UC San Diego
Cognitive Science

Janet Tung's Dissertation Defense

Navigation With a Purpose: Environment and Goal-Mediated Representations of Space in the Rat Brain During Complex Task Paradigms

Monday, December 8th, 2025
10:00am – 12:00pm, Cognitive Science Building (CSB), Room #180
or https://ucsd.zoom.us/j/95787597647

Abstract:

Navigation through the space that surrounds us is essential to survival. Movement within an environment can serve a multitude of goals for mammals: migration, foraging, chasing prey, evading predators, and so on. Success in these tasks often involves complex interactions with one's surroundings that must be computed and translated into goal-directed actions. Neural circuits supporting these interactions must dynamically integrate external information with existing spatial representations and self-movement processes. They must also be able to adapt their functionality to suit changing task demands, which may sometimes require rapid reference frame shifts: for example, from single-minded, high-speed pursuit to reorientation and finding one's way back to the pack or den. To better understand the mammalian brain's representation of goal-directed spatial cognition, we focused on key structures in the spatial system: the hippocampal formation (areas CA1, CA3) and the subiculum as well as interconnected neocortical areas, posterior parietal cortex (PPC) and secondary visual (V2), which are involved in the processing and representation of visual and movement information.

We conducted in vivo electrophysiological recordings on freely moving rats trained to carry out goal-directed navigational tasks. First, we examined the self-motion tuning of PPC neurons during pursuit of a floor-projected visual target compared to free foraging conditions. We found that during pursuit, animals engaged in predictive behaviors, tailoring movement to anticipated locations of the target. As a population, PPC neurons responded to the pursuit condition by increasing self-motion tuning in three ways: the proportion of self-motion sensitive PPC neurons increased; individual neurons exhibited additive or multiplicative gain; and the temporal latency window between neuron firing activity and self-motion tuning expanded by a couple hundred milliseconds. We also found that about one half of PPC neurons with self-motion sensitivity encoded the egocentric position of the visual target.

In the second and third experiments, we designed a segmented task with three sub-goals, designed to engage different frames of reference: route-centered, object-centered, and arena-space-centered. We found that neuron populations in PPC, V2, hippocampus, and subiculum exhibited task-modulated differentiation between these phases and free foraging in their firing rates and spatial tuning. In the hippocampus, CA1 and CA3 neurons exhibited differential responses; CA3 was more sensitive to task-relevant behavioral measures and engaged in greater differentiation between phases, while the CA1 population displayed unbiased coverage of space in all phases, but significantly increased spatial tuning in free forage. Subiculum neurons also exhibited task-modulated differences in activity as well as selective expression of geometrically repetitive place fields enabling discrimination between trial types. We found PPC neurons to be tuned to both physically bounded, metrically equivalent routes as well as unbounded routes of varying distances.

Committee members:

Dr. Douglas Nitz (Chair) - UCSD Cognitive Science
Dr. Andrea Chiba - UCSD Cognitive Science
Dr. Anastasia Kiyonaga - UCSD Cognitive Science
Dr. Lara Rangel - UCSD Cognitive Science
Dr. Bradley Werner - UCSD Scripps Institution of Oceanography (SIO)