Learning useful representations to solve a place-odor association task

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Fleischmann Lab

Collaborators


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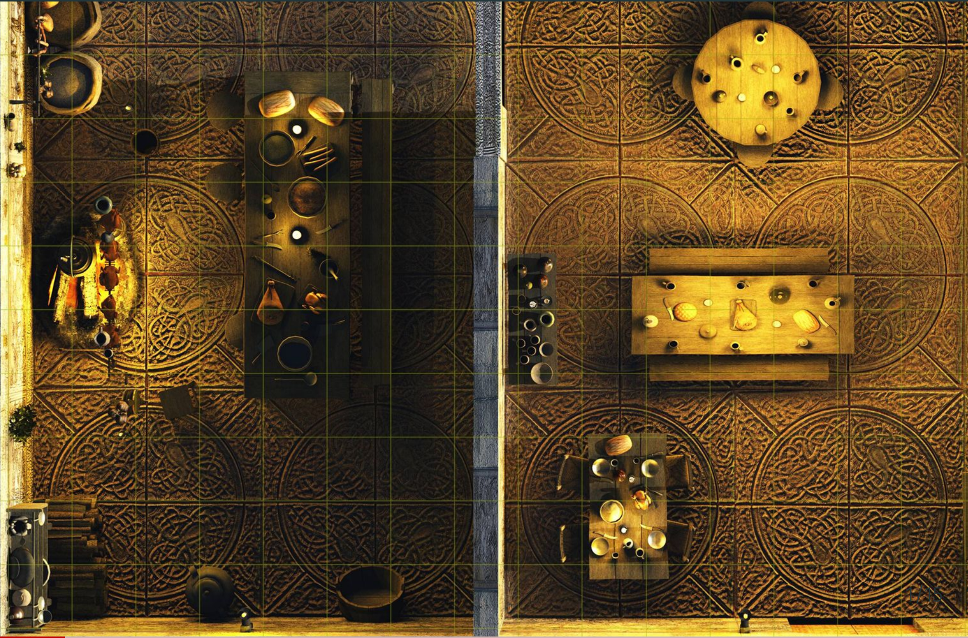
Jason Ritt

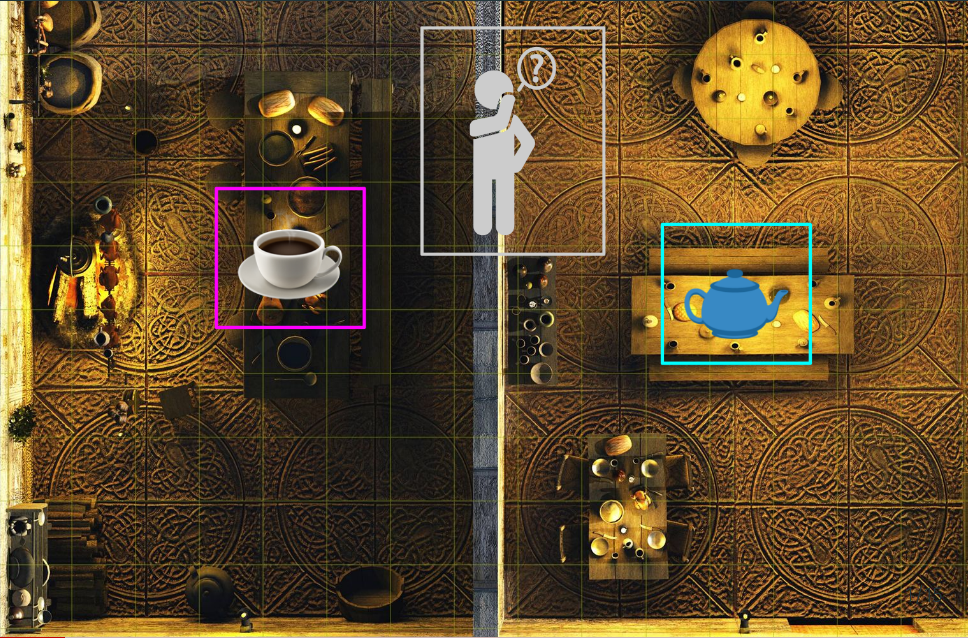

Olivia McKissick


Alex Fleischmann

Odor-place association

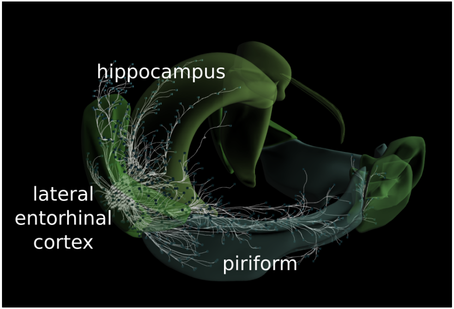


Odor-place association

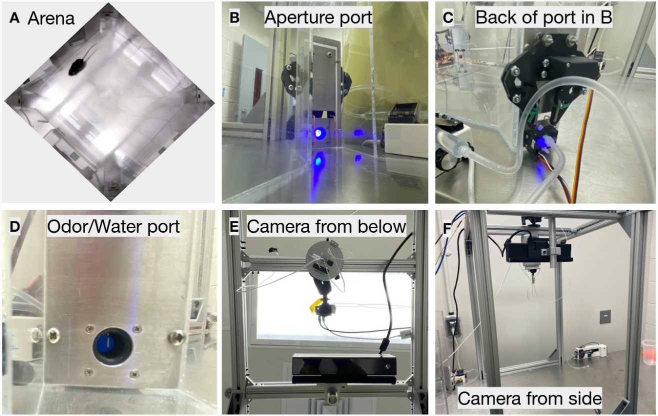


The LEC is key to sensory associations and spatial memory

- Piriform encodes olfactory information
- Hippocampus encodes spatial information
- Lateral Entorhinal Cortex (LEC) encodes both olfactory & spatial information



Diamond arena experimental setup



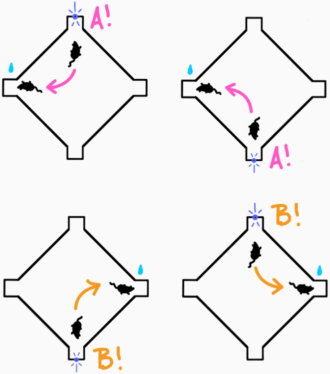
Olivia McKissick

→ 1P calcium imaging recording on freely moving mice

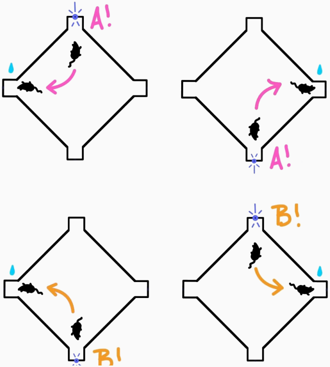
Diamond arena olfactory task

Olivia McKissick

Allocentric (go west/east)



Egocentric (go right/left)



What is Reinforcement Learning and why use it ?

- Theoretical framework hypothesized to be implemented in the brain
- Tool to model behavior
- Goal of the agent : maximize rewards
- Natural fit for behavioral experiments involving rewards and learning

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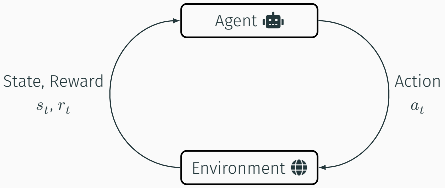

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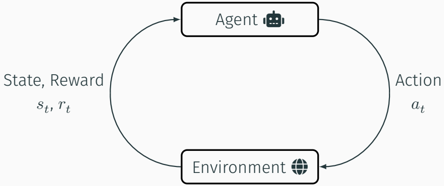

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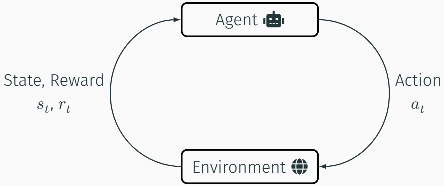

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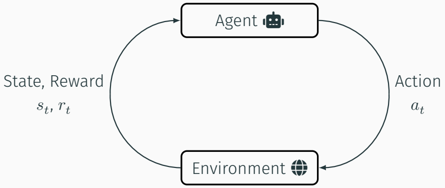

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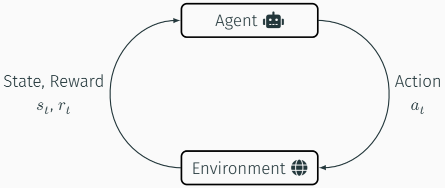

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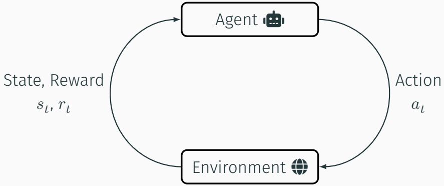

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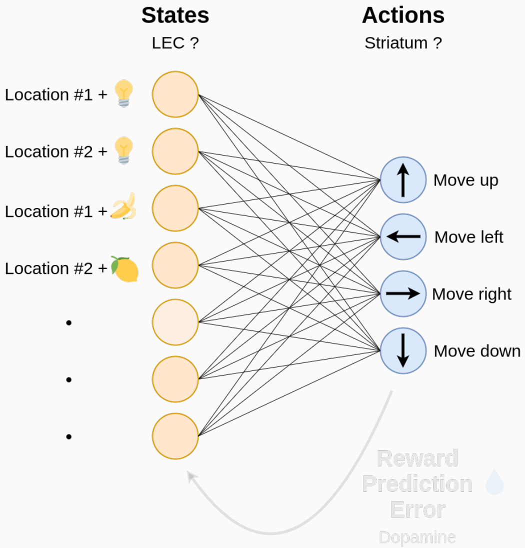
RL maps states to actions



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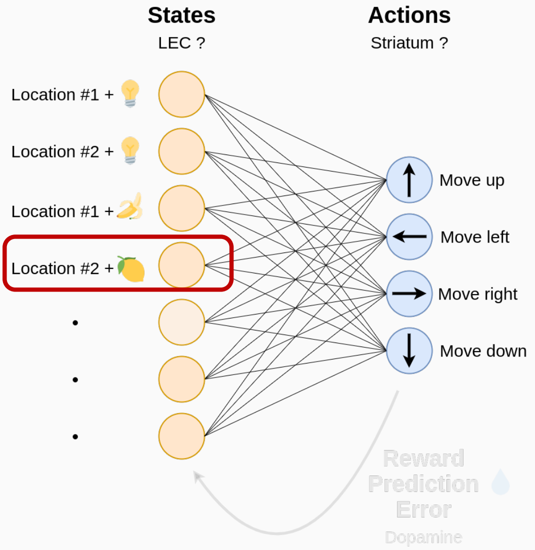

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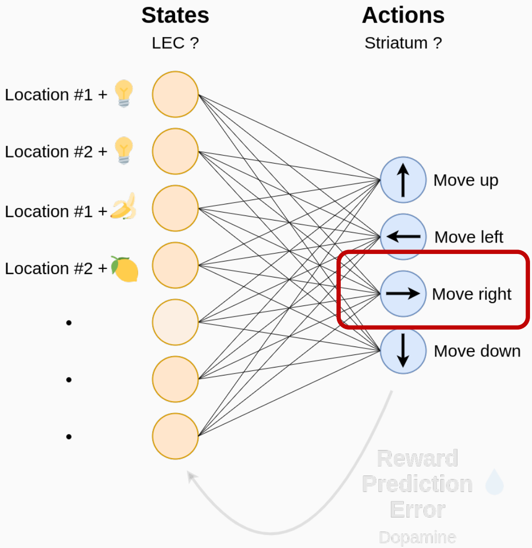

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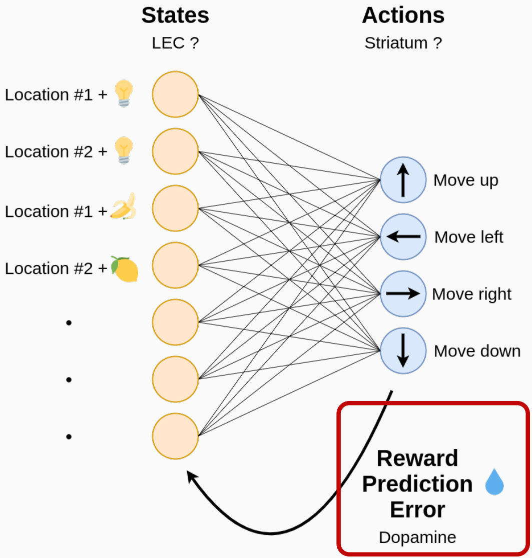

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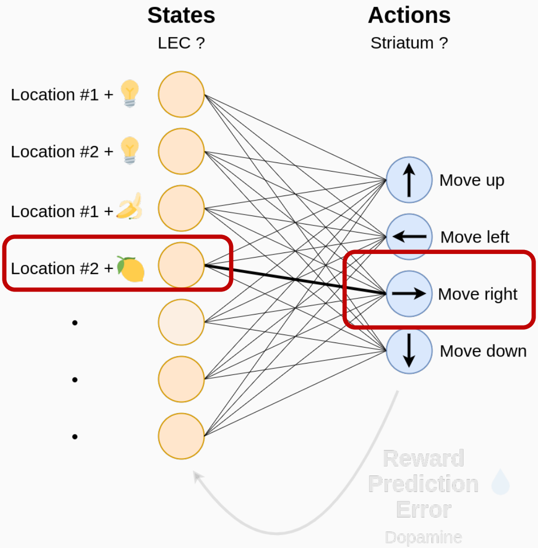
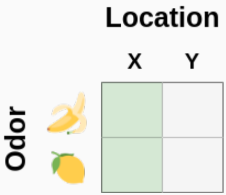


Which representations are needed by the brain to learn a place-odor association task ?

The joint representation encodes odor + location

Location only



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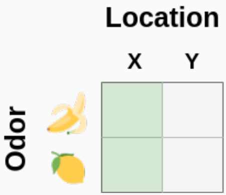
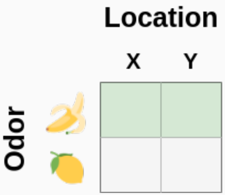


Odor only



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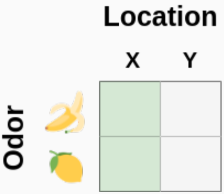
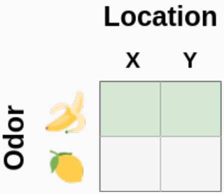
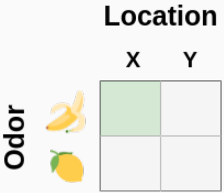


Odor only

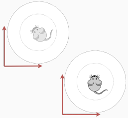


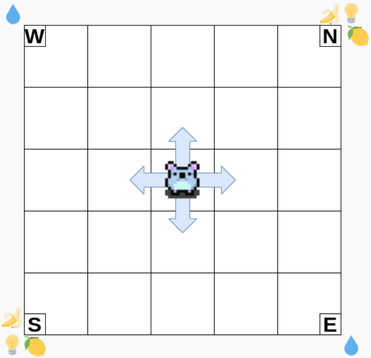
Joint



The model

Allocentric





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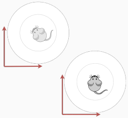

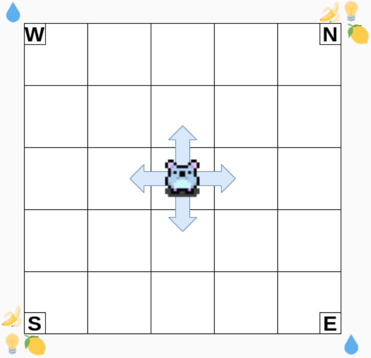

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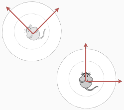
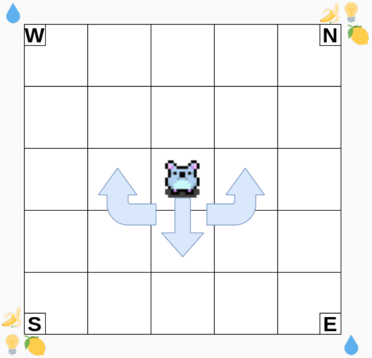
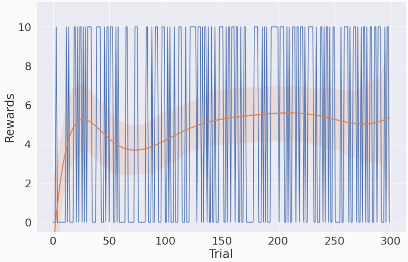




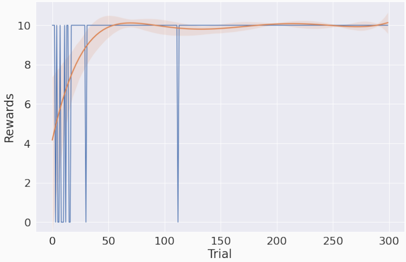
Maximizing rewards

Without joint representation



→ The agent doesn't learn

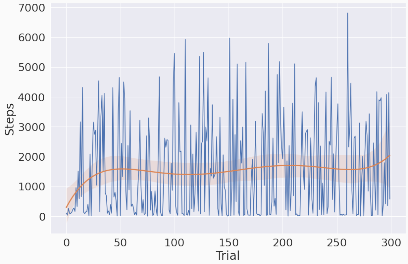
With joint representation



→ The agent learns to solve the task

Minimizing the number of steps to solve the task

Without joint representation



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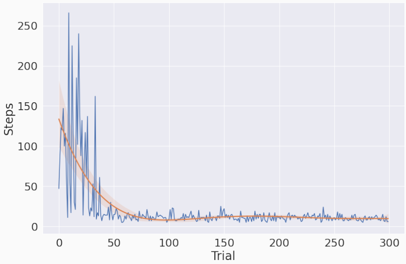
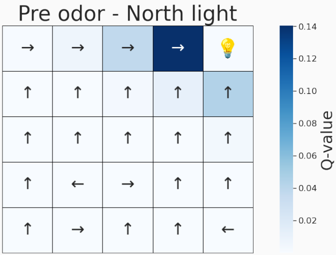
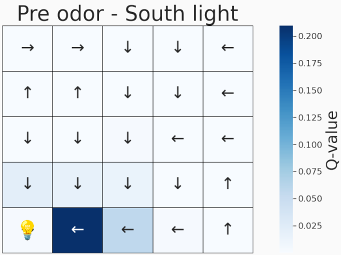


→ The agent learns to solve the task

What policy did the agent learned ?





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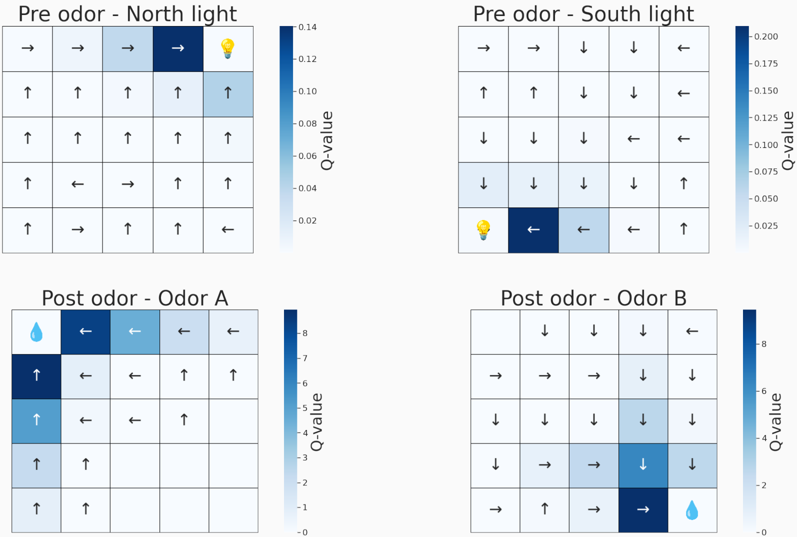
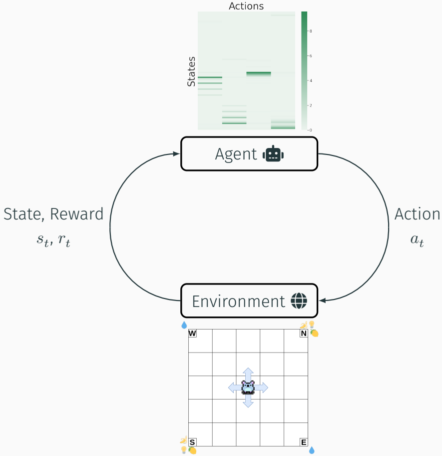
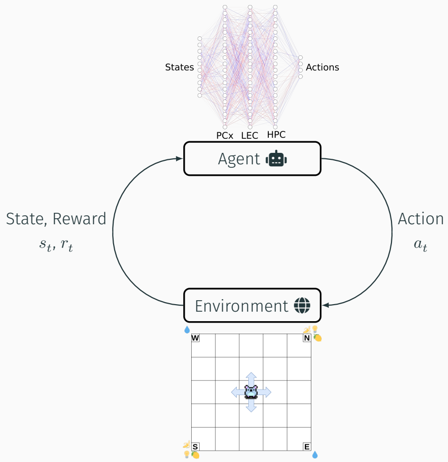


Our RL model so far



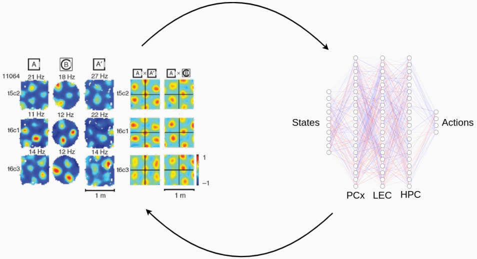
- Tabular model that maps states to actions
- No generalization
  $\rightarrow$ each state needs to be visited by the agent to compute a prediction of getting a future reward

Next step : from tabular RL to deep RL



- Neural network does the mapping from states to actions
- Learn to extract features/representations from the simulation data
- Better generalization $\rightarrow$ the agent does not need to visit each state to compute a prediction of getting a future reward

What types of representations are in use to solve an odor-place association task ?



Experimental data

Simulation

→ Look for candidate patterns in the data: place cells, grid cells,...?

→ Compare the experimental data with the representations learned from scratch by the neural network

Summary

- LEC as candidate brain area for studying how odor & place information are integrated in the brain
- We use Reinforcement Learning to model behavior involving rewards and learning
- The joint representation is needed to solve an odor-place association task
- We expect to use Deep Reinforcement Learning to investigate other types of representations that may be at play

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Acknowledgments

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- Camille Donoho
- Timothy Pyon

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Policy learned in the egocentric version