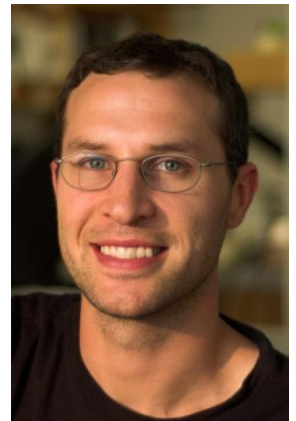


# A neural mechanism for the generation of sparse, informative representations in the hippocampus

Loren Frank and Mattias Karlsson

Keck Center for Integrative Neuroscience  
Department of Physiology  
University of California, San Francisco

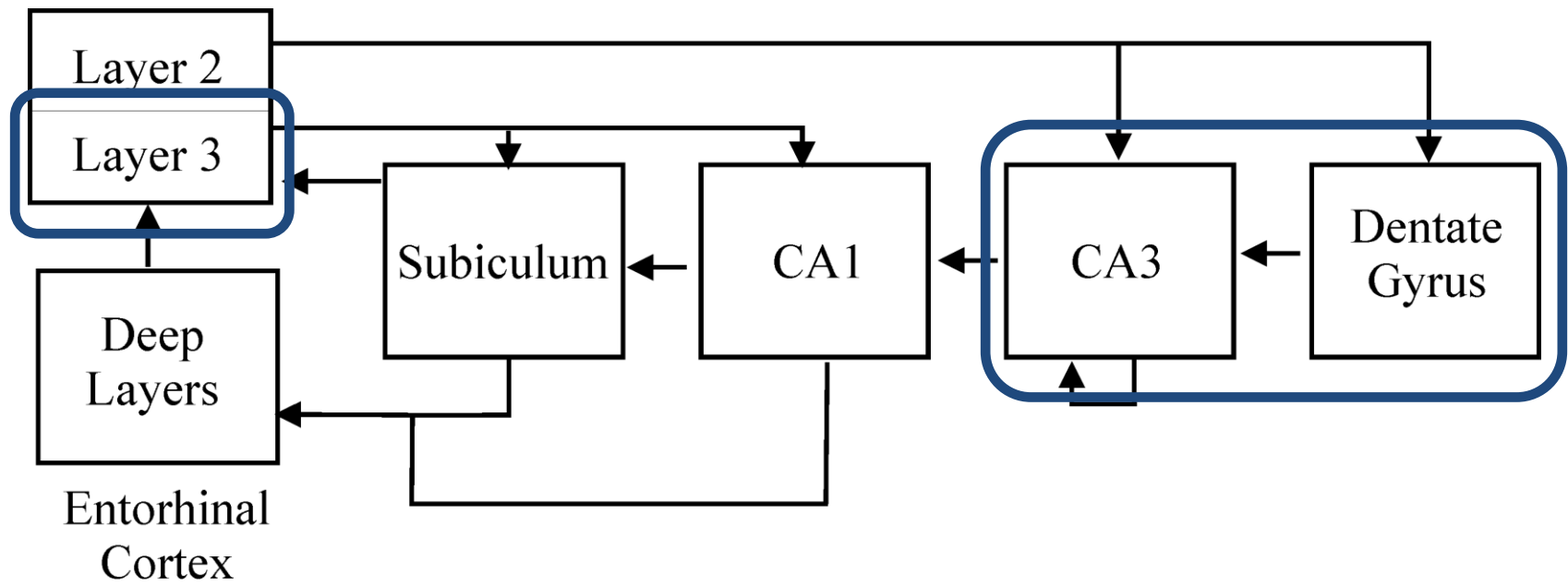


Mattias Karlsson

# Questions

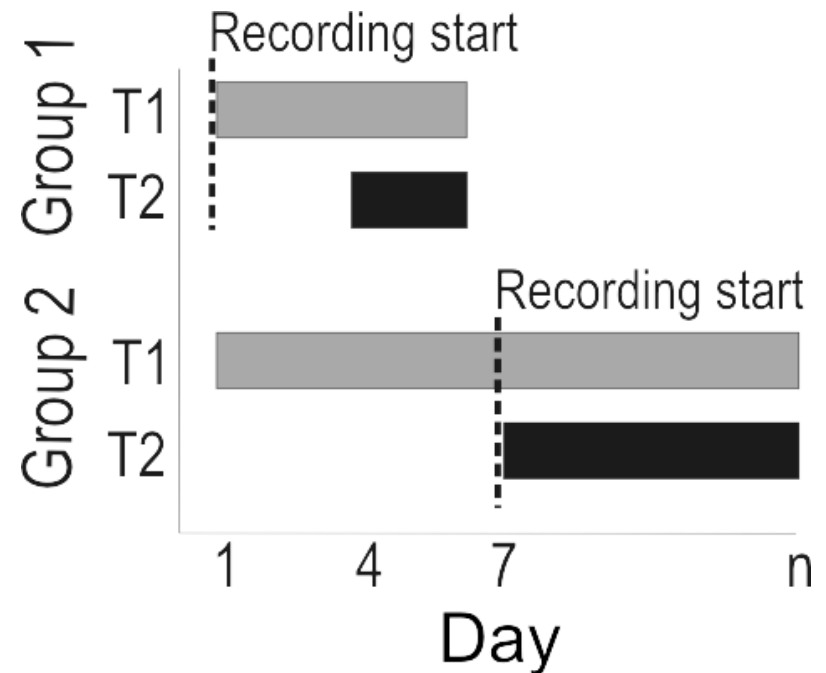
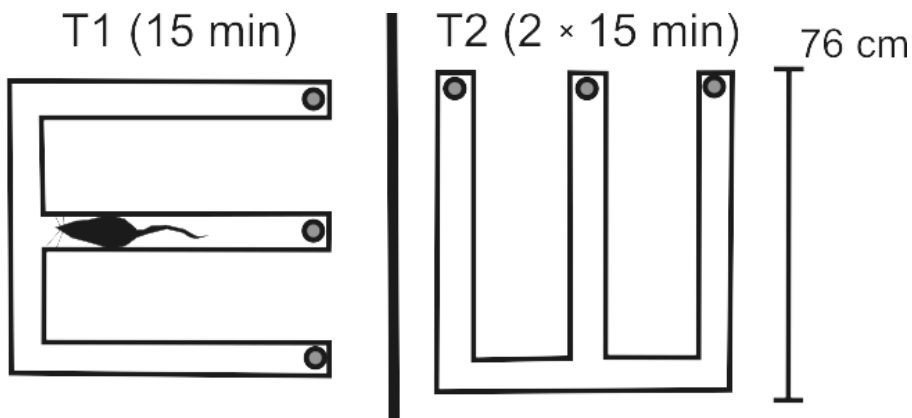
- How does an memory system represent new associations?
- How are the neurons that participate in a new associative representation selected?

# Anatomy – Inputs to CA1



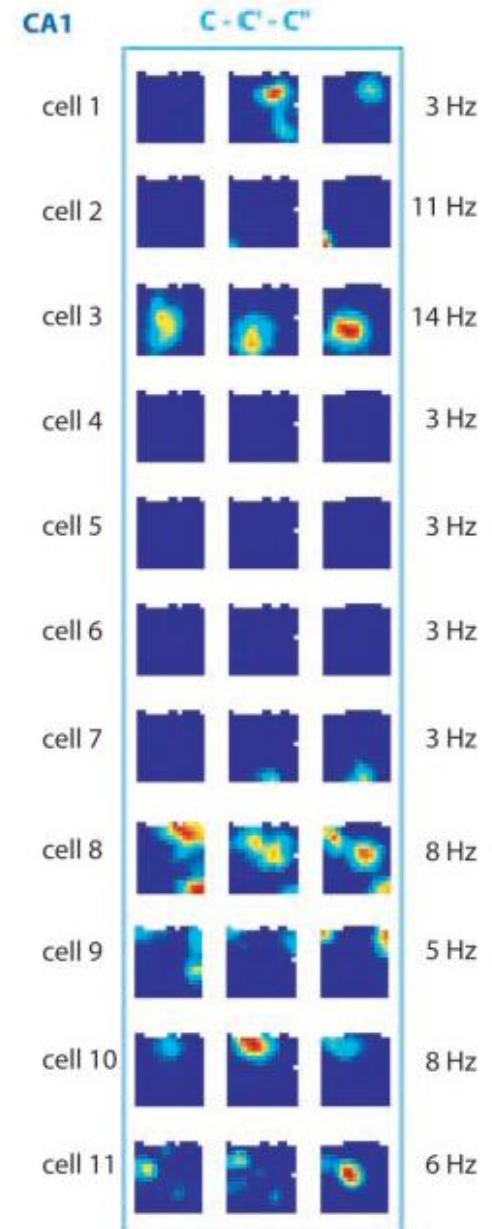
# Methods

Simultaneous recordings from CA1  
and CA3 (30 tetrodes)



# Dynamics and Firing Rates?

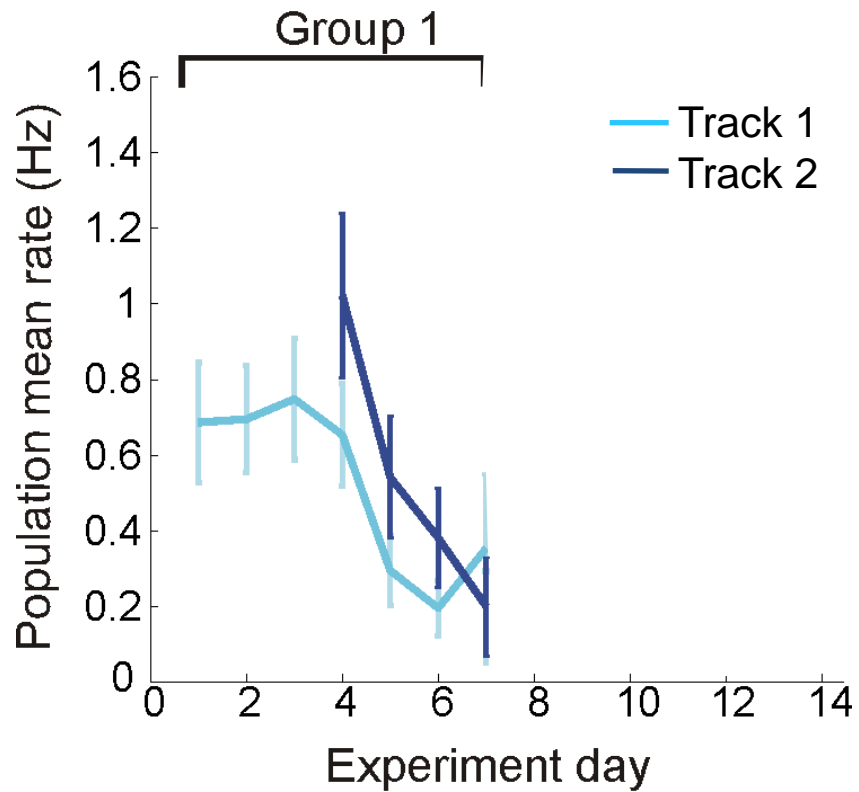
- Question: Do absolute firing rates matter?
- Common wisdom: Not really.



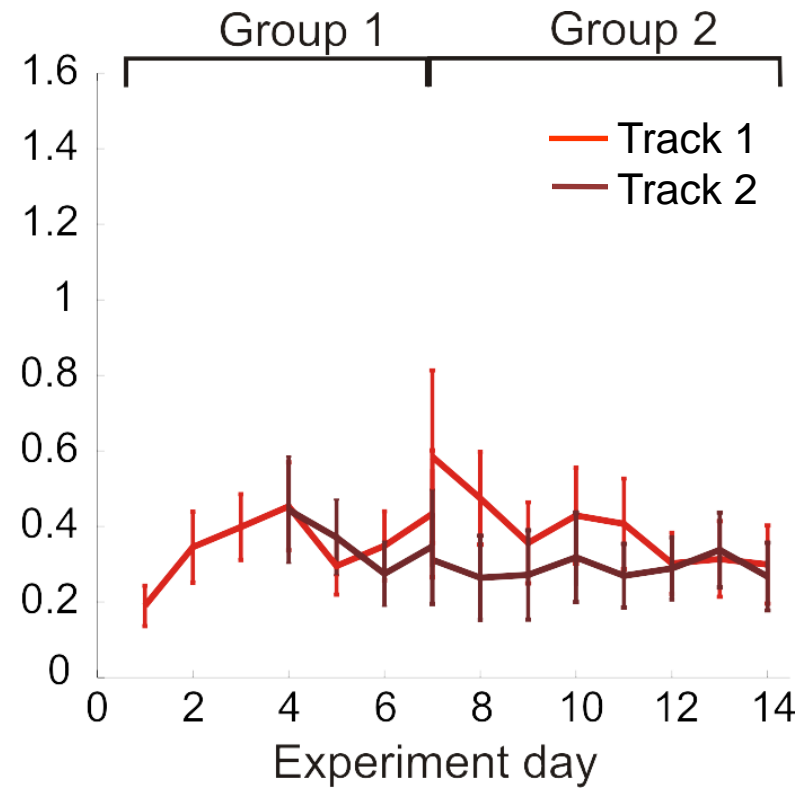
Leutgeb et. al, 2004

# Firing Rates Across Days

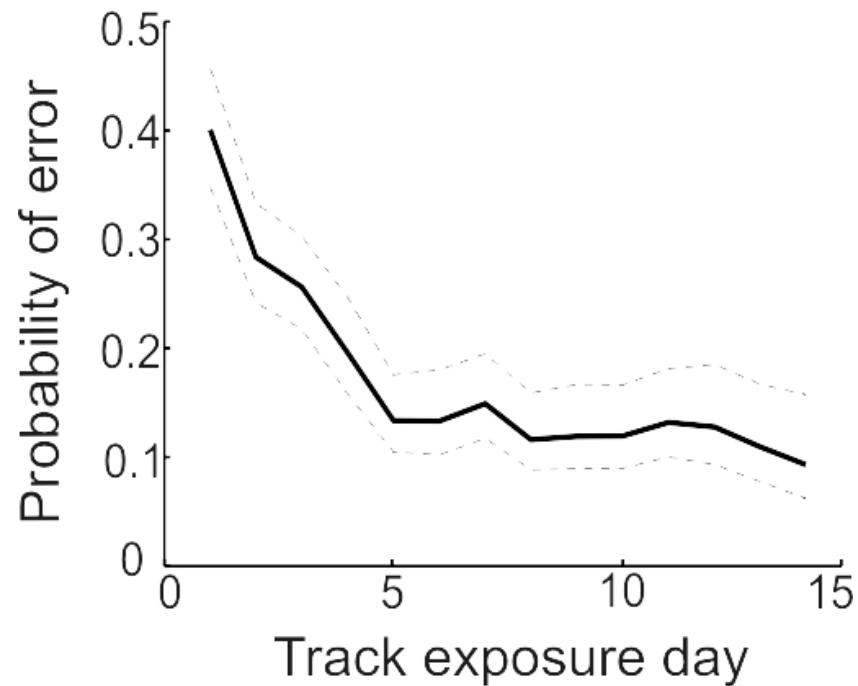
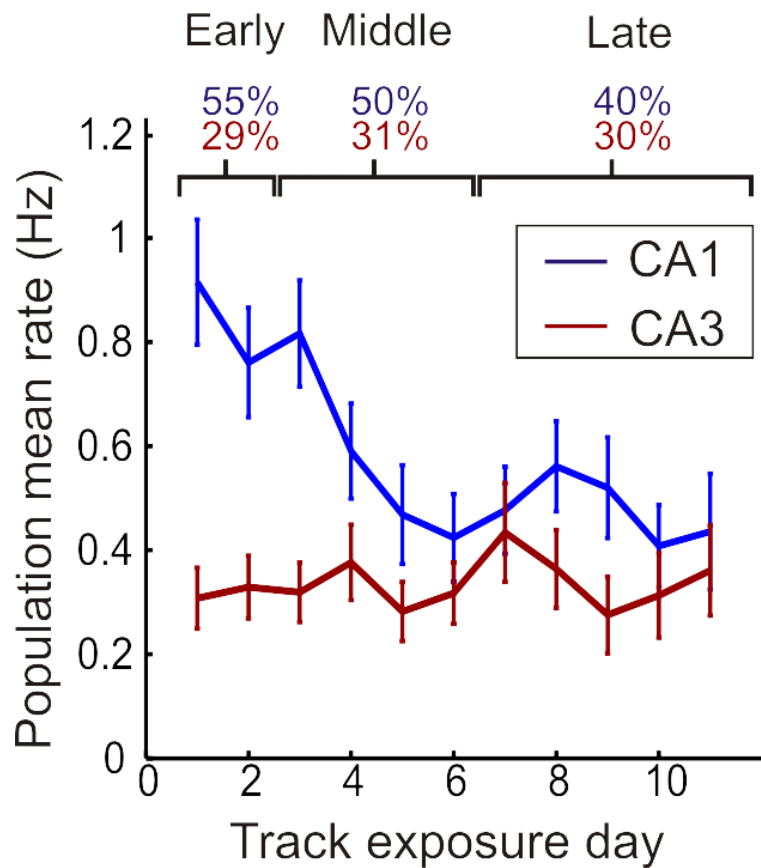
## CA1



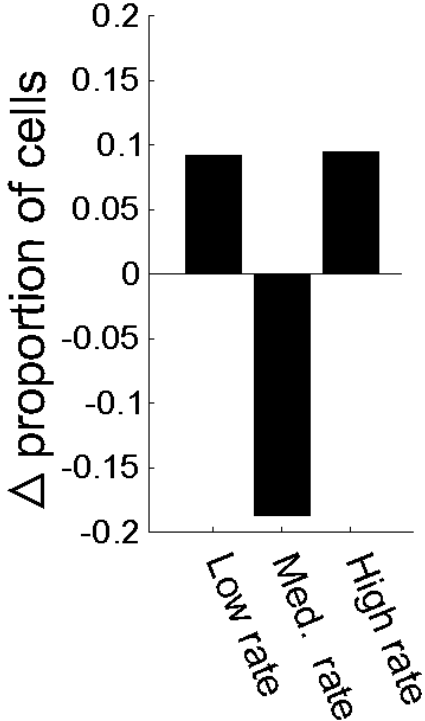
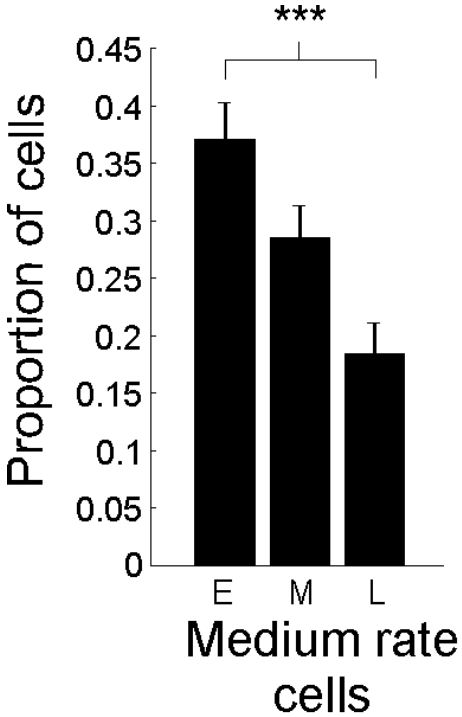
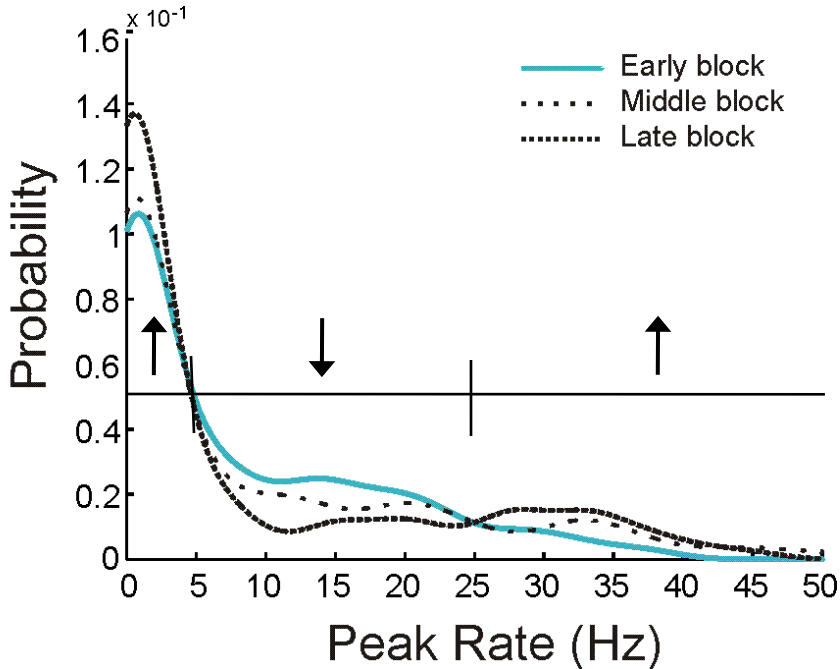
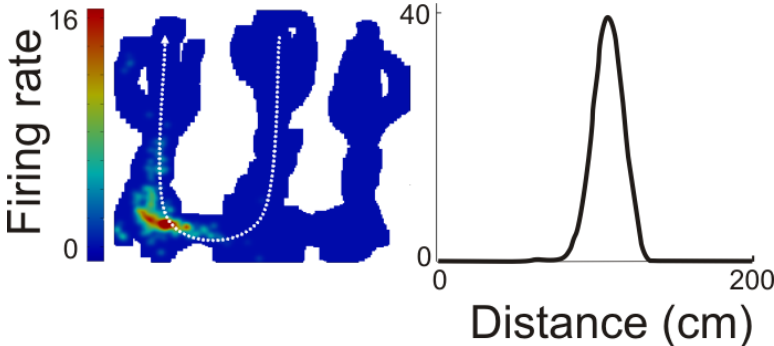
## CA3



# Firing Rates And Behavior



# Interaction with Spatial Coding – CA1

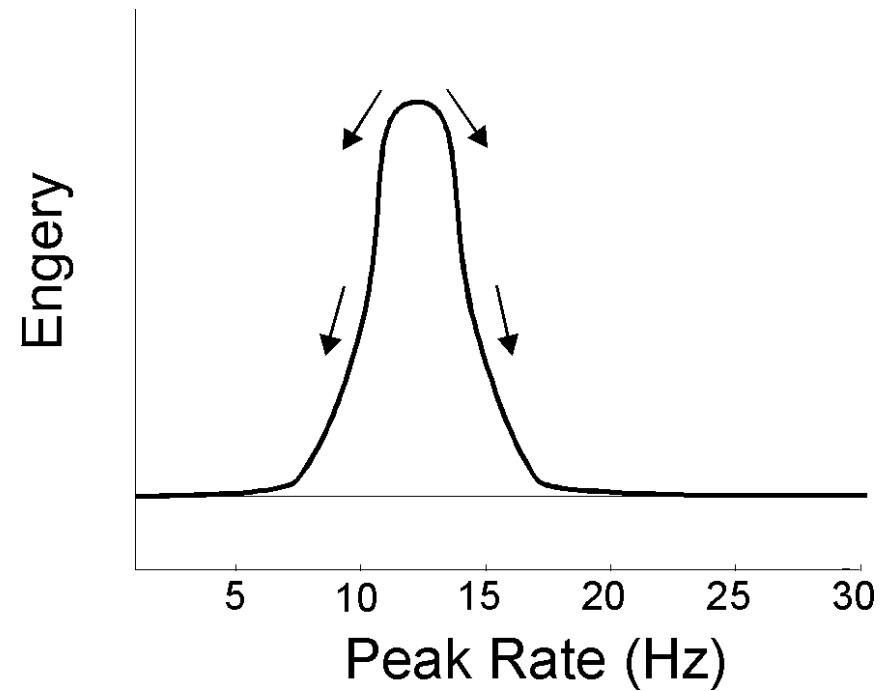
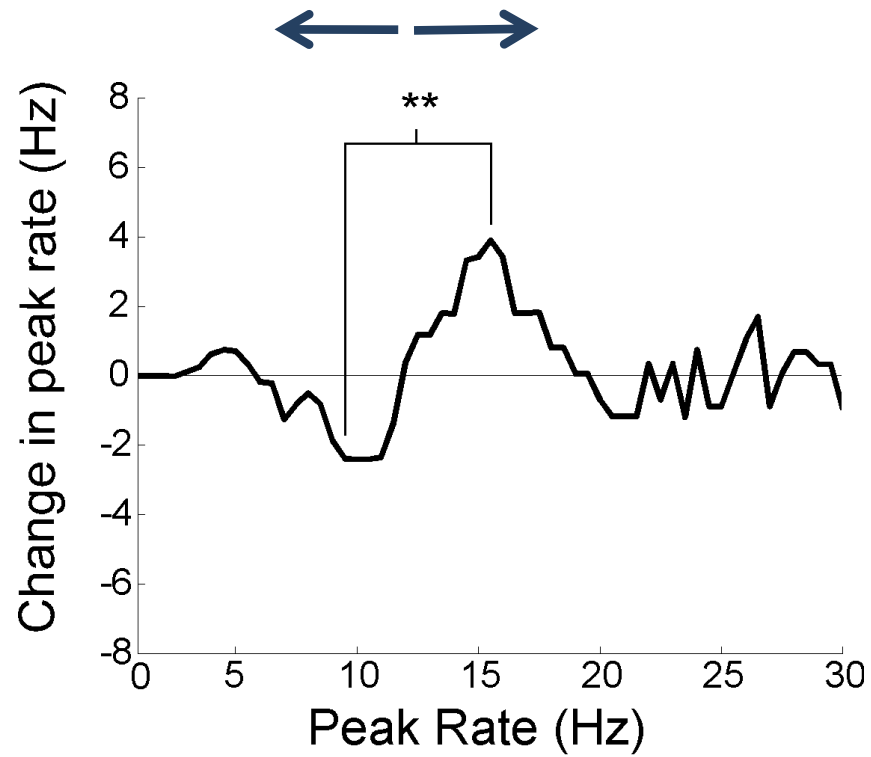




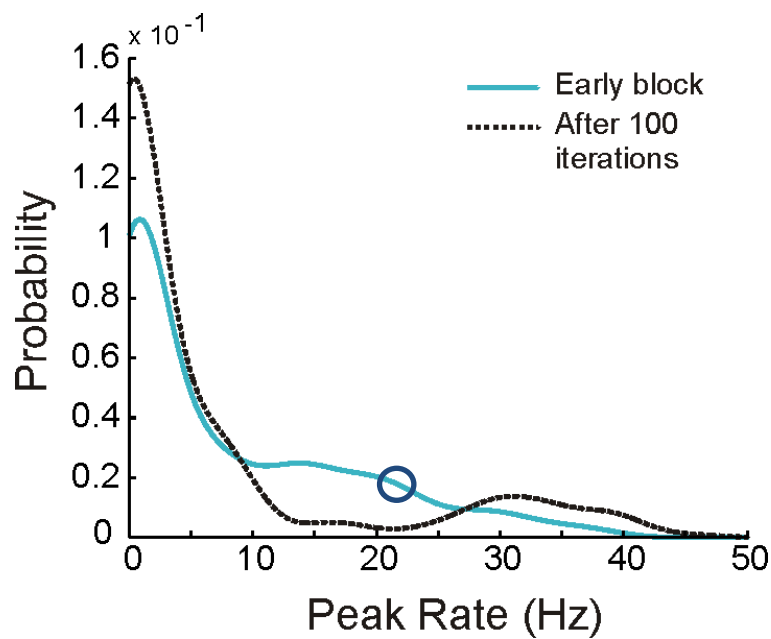
# Deriving the Dynamics of the CA1 Population

- Two runs on novel environment per day
- Question: how do dynamics within a day relate to across day changes?
- Subtract novel run 1 peak rate from novel run 2 peak rate for all neurons in the middle group (days 3 – 7)

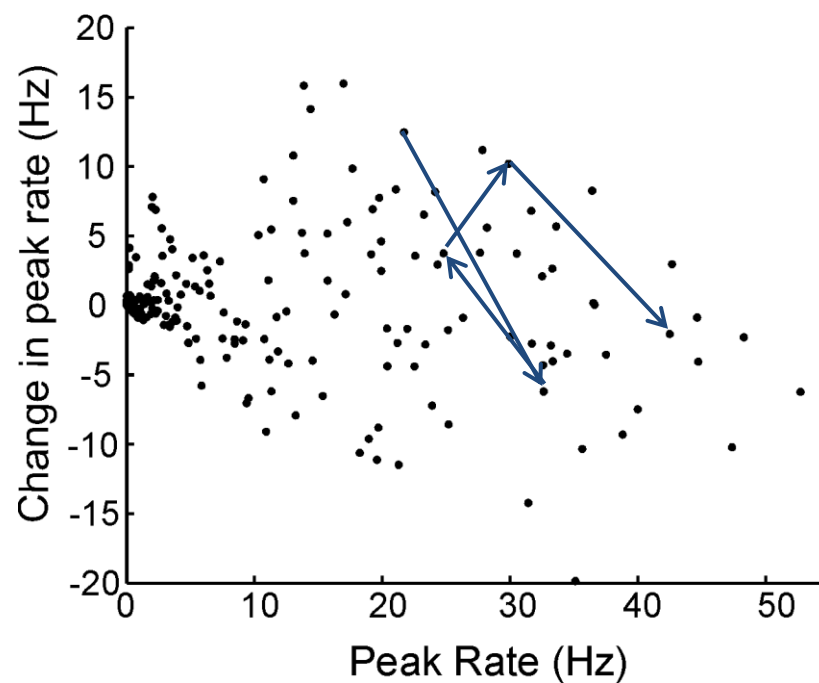
# Dynamics of the CA1 Population



# Within Day Dynamics and Long Term Changes



Middle Block Within-Day Dynamics



# Conclusions

- CA1 output doubles in novel environments.
  - Likely to be the source of the hippocampal “novelty” signal seen in human studies.
- The decrease in firing is associated with the suppression of low peak rate cells and the enhancement of higher peak rate cells.
- CA1 dynamics actively select high peak spatial rate, informative neurons to persist as part of a long lasting representation.

# Lab members and collaborators

## **Lab Members**

Margaret Carr

Sen Cheng

Yuri Dabaghian

Surya Ganguli

Sheri Harris

## **Mattias Karlsson**

Caleb Kemere

Steven Kim

Annabelle Singer

## **Stanford**

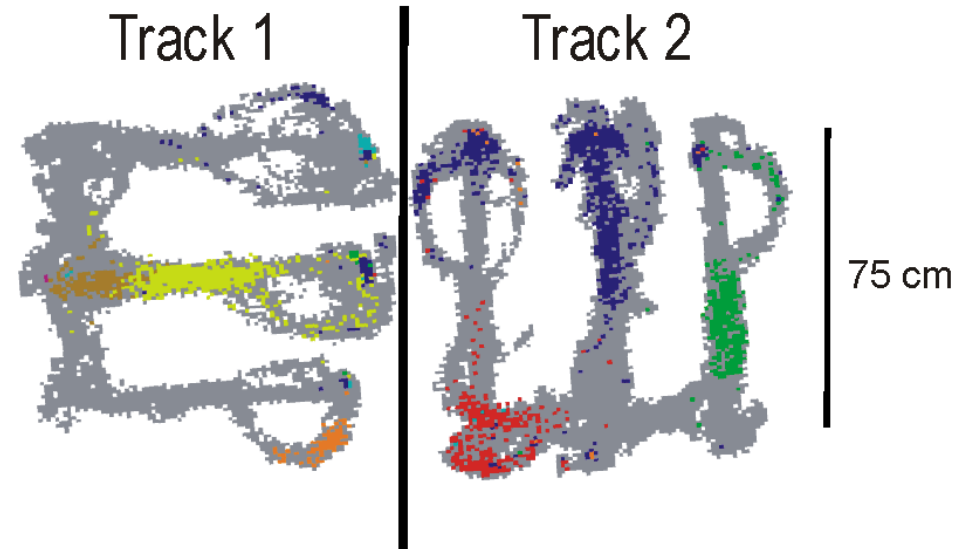
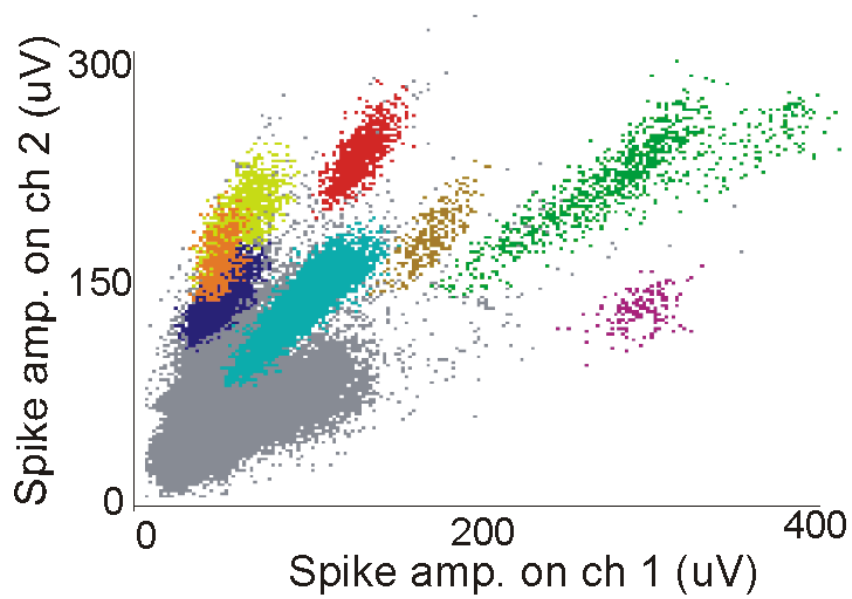
Karl Deisseroth

Feng Zhang

## **MGH / M.I.T.**

Emery Brown

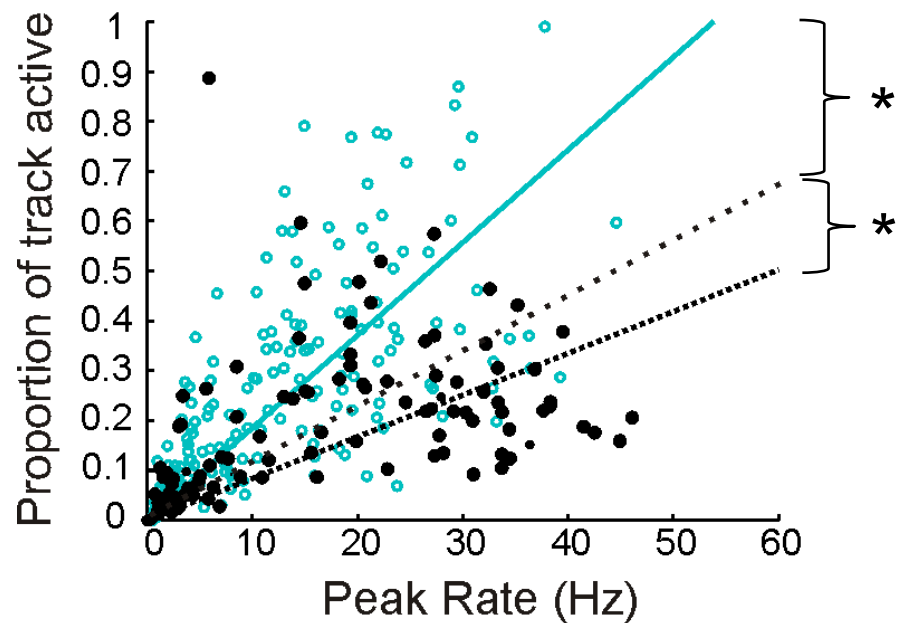
# Data



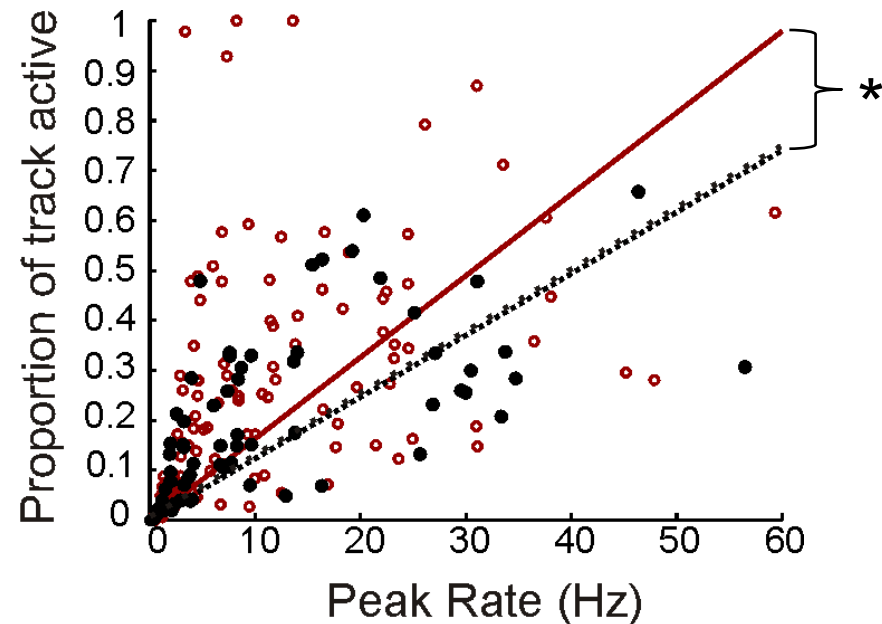
- 678 CA1 neurons
- 939 CA3 neurons

# Continued evolution of spatial responses

CA1

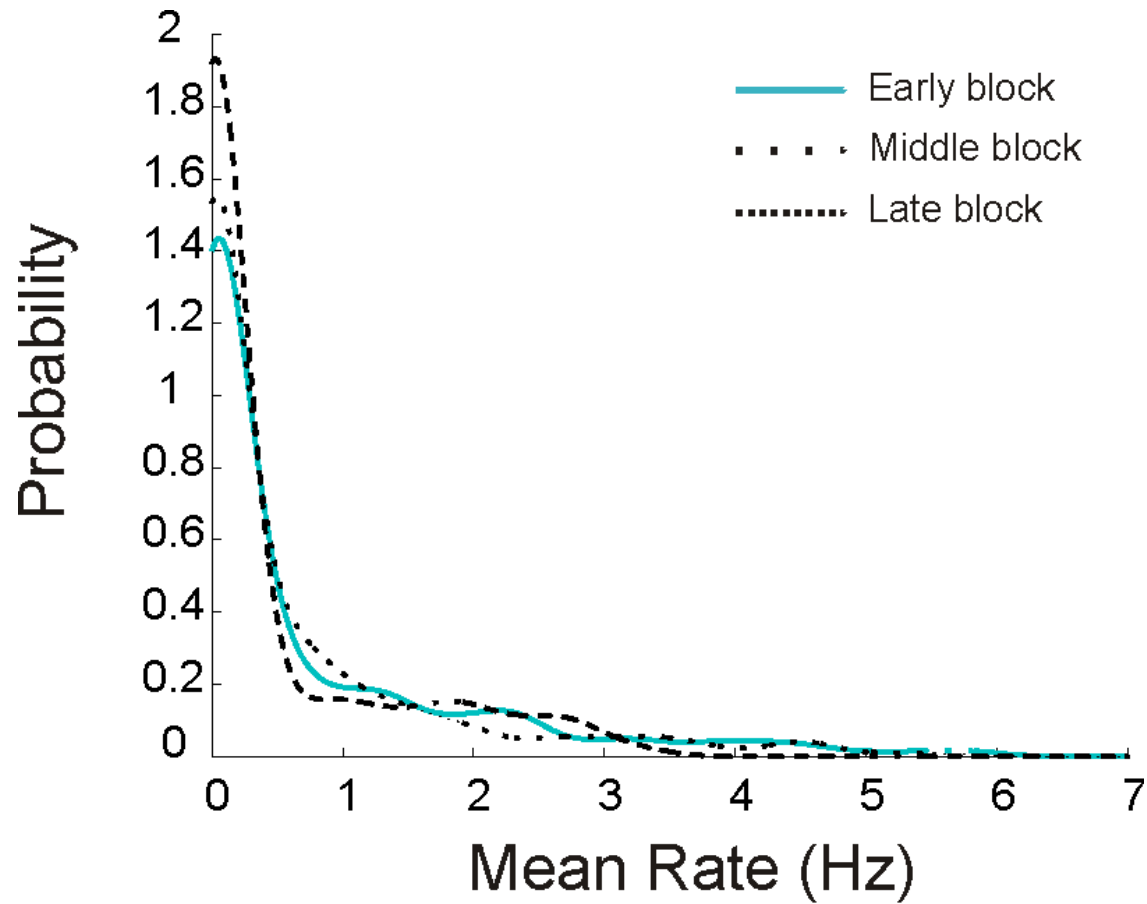


CA3



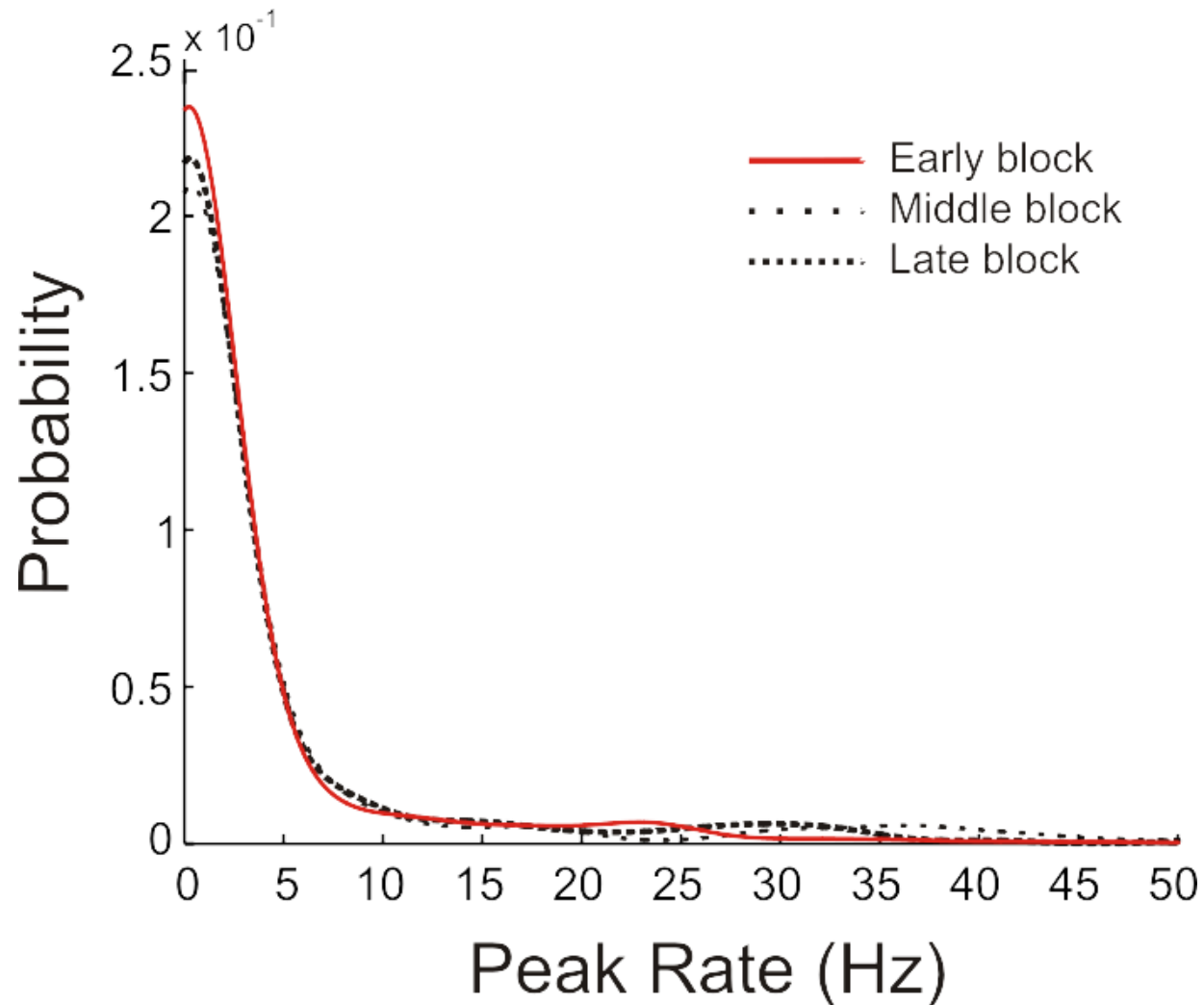
- Early block
- ..... Middle block
- . - . - . Late block

# Evolution of Rate Distribution



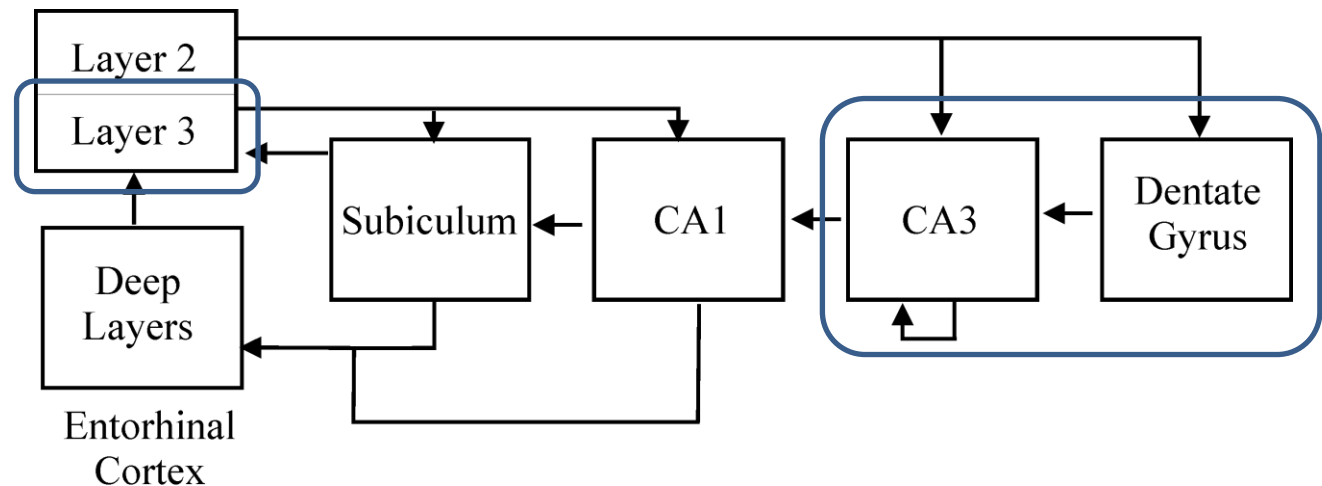


# Interaction with Spatial Coding – CA3



# Conclusions

- CA3 and CA1 have different roles in learning.



- CA1 undergoes annealing to develop a sparse, informative representation.