The relationship of extracellular fields - neural oscillations and spikes

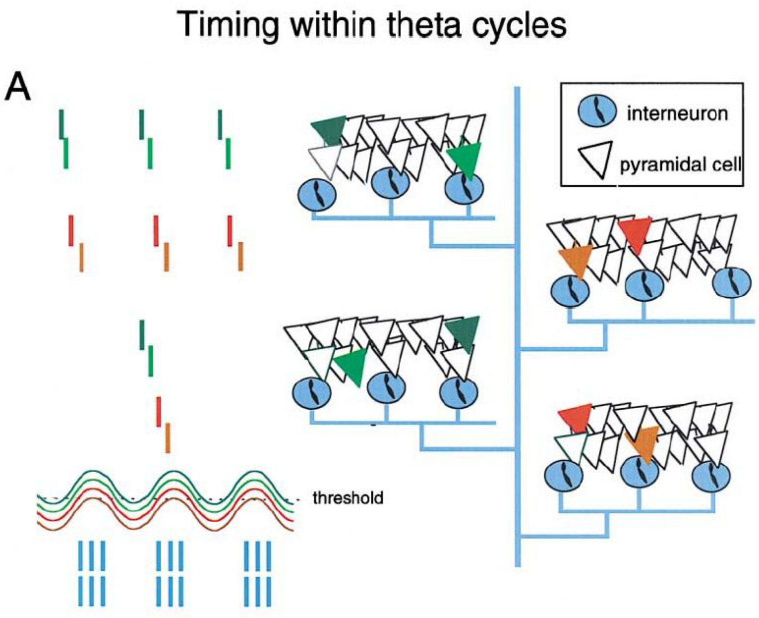
Cong Wang, Hoi Ming Ken Yip, Vicky Zhu, Weihao Sheng, Yongxiang Xiao

Murky Stoats/ Lucky Coi   23/07/2021

neuromatch academy




Synchronization of unit activity: a key ingredient of neural oscillations

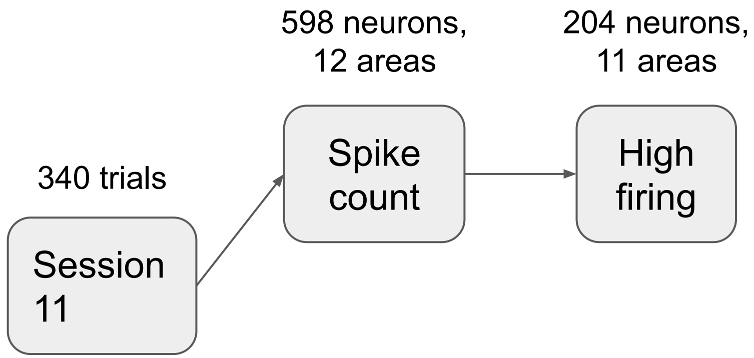


Our research question: Which cell type's spiking activities are better predictors of neural oscillations.

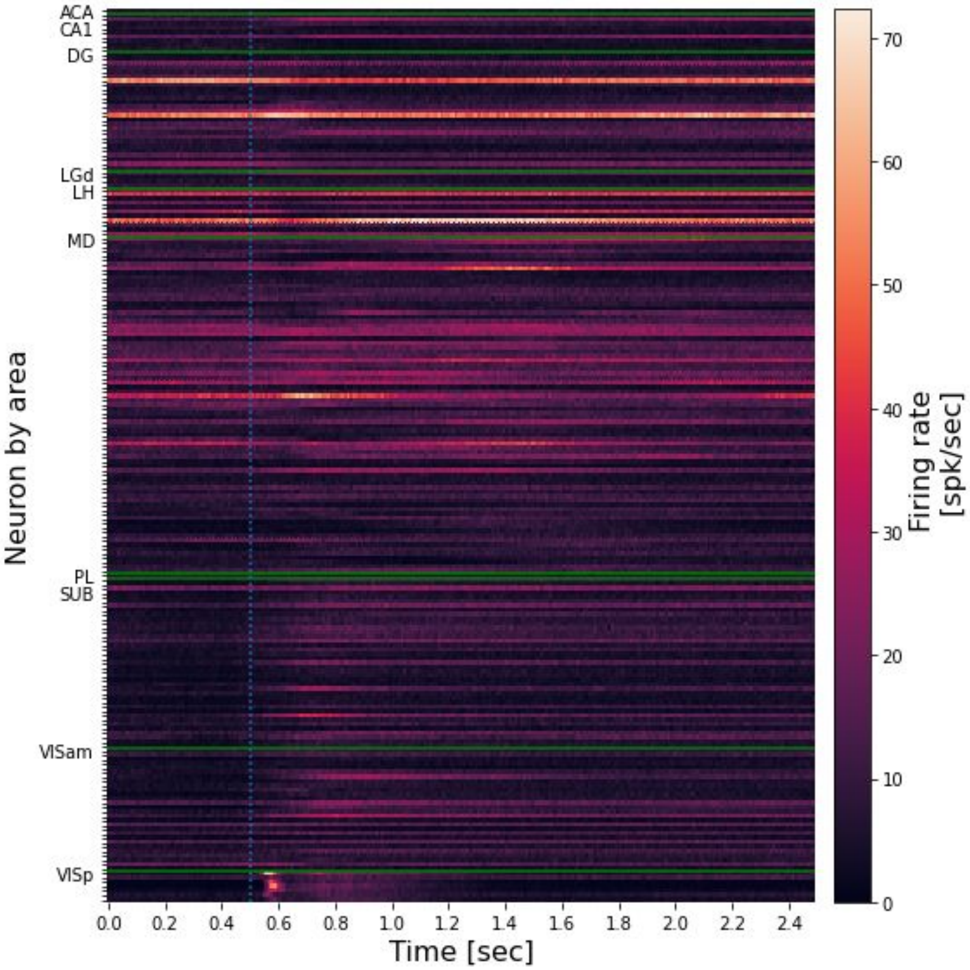
Our hypothesis: interneurons can better reconstruct theta oscillation than principal neurons.

Buzsaki, G. (2002). Theta oscillations in the hippocampus. Neuron, 33(3), 325-340.

Steinmetz dataset

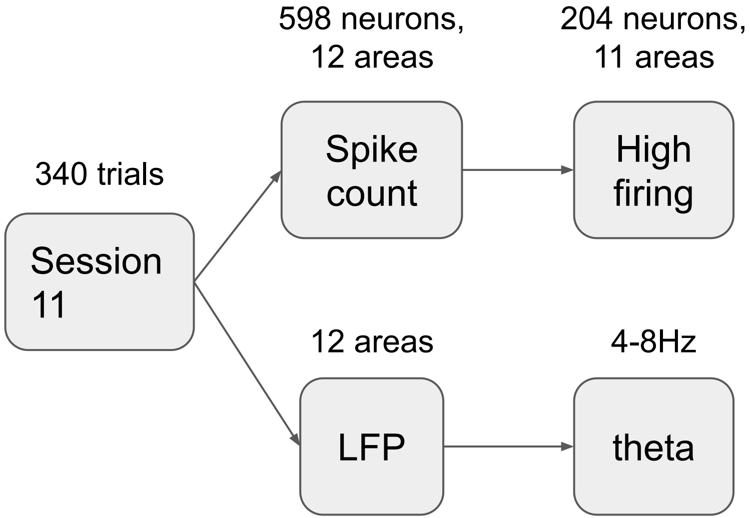


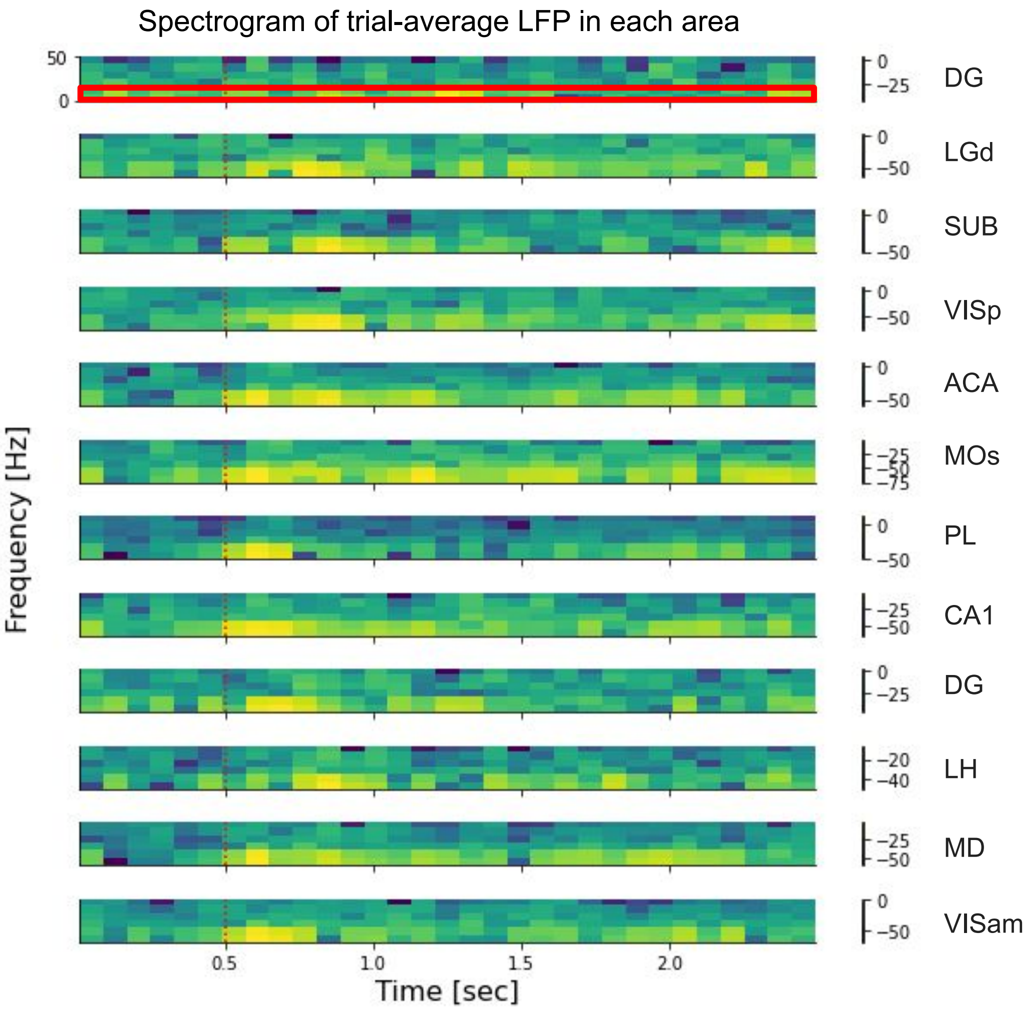
Trial-averaged firing rates



Steinmetz, Nicholas A., et al. “Distributed coding of choice, action and engagement across the mouse brain.” Nature 576.7786 (2019): 266-273.

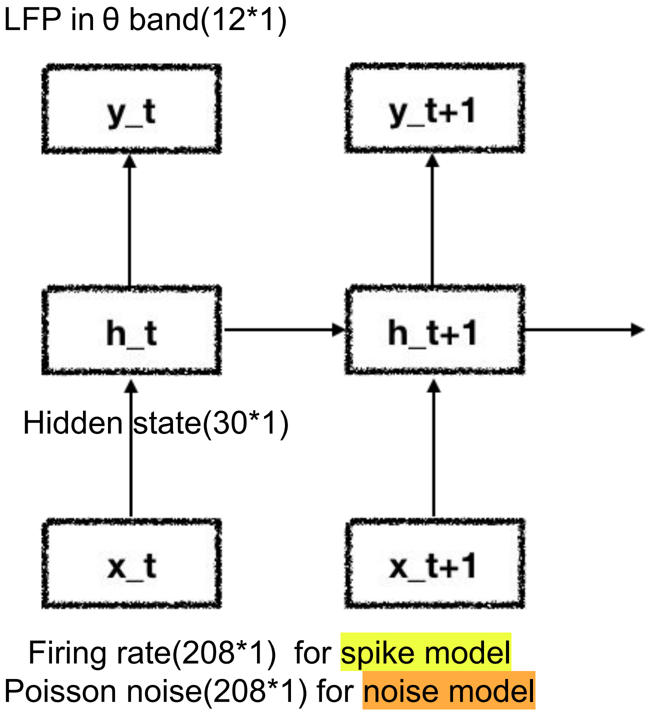
Steinmetz dataset

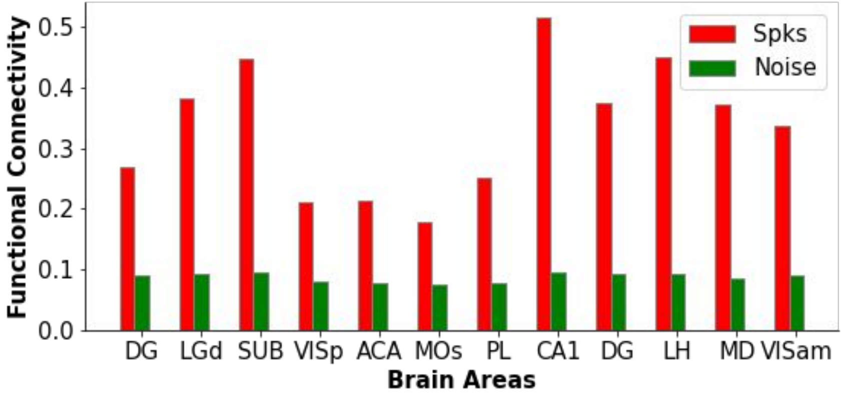


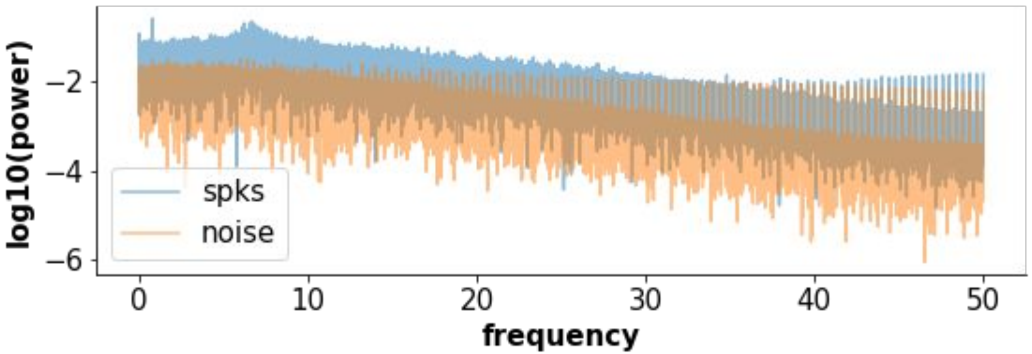


Steinmetz, Nicholas A., et al. "Distributed coding of choice, action and engagement across the mouse brain." Nature 576.7786 (2019): 266-273.

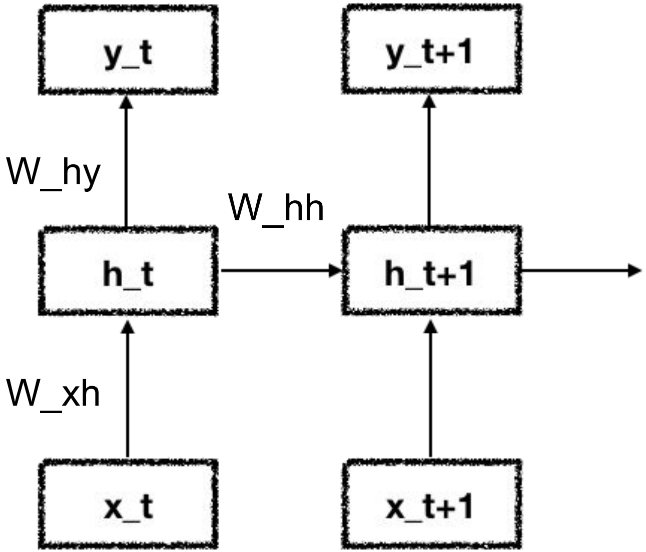
RNN architecture & model evaluation





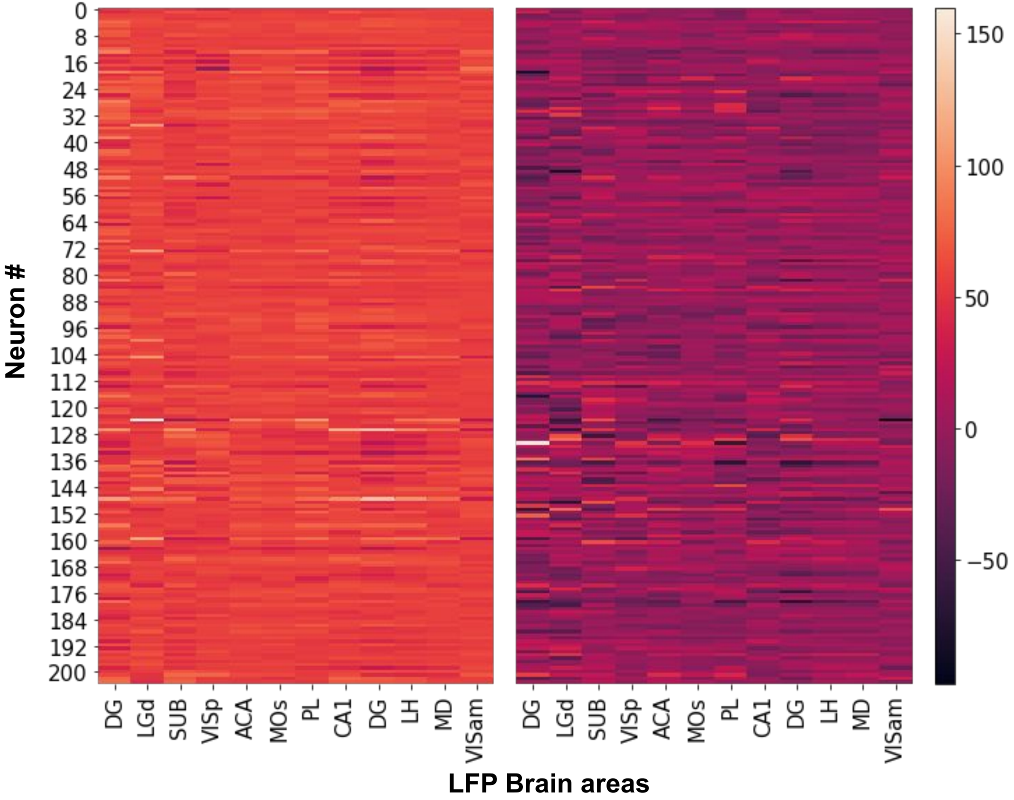


RNN architecture & model evaluation

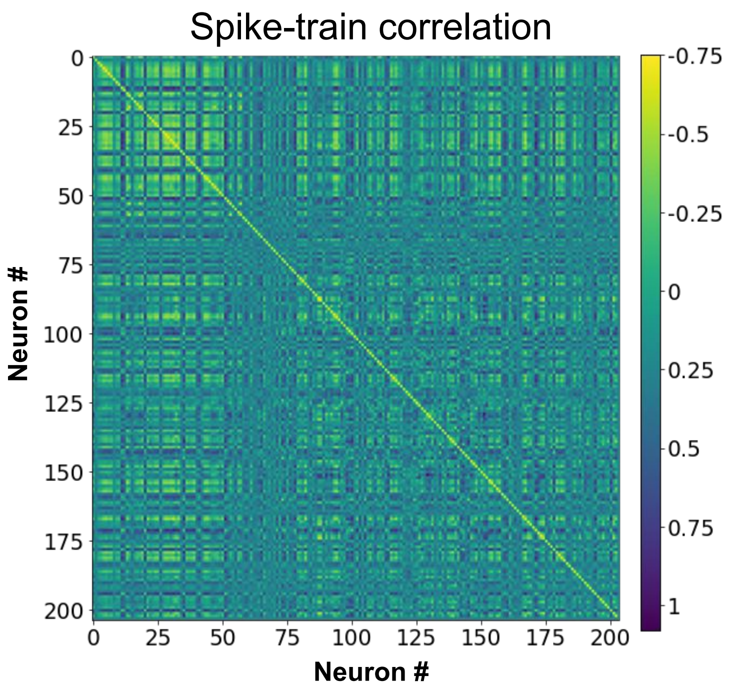


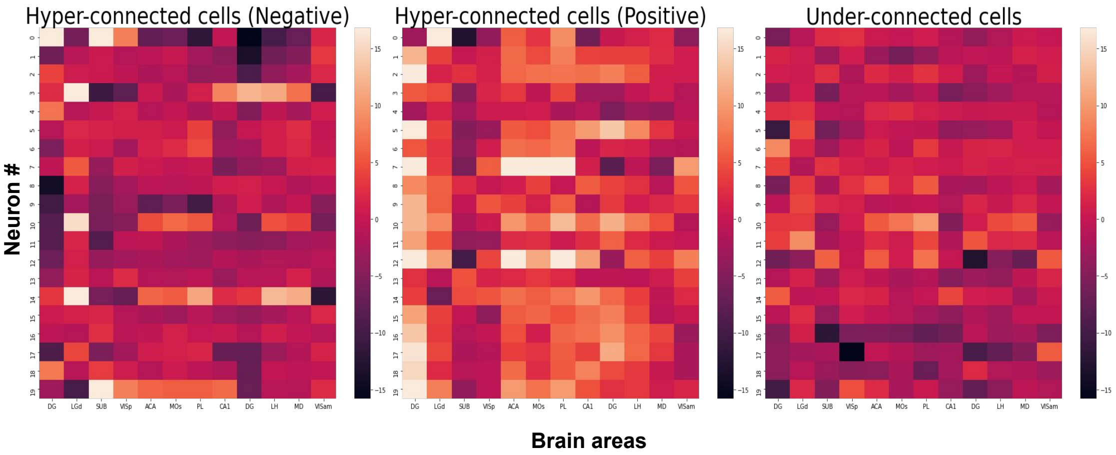
Define: Training weight = W_xh @ W_hy

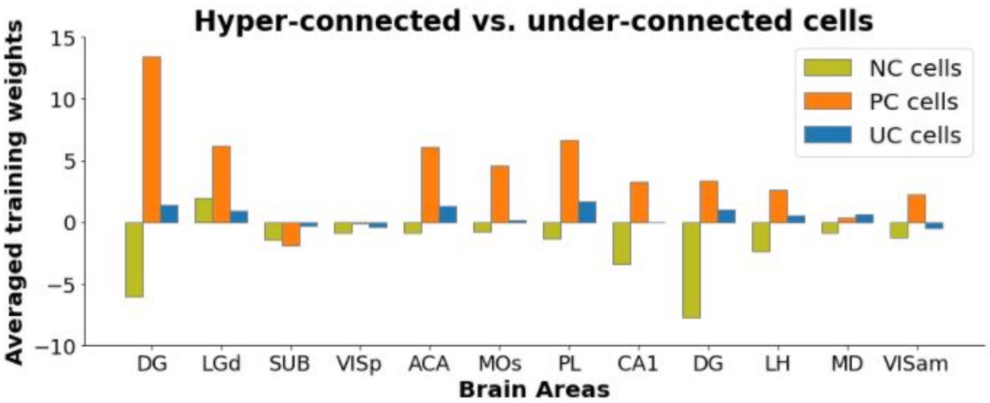
Training weight in spike model & in noise model



Hyper-connected and under-connected training weights

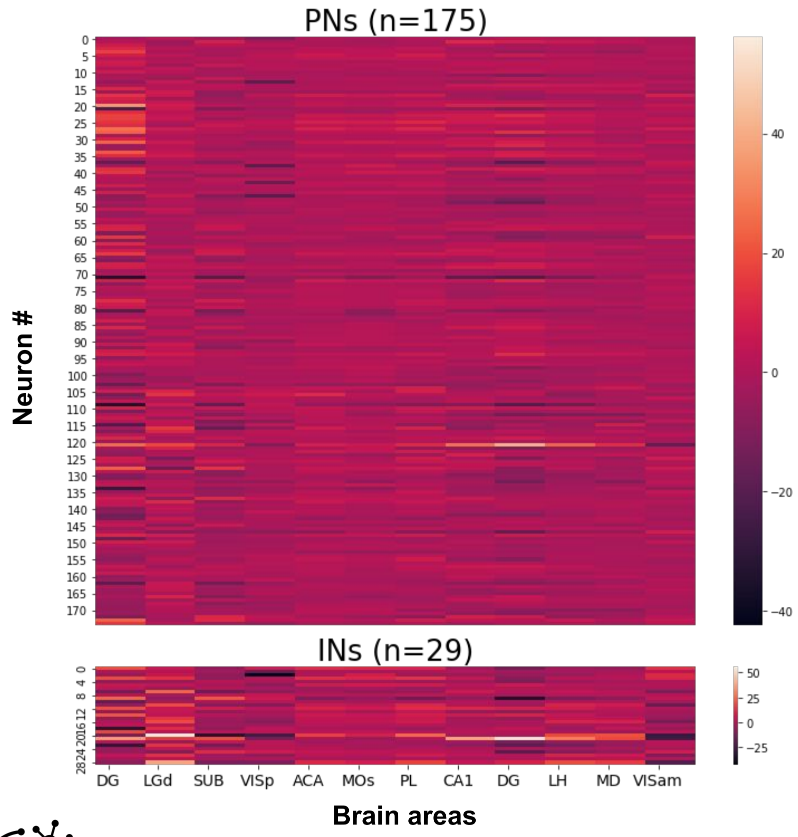


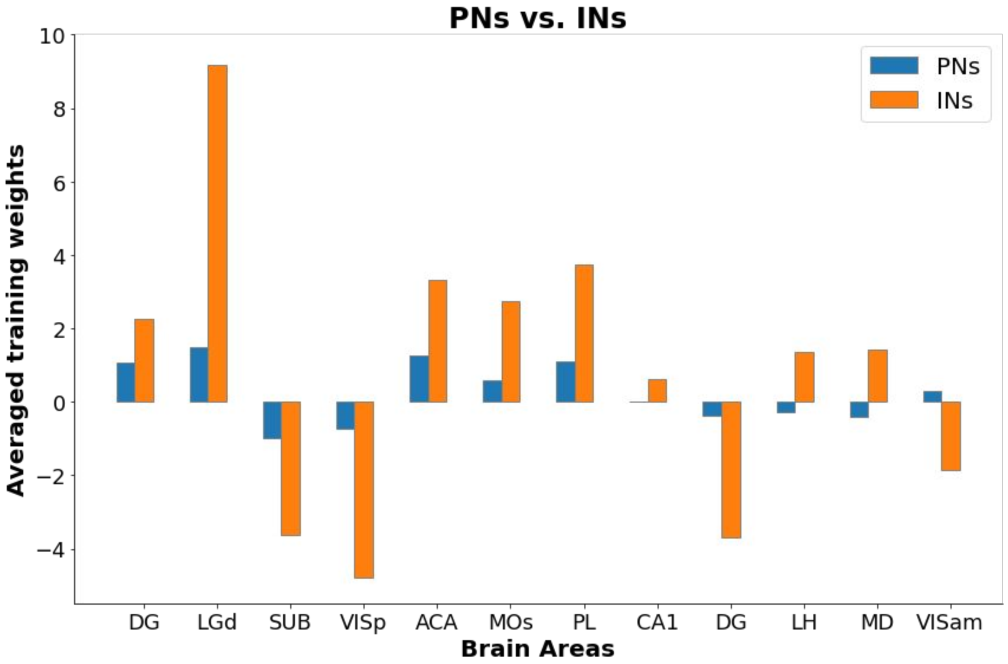




Negatively hyper-connected neurons (n=20)
Positively hyper-connected neurons (n=20)
Under-connected neurons (n=20)

Principal neurons (PNs) and Interneurons (INs) training weights





Conclusions

- Developed RNN model with linear recurrent unit
- spiking activity -> LFP in θ band
- Findings:
  - Hyper-connected cells > under-connected cells
  - Interneurons > principal neurons

Acknowledgement and great teamwork!

Mentor

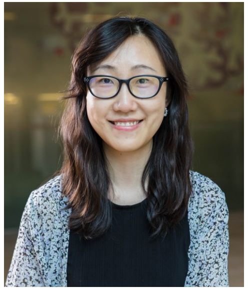
Andrea Hasenstaub

TA

Kai Chen

Nitin Anisetty

Our team



Cong Wang

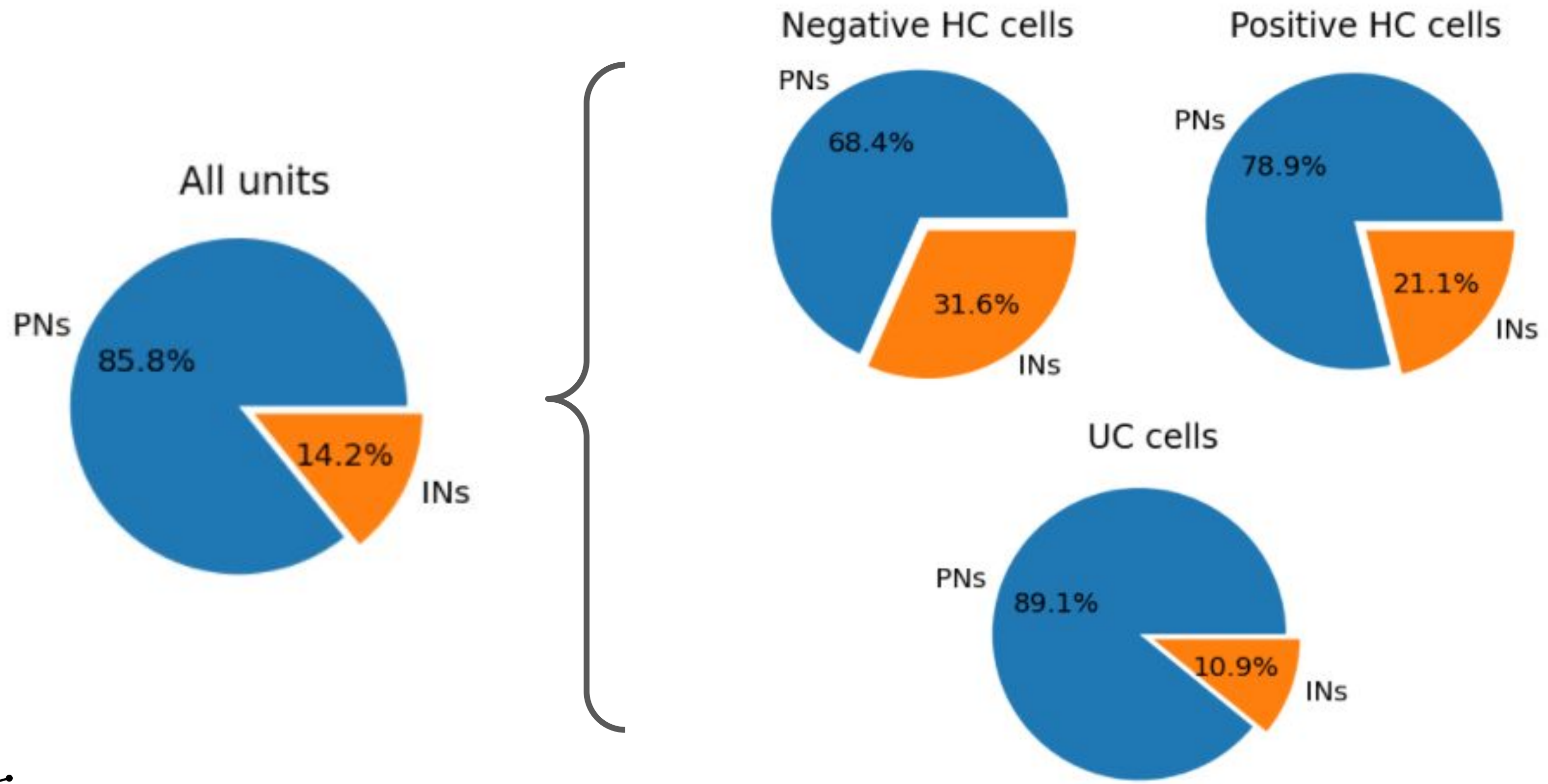
Hoi Ming Ken Yip

Yongxiang Xiao

Vicky Zhu

Weihao Sheng

Unit functional connectivity vs. Cell types



Single-neuron firing rate vs. training weights