Dynamic Interfacing Between Allocentric and Egocentric Frames via the Parietal-Hippocampal Network During Spatial Navigation

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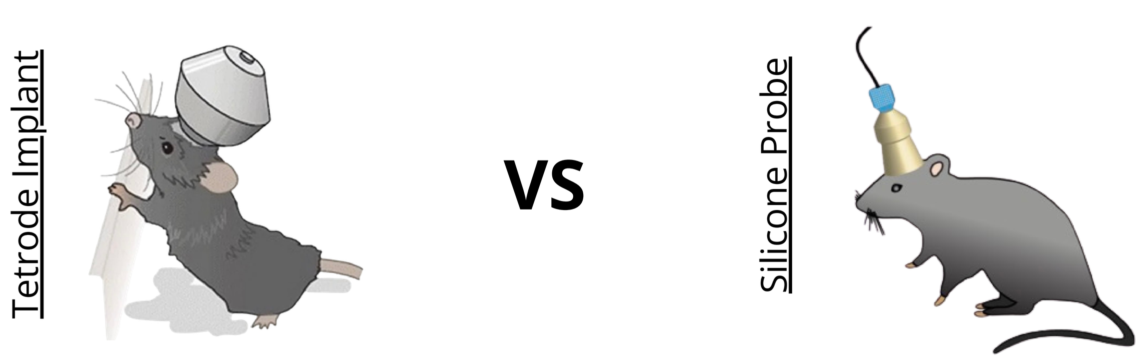
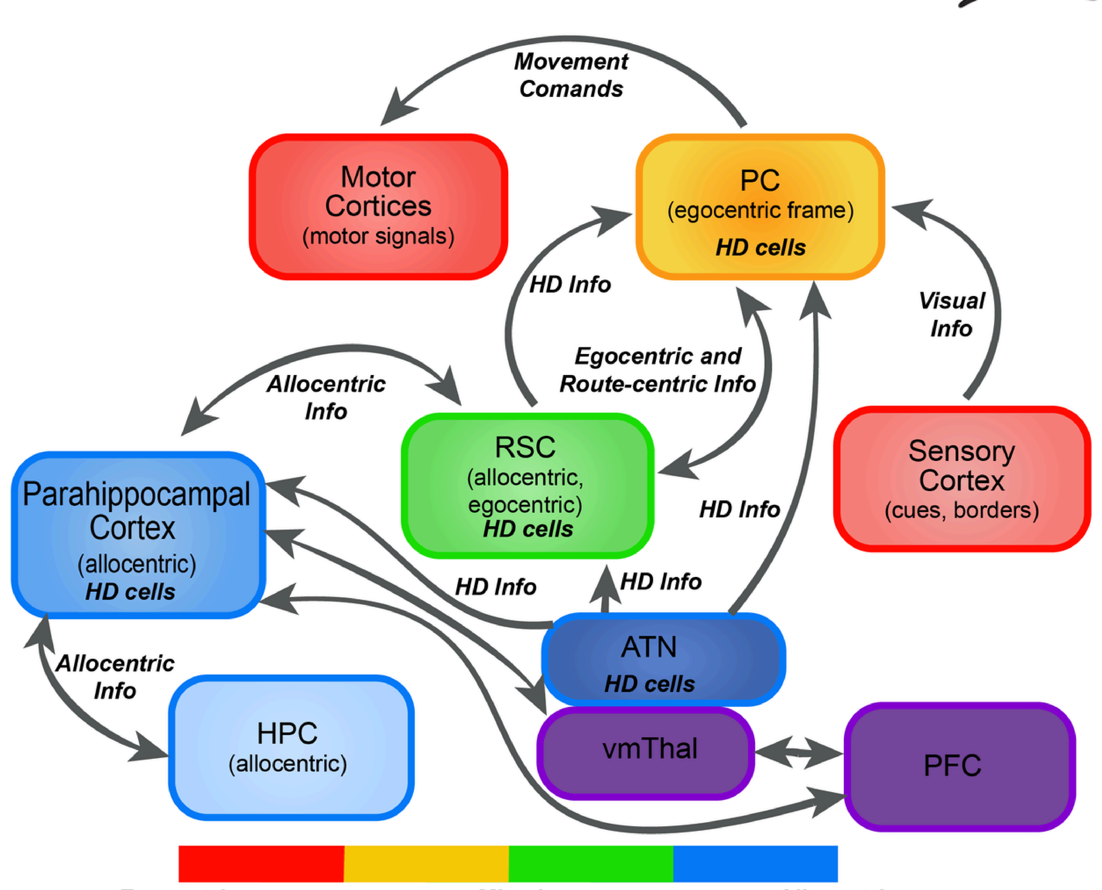
Introduction/Background

- **Spatial navigation** requires integrating multiple frames of reference:
  - **Allocentric**: world-centered
  - **Egocentric**: body-centered
- **Neural network involved**: Hippocampus (HPC), Parietal Cortex (PC), Retrosplenial Cortex (RSC), Anterior Thalamic Nuclei (ATN), etc.
  - HPC → encodes allocentric position
  - PC & RSC → transform sensory-motor info to spatial maps
- **Previous work**: PC-HPC bidirectional coordination (Zheng et al., 2025)
  - Limitation: Did not separate reference frames clearly
- **Goal of study/ Purpose**: Identify neural signatures of allocentric, egocentric, and transformation states
- **Hypothesis**:
  - ATN/PC head direction info + HPC goal direction info converge in PC → create body-centered action plans

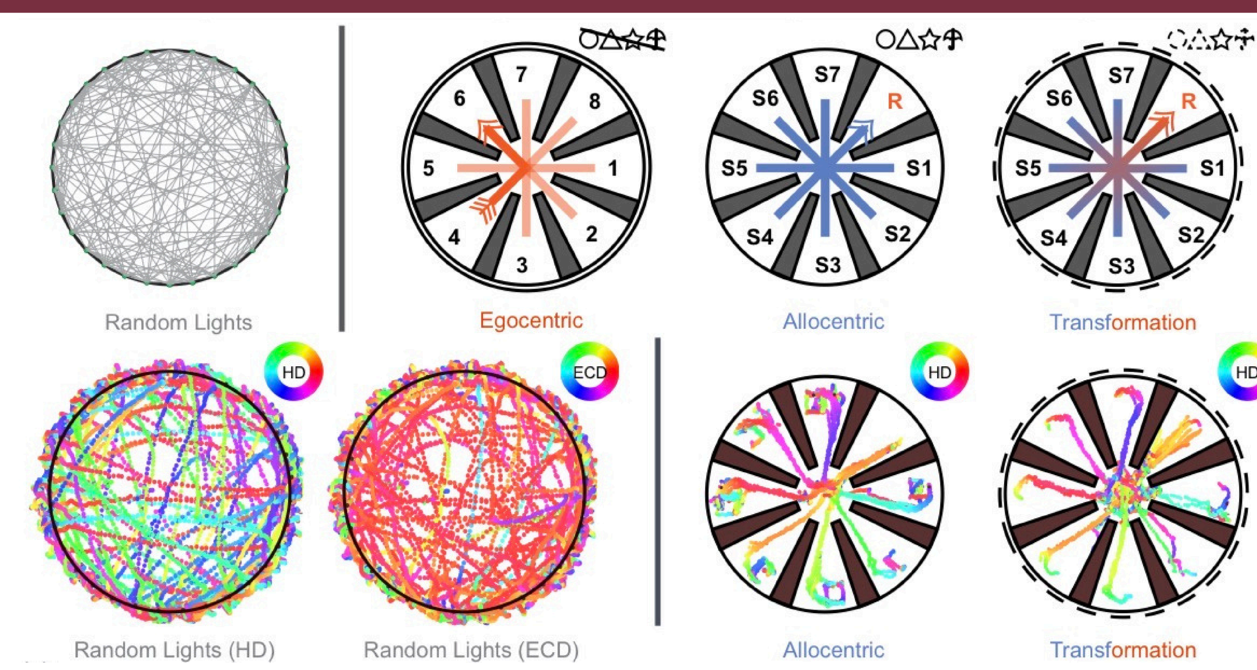
- **Local Field Potentials (LFPs)**: low-frequency electrical signals from groups of nearby neurons, reflecting summed synaptic activity in a brain region.
  - **Measurement of Local Field Potentials (LFPs)**:
    - ***Tetrode Implant***
      - Four twisted microelectrodes recording nearby neurons
      - Fewer recording sites; limited spatial coverage
    - ***Silicone Probe***
      - Thin multi-channel probe recording from many sites along its length
      - Very fragile; expensive





Proposed network model of spatial reference integration

Methods



Behavioral diagram across random lights, egocentric, allocentric, and transformation conditions

1. **Random Lights – Cell Classification**
   - 32 lights randomly illuminated → rat navigates for reward
   - Purpose: classify neurons by spatial & movement tuning
2. **Egocentric Navigation**
   - Reward relative to the rat's starting position (body-centered)
   - Distal cues removed
   - Procedure: Place → Cover → Remove cover → Navigate → Reward
3. **Allocentric Navigation**
   - Reward fixed in the environment (world-centered)
   - Rats use distal cues
   - Procedure: Place → Remove box → Navigate using cues → Reward
4. **Transformation Task**
   - Encode reward using distal cues → cues removed
   - Tests allocentric → egocentric transformation
   - Procedure: Place → Cover → Block cues → Remove cover → Navigate → Reward

Subject:
- Total N = 4
- Species: Laboratory rat (*Rattus norvegicus*)
- Genotype: Fischer-Brown
- Sex: M & F

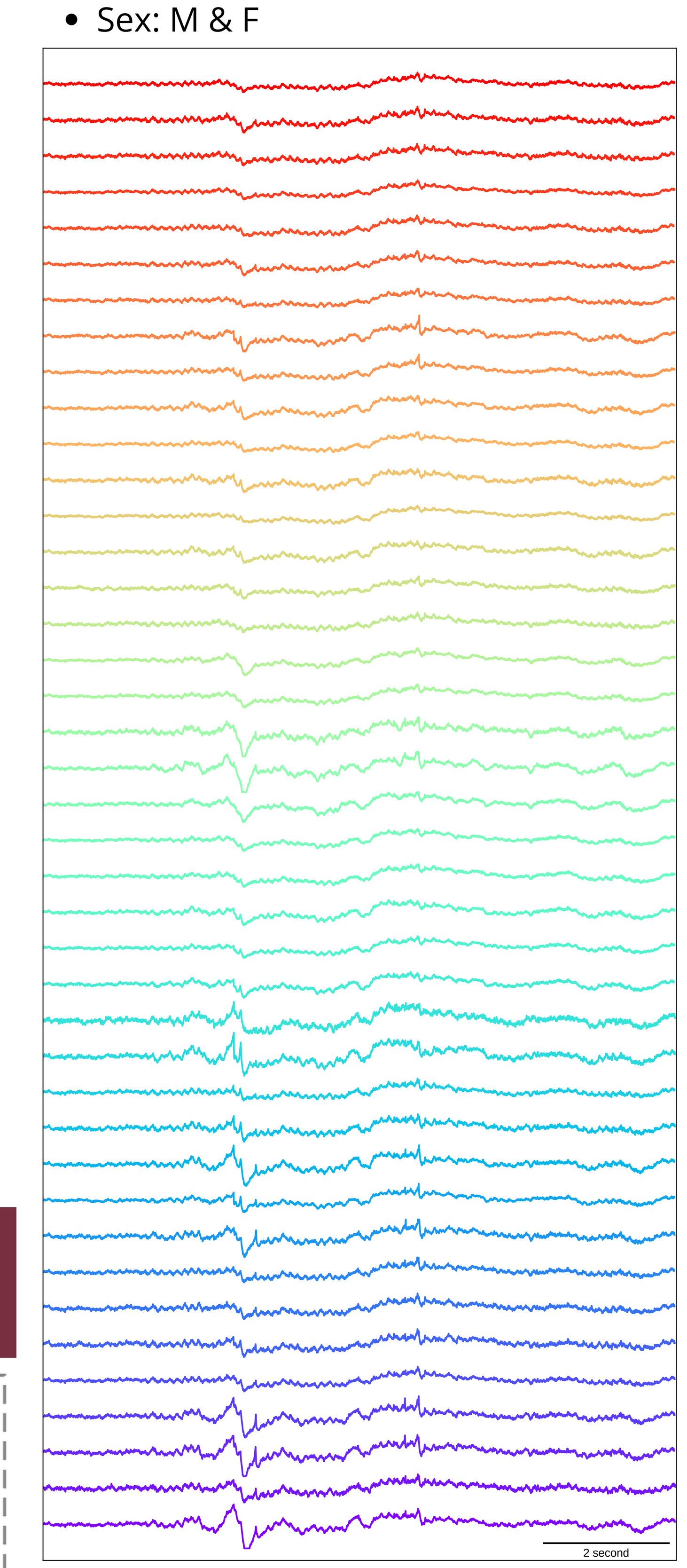
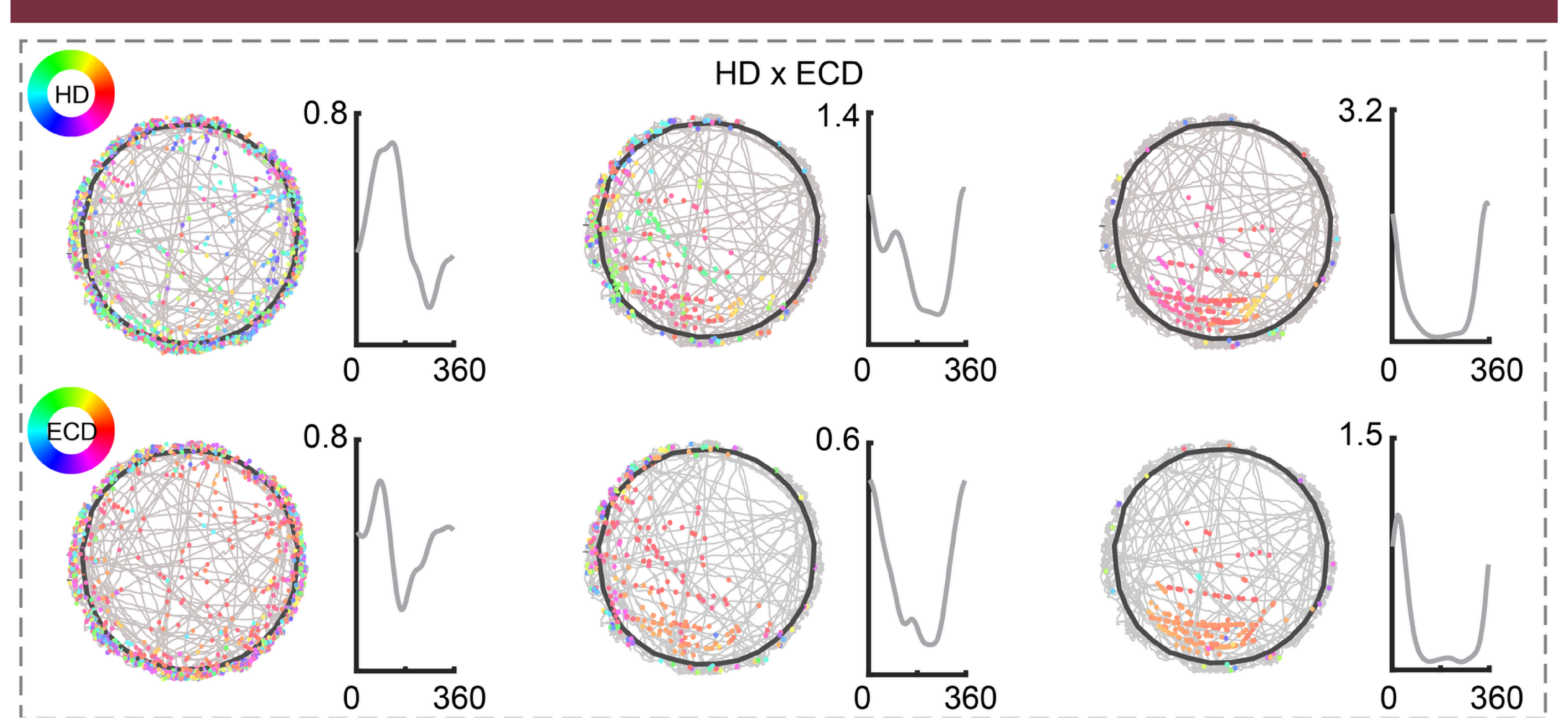


Diagram of Silicone probe recording channels of Local Field Potentials

Results



HD-only, ECD-only, and HD x ECD tuning are found in the Random Lights task. For each cell, spiking locations are plotted along the maze trajectory, color-coded as HD or ECD. HD-only cells (not shown) exhibit direction-locked firing aligned to head orientation, ECD-only cells (not shown) fire based on cue direction relative to the animal, and HDxECD cells show conjunctive tuning to both reference frames. Corresponding tuning curves (right) illustrate selective angular modulation for each cell type.

- Results shown are pooled data from rats in previous semesters with successful tetrode implants.
- These recordings were used to analyze parietal and hippocampal activity during navigation and examine allo–ego interactions.
- Fall 2025 data are excluded due to implant failure and non-viable recordings (see discussion section).

Discussion/ Next Steps

- This study examines how allocentric and egocentric spatial frames interact during navigation, focusing on coordinated neural activity within the parietal–hippocampal network during spatial tasks. By recording single-unit activity from both regions, we aim to better understand how internal representations of space are dynamically integrated.
- In Fall 2025, we transitioned from tetrodes to silicon probes to increase recording density and capture more simultaneous neural signals. Although silicon probes offer higher channel counts, somehow the recording settings were not set properly which would only allow us look into LFP oscillations (0.1-1000 Hz) instead of detecting spikes (600-6000 Hz). As a result, the collected data were not viable for analysis that involves spike sorting and cell classification.
- For Spring and Summer 2026, we will return to tetrodes, which have demonstrated greater mechanical stability in our lab. While tetrodes provide lower channel density, their reliability and flexibility increase the likelihood of obtaining clean, single-unit recordings across sessions.
- A new surgery is planned for mid–Spring 2026, followed by recovery and reintroduction to spatial navigation tasks. The goal is to obtain stable, analyzable neural data that will allow us to properly assess parietal–hippocampal coordination and allocentric–egocentric frame integration.
- This project does not have a definitive end date and will continue in future semesters, with ongoing refinement of surgical techniques and recording strategies to improve data quality and uphold ethical research standards.

References

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