Naturalistic decision-making dynamics in spiking neuron circuits

John C. Ksander, Donald B. Katz, & Paul Miller

Brandeis University, Waltham, Massachusetts

Introduction

- Foraging behavior
  - Sequence of successive decisions between:
    - Consume immediately available food (“stay”)
    - Seek an alternate food source (“leave”)
  - Studied with 2AFC taste preference task
- Modelling brain implementation as multistable network
  - Replicates taste-decision behavior well (Miller & Katz 2013)
  - Taste, consumption behavior correspond to sudden changes in cortical activity (Jones et al., 2007;Sadacca et al., 2016)

Brain implementations

“Enticed to stay”

- Naturally inclined to leave
- Rapid transitions without hedonic stimuli

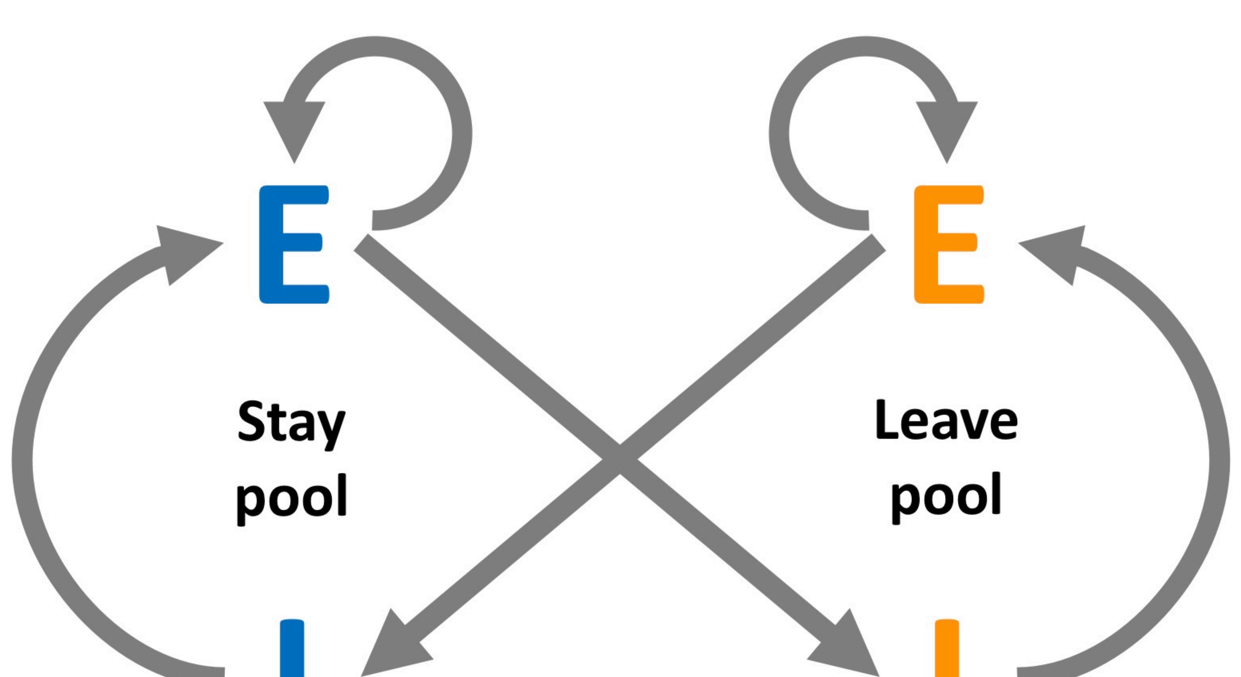
“Repelled to leave”

- Naturally inclined to stay
- Rarely transitions without aversive stimuli

Goal of present study

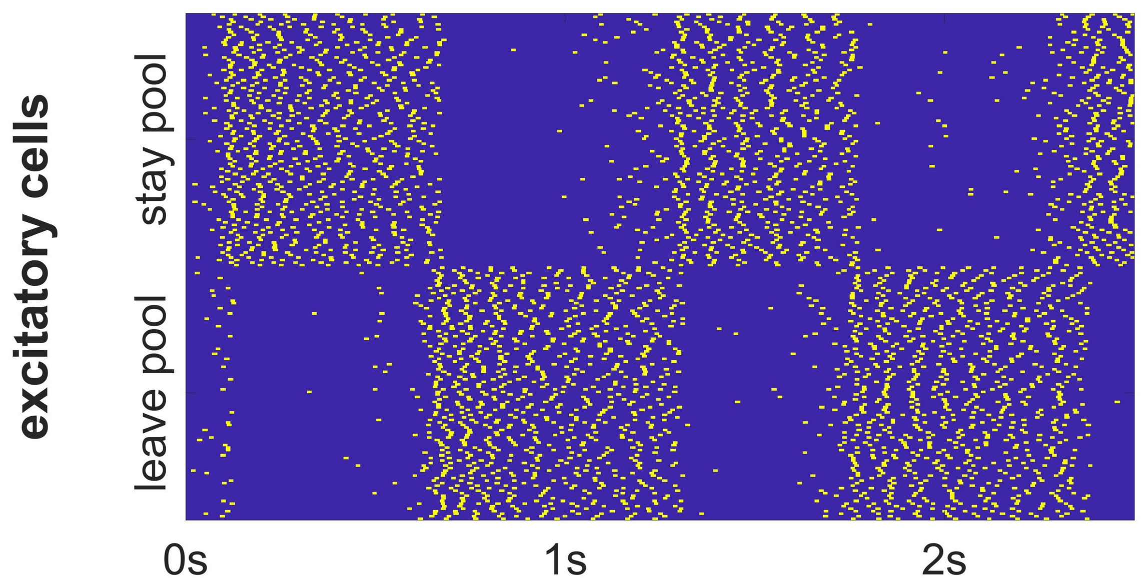
- Produce taste-preference behavior with bistable network
- Test whether “entice to stay” and “repel to leave” accounts predict different neural dynamics during network transitions

Model architecture



- 250 voltage-based spiking model neurons (Brette & Gerstner 2005)
- Organized in two pools of 100 excitatory & 25 inhibitory cells

Bistability



Simulations

1. Basic taste-preference behavior in a task with unequally palatable stimuli
2. Parameter search (without stimuli) to find networks with “entice to stay” and “repel to leave” characteristics
3. Sampling behavior and network dynamics following “entice to stay” and “repel to leave” implementations

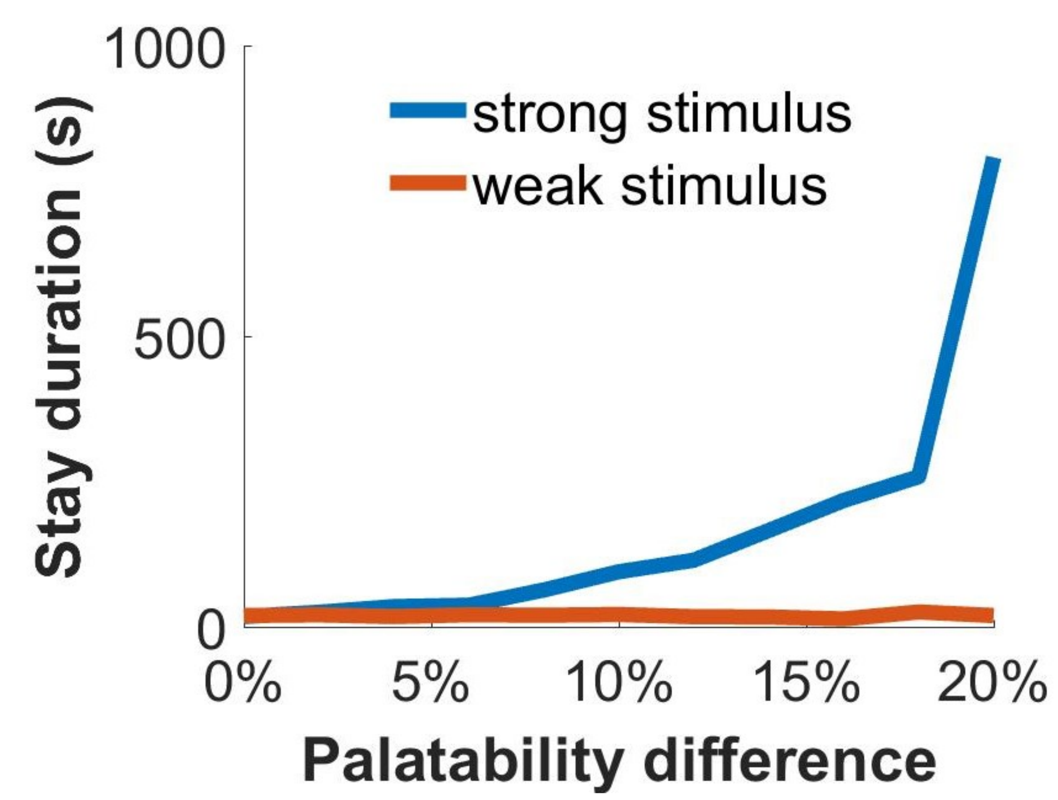
Palatable stimulus

- Spiking input to excite-stay cell group (E)
- Applied in basic preference & “entice to stay” sims.

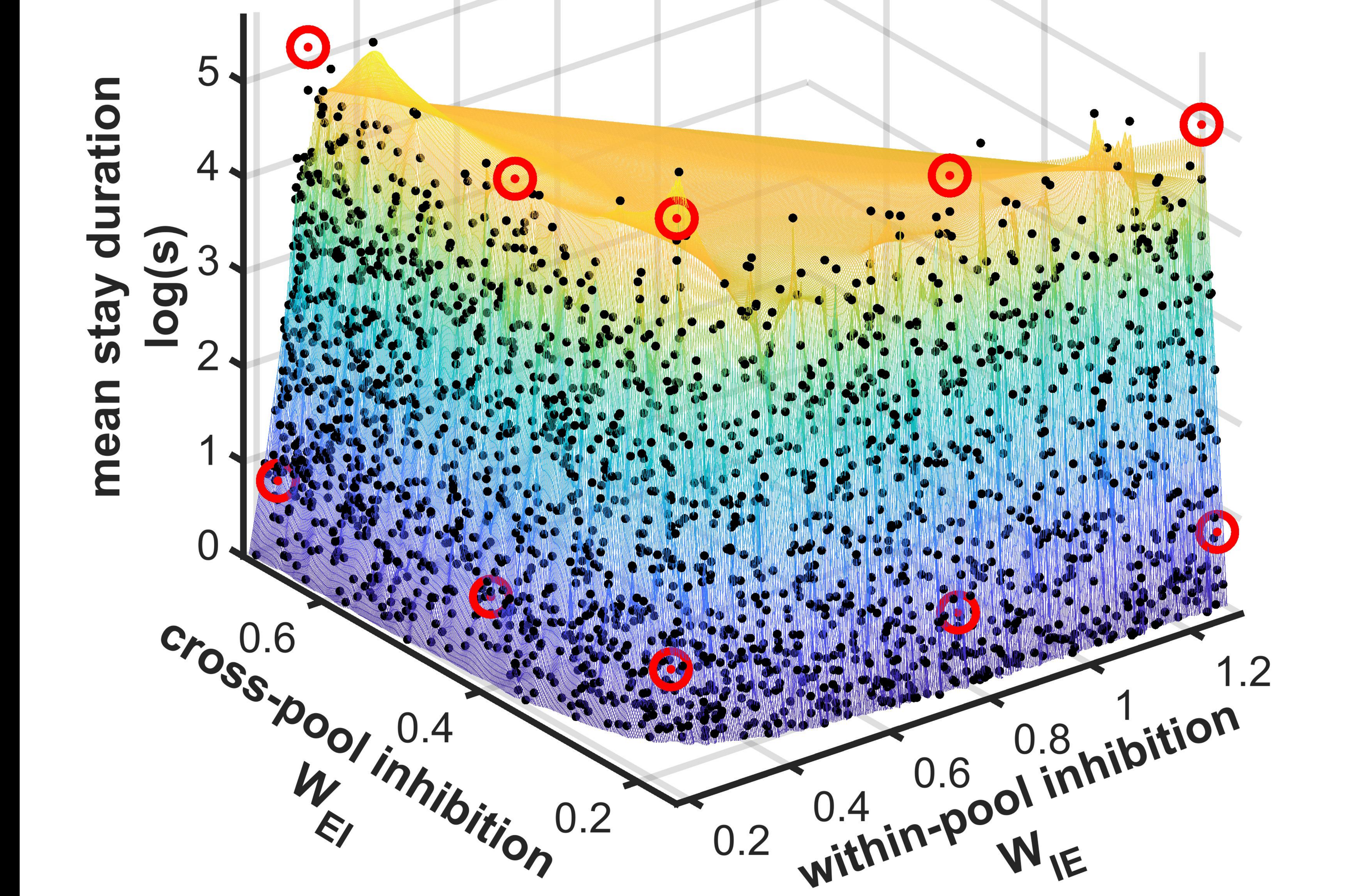
Aversive stimulus

- Spiking input to excite-leave cell group (E)
- Applied in “repelled to leave” simulations

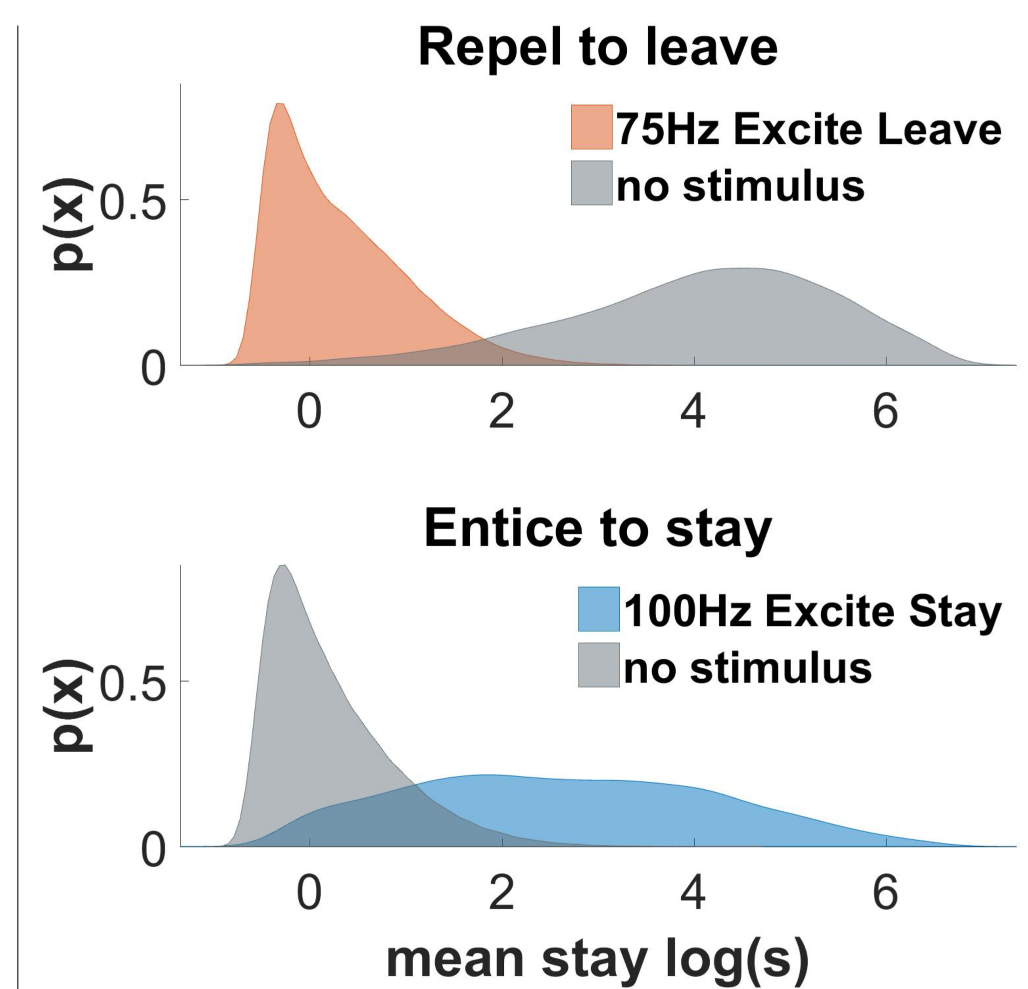
Taste-preference behavior

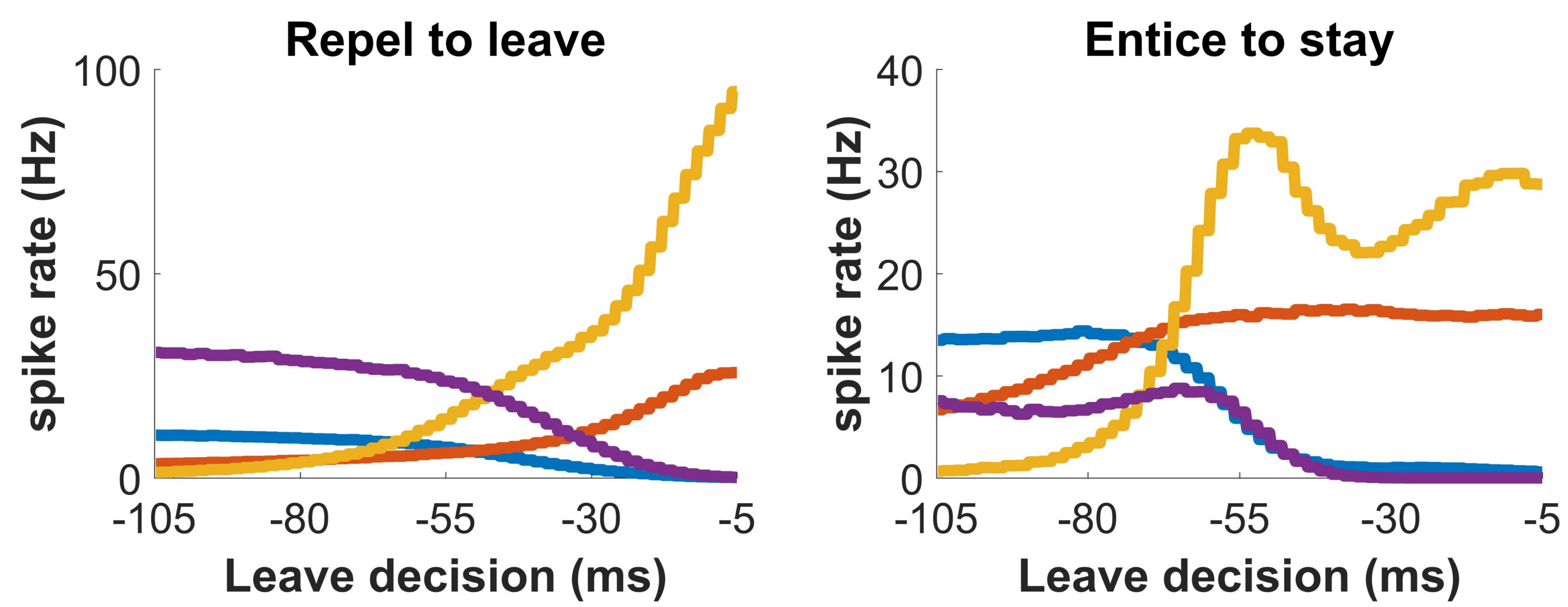


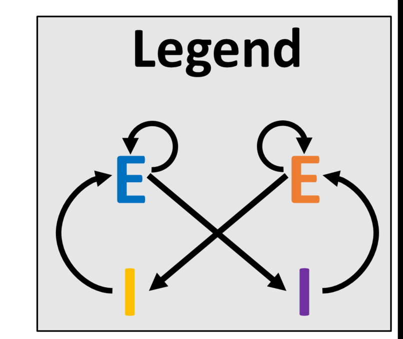
Results



Networks show “entice to stay” (top ridge) & “repel to leave” (bottom ridge) behavior in simulations without stimuli







Conclusions

- Modeling framework replicates taste-preference behavior, following either “entice to stay” or “repel to leave” implementations by changing within/cross-pool inhibition
- Both accounts replicate sampling behavior, but preliminary results show different predictions for network dynamics during state-transitions
- State-transitions identified in neural recordings with hidden Markov modeling can test predictions

Funding

This research was made possible with support from NIH (NINDS) funded under the BRAIN initiative (R01NS104818) and the NIGMS Brain, Body, & Behavior Training Grant (T32GM084907).