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The attractor dynamics of behavioral flexibility in spatial and reversal learning

Tuesday 18 June 2024 13:40 (45 minutes)

To survive in a changing world, animals often need to suppress an obsolete behavior and acquire a new behavior. This process is known as reversal learning (RL). The neural mechanisms underlying RL in spatial navigation has received limited attention and it remains unclear what neural mechanisms maintain behavioral flexibility.
We extended an existing closed-loop simulator of spatial navigation and learning, based on spiking neural networks (Ghazinouri et al. 2023). The activity of place cells and boundary cells were fed as inputs to 40 action selection neurons that each represents one direction of movement. The activity of these neurons drove the movement of the agent. When the agent reached the goal, behavior was reinforced with spike-timing-dependent plasticity (STDP) coupled with an eligibility trace which marks synaptic connections for future reward-based updates. The modeled RL task had an A-B-A design, where the goal was switched between two locations A and B every 10 trials.
Agents using symmetric STDP excel initially on finding goal A, but fail to find goal B after the goal switch, persevering on goal A. Injecting short pulses noise to action neurons, using asymmetric STDP, and using small place field sizes was effective in driving spatial exploration in the absence of rewards, which ultimately led to finding goal B and, hence, reversal learning. However, this flexibility comes at the price of lower performance.
Our work shows three examples of neural mechanisms that achieve flexibility at the behavioral level, whose differences can be understood in the terms of attractor dynamics.

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References

Ghazinouri, B., Nejad, M. M., and Cheng, S. (2023). Navigation and the efficiency of spatial coding: Insights from closed-loop simulations. Brain Structure and Function

Preferred form of presentation

Talk (& optional poster)

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Spatial navigation, Reversal learning, Behavioral flexibility

Topic area

Models and applications

Speaker time zone

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