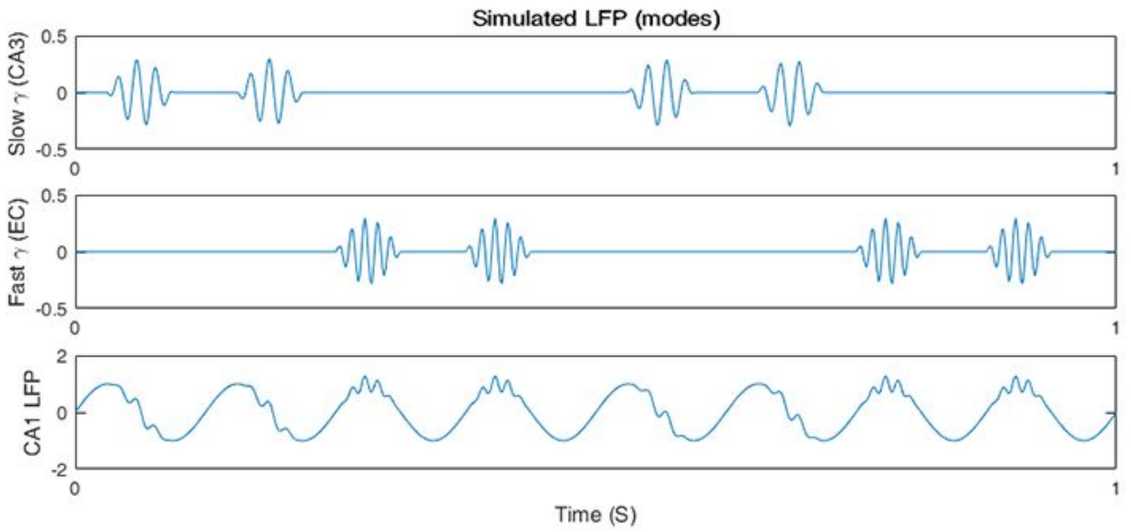
Explains offset modes?

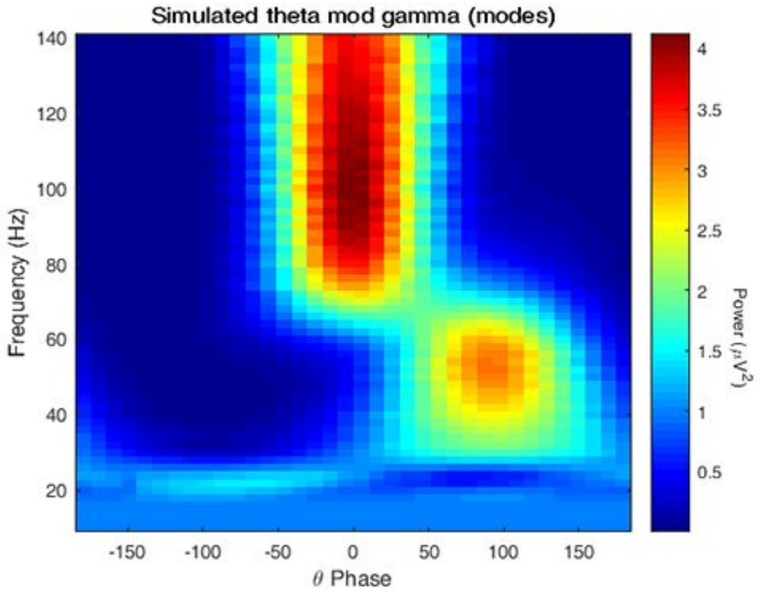
Top figure from Colgin 2009:
Fast and slow gamma are offset.

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

EC: Fast gamma, CA3: Slow gamma

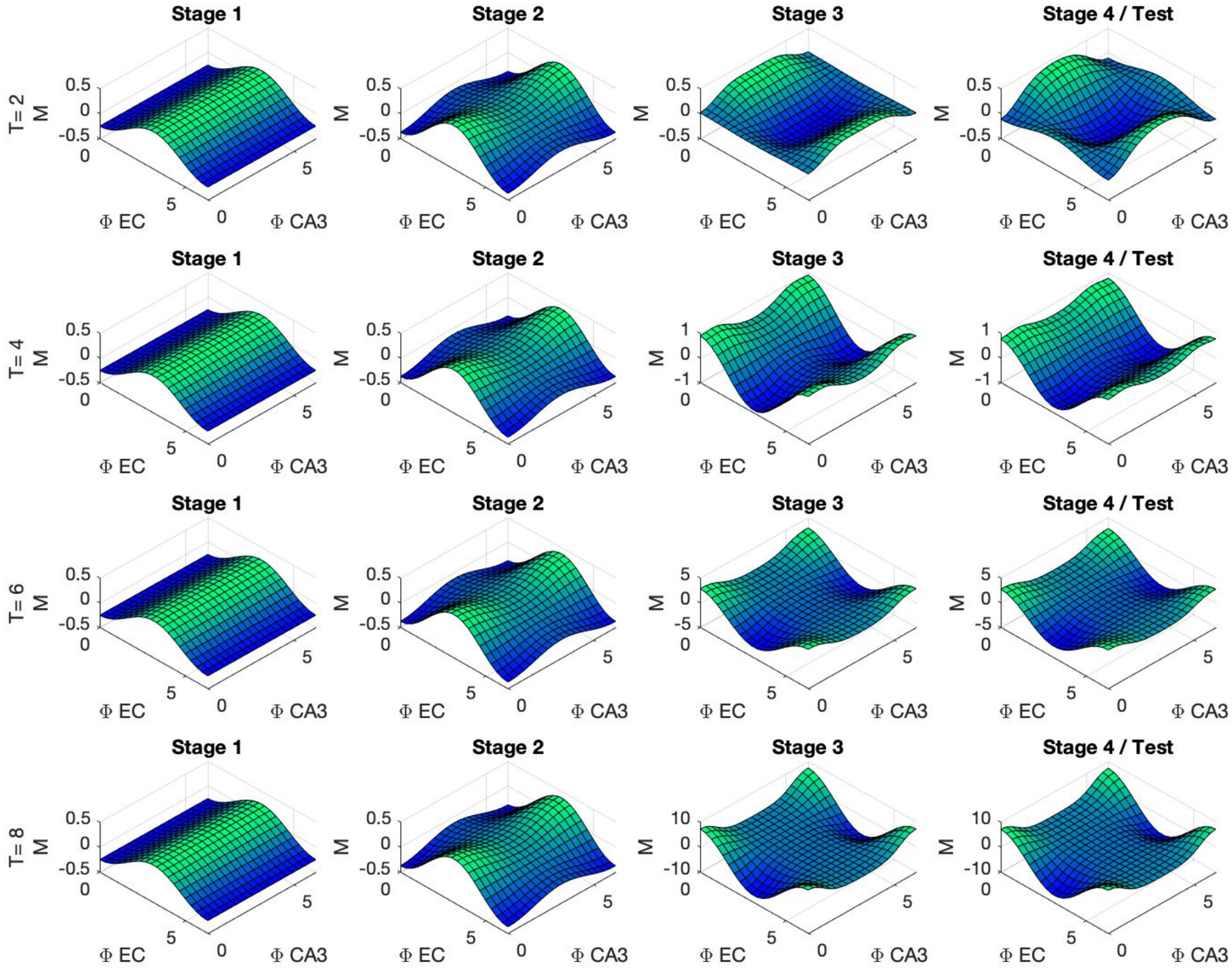






Model Properties

Dynamically training leads to altered plasticity...



Indiana University (Present work conducted)

Newman Lab: Dr. Ehren Newman (IU)

https://memlab.sitehost.iu.edu/

Also thanks to Dr's John Beggs and Josh Brown

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UC Irvine (Current research position)

Fortin Lab: Dr. Norbert Fortin (UCI)

McNaughton Lab: Dr. Bruce McNaughton (UCI)

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