Coordination between nonlocal hippocampal representations and the collicular orienting system

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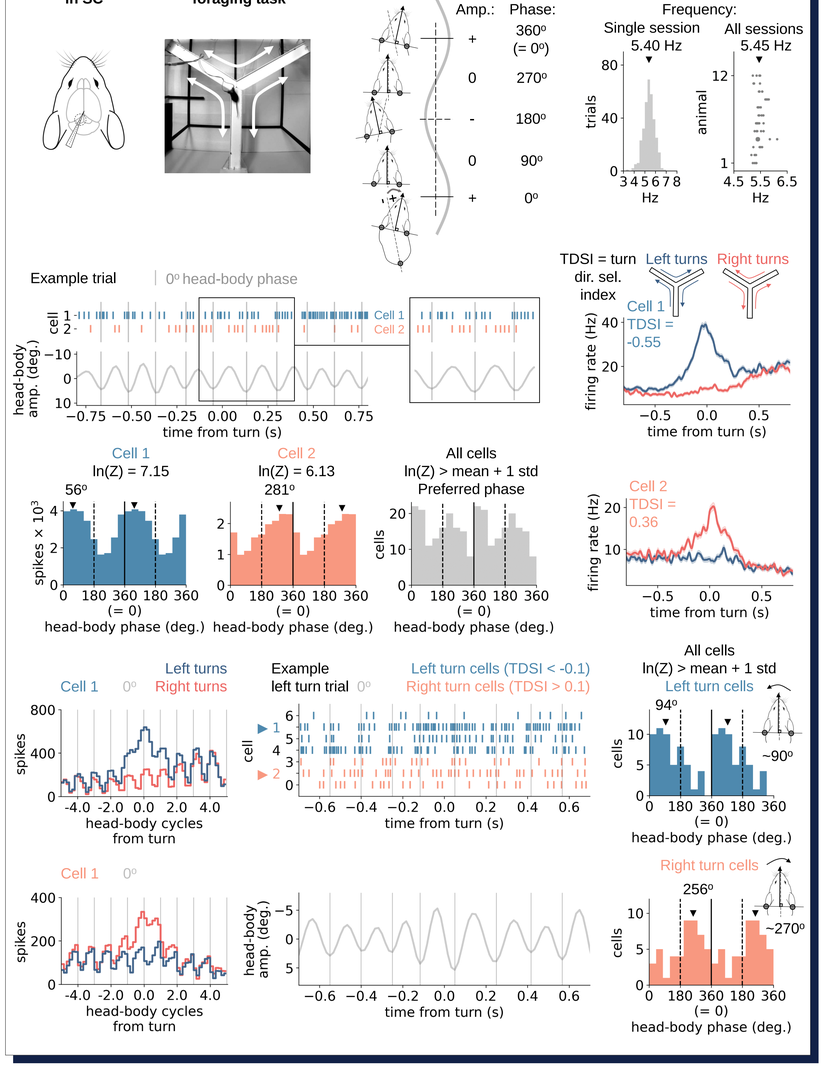
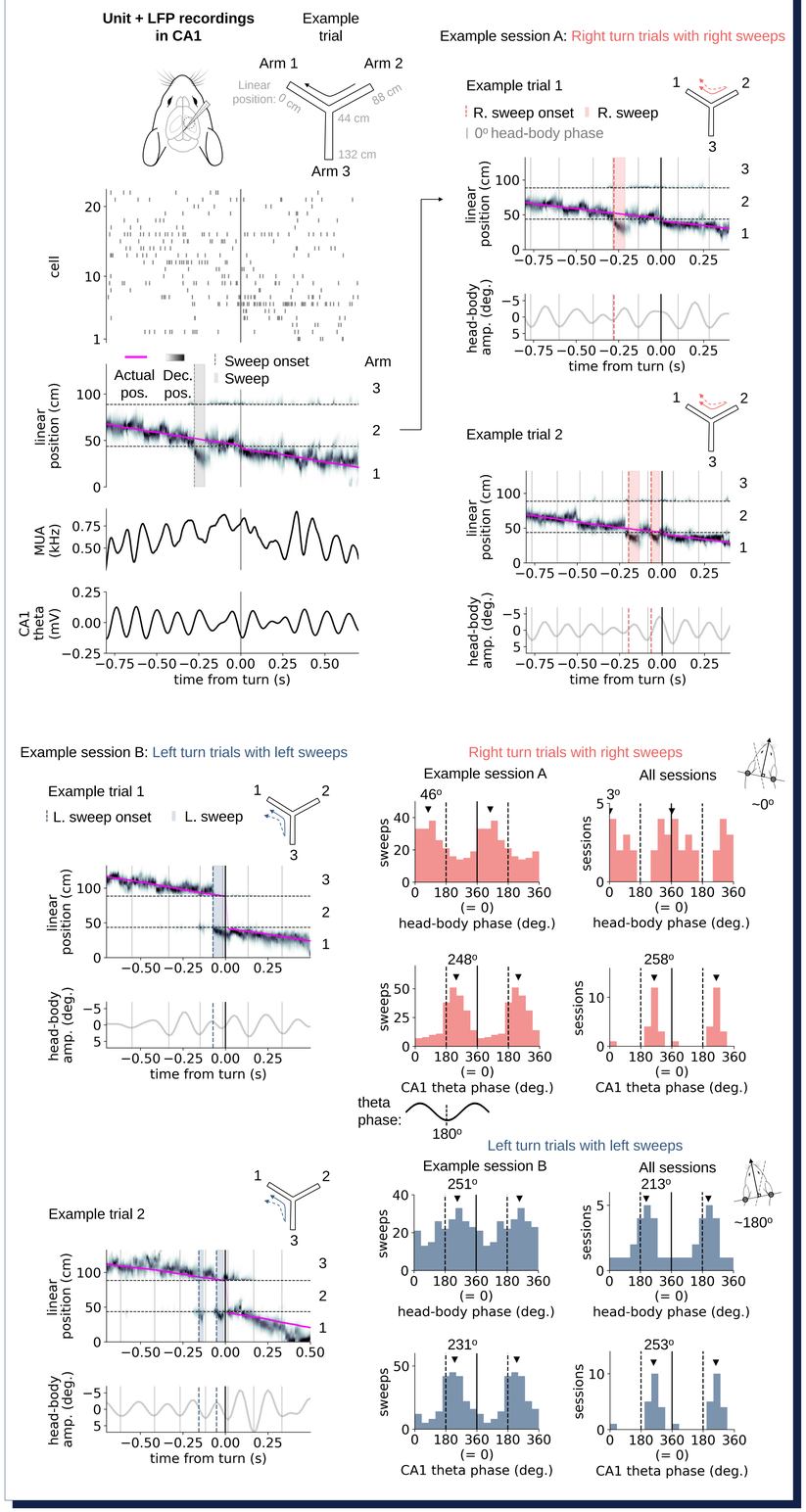
Abstract

Studies on hippocampal place cells have found neuronal sequences representing nonlocal spatial trajectories that sweep ahead of the animal and orient towards possible left or right future paths. **Do these nonlocal orienting sweeps in the hippocampus occur in coordination with an orienting command center in the brain?** To address this question, we recorded neural activity in the hippocampus and the superior colliculus (SC), a midbrain structure implicated in the control of spatial orienting movements, as mice navigated a Y-maze. We classified hippocampal sweeps based on their directionality and SC neurons based on their turn direction preference on the maze. We discovered that the activity of SC neurons is modulated by a left/right head-body oscillation characteristic of locomotion. Strikingly, SC neurons with opposite direction preferences fire preferentially at opposite phases of the head-body oscillation. Similarly, we found that the onsets of hippocampal sweeps occur in phase with the locomotor head-body oscillation. Notably, the onsets of hippocampal sweeps of opposite directions occur at opposite phases of the head-body oscillation. Lastly, we investigated whether SC neurons fire differently depending on the direction of ongoing hippocampal sweeps. We found that SC neurons fire more during trials that contain sweeps in their preferred direction compared to trials that contain sweeps in their non-preferred direction. Together, our results reveal a coordination between nonlocal hippocampal representations and the SC orienting system.

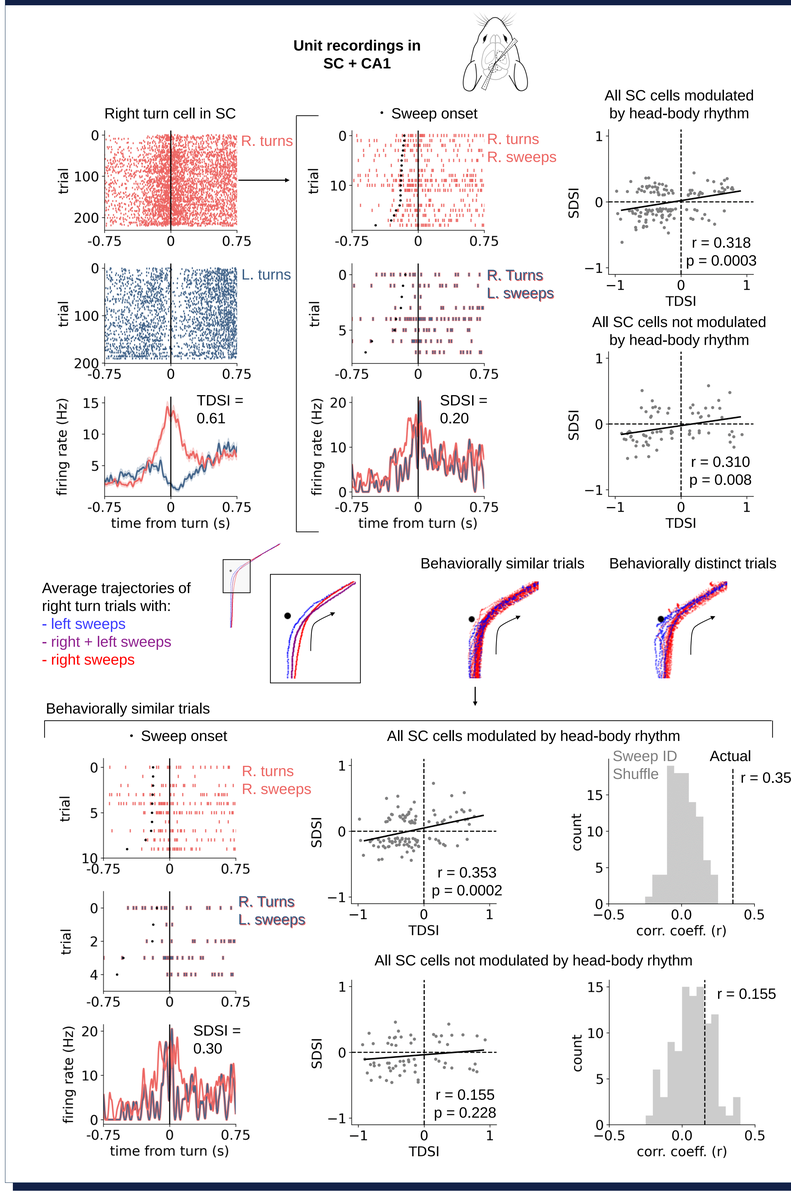
A locomotor rhythm organizes directional firing of SC neurons



The onsets of hippocampal sweeps occur in phase with the locomotor rhythm in a direction-dependent manner



SC neurons fire more during trials that contain hippocampal sweeps in their preferred direction



Conclusions

- The activity of SC neurons is modulated by a ~5.5 Hz locomotor head-body rhythm.
- SC neurons with opposite direction preferences fire preferentially at opposite phases of the locomotor rhythm.
- The onsets of hippocampal sweeps of opposite directions occur at opposite phases of the locomotor rhythm.
- SC neurons modulated by the locomotor rhythm fire more during trials that contain hippocampal sweeps in their preferred direction.
- **These results reveal a coordination between hippocampal sweeps and the SC orienting system and point to a role for motor command centers in the organization of nonlocal or 'simulated' experience.**

Funding: HHMI, UCSF Discovery Fellowship. Acknowledgements: Eric Denovellis, Leo Ruan, Pooja Saraf, Qin Ying Wu.