



Learning useful representations to solve a place-odor association task

Andrea Pierré

April 4, 2023

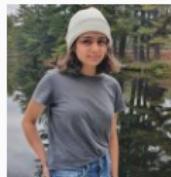
Fleischmann Lab



Collaborators



Matt Nassar



Niloufar Razmi



Jason Ritt

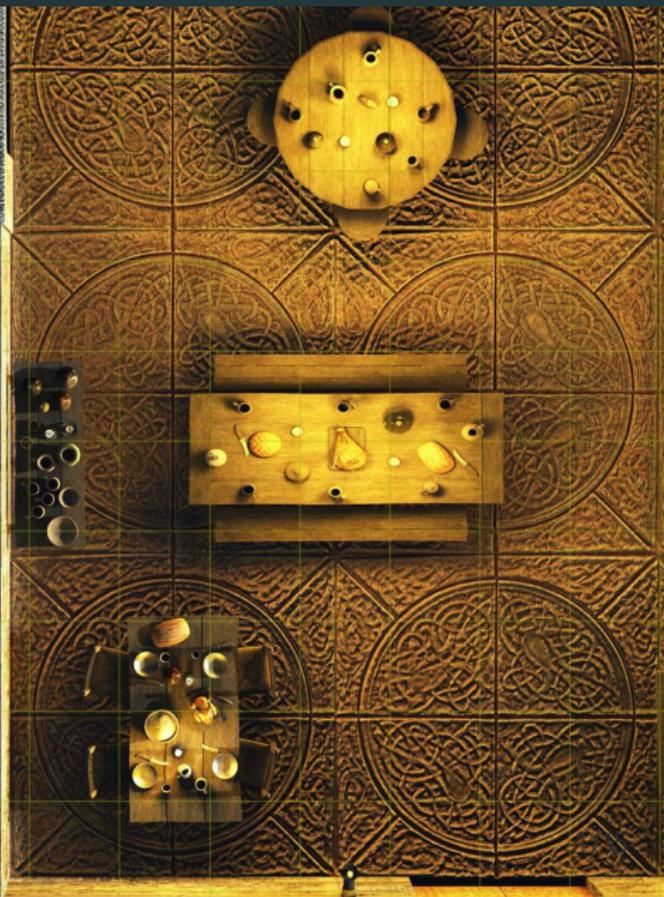
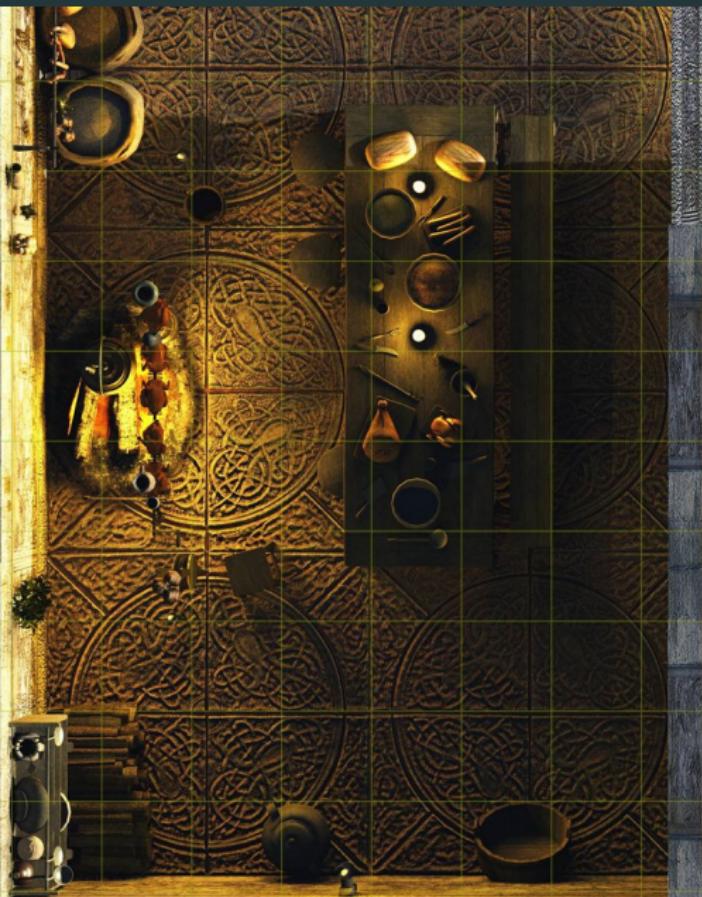


Olivia McKissick

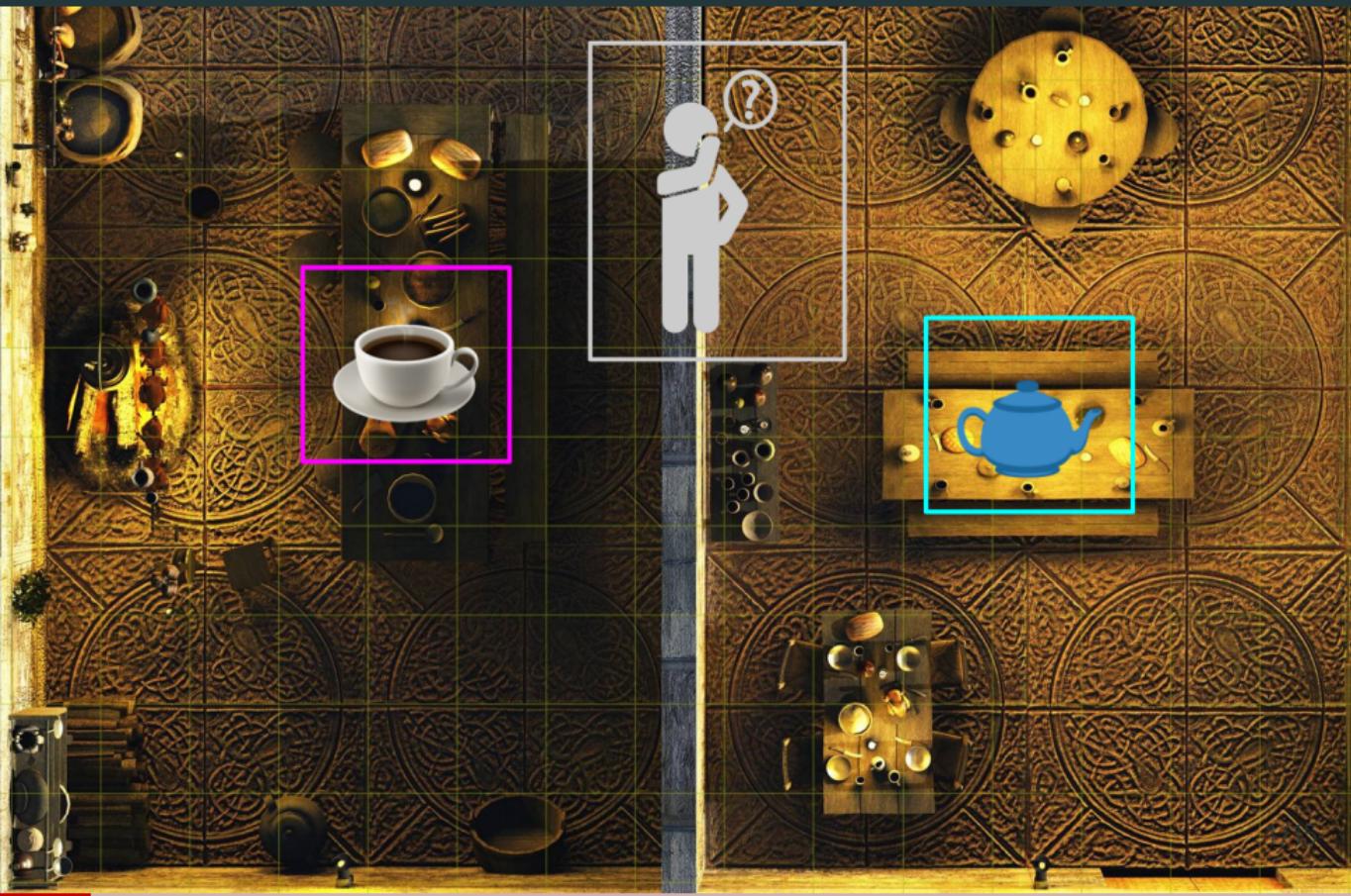


Alex
Fleischmann

Odor-place association

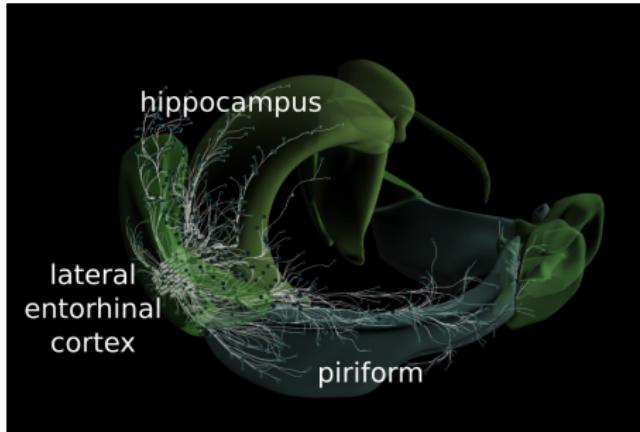


Odor-place association

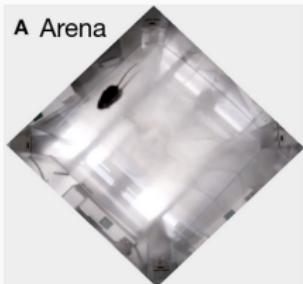


The LEC is key to sensory associations and spatial memory

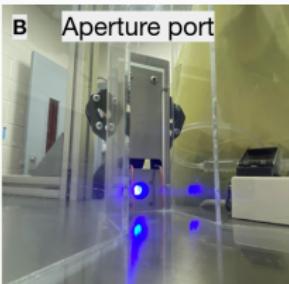
- **Piriform** encodes olfactory information
- **Hippocampus** encodes spatial information
- **Lateral Entorhinal Cortex (LEC)** encodes both olfactory & spatial information



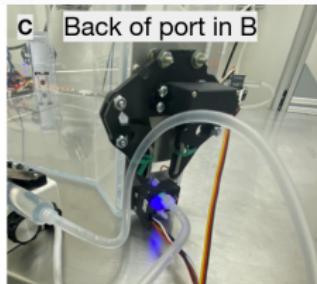
Diamond arena experimental setup



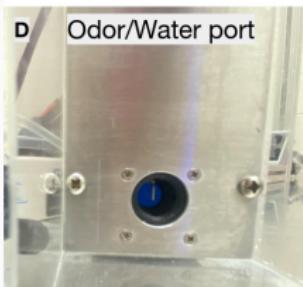
A Arena



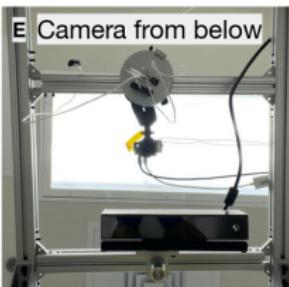
B Aperture port



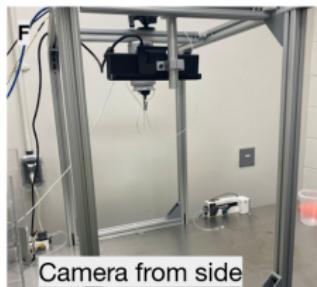
C Back of port in B



D Odor/Water port



E Camera from below



Camera from side

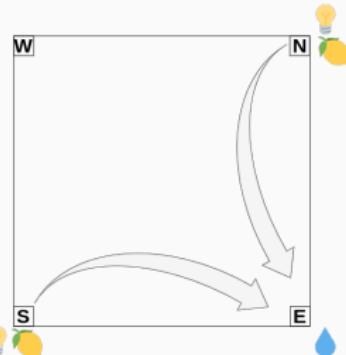
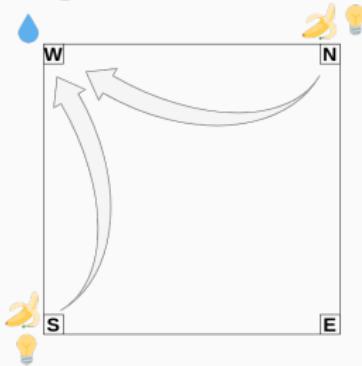


Olivia
McKissick

→ 1P calcium imaging recording on freely moving mice

Diamond arena olfactory task

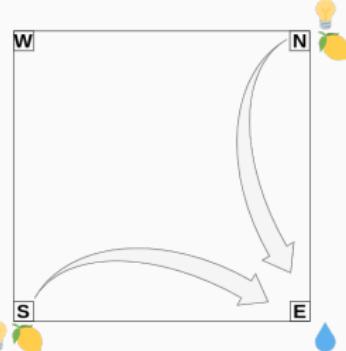
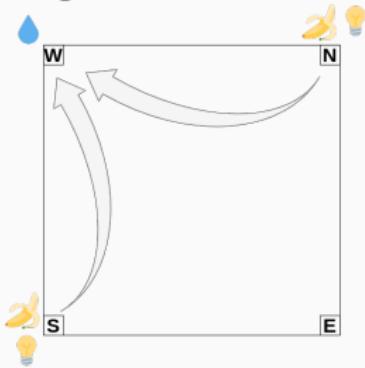
Allocentric
(go west/east)



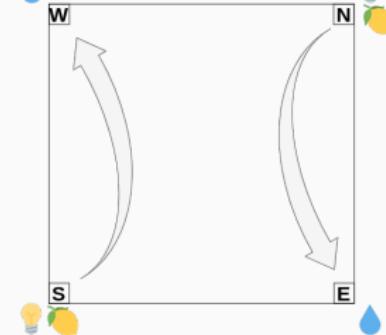
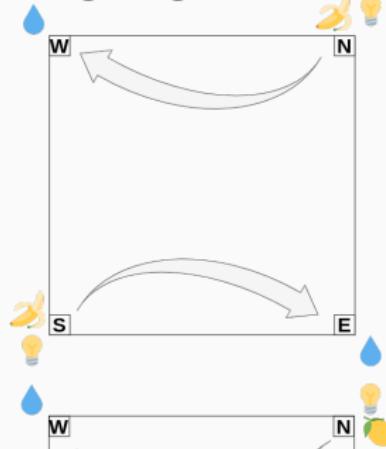
Olivia
McKissick

Diamond arena olfactory task

Allocentric
(go west/east)



Egocentric
(go right/left)



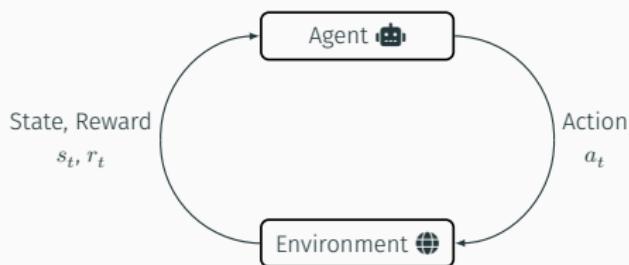
Olivia
McKissick

What is Reinforcement Learning and why use it ?



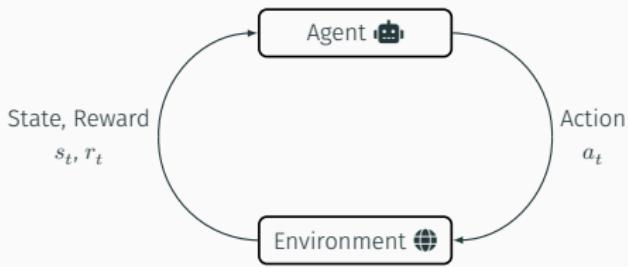
- Theoretical framework hypothesized to be implemented in the brain
- Tool to model behavior
- Goal of the agent: maximize rewards
- Natural fit for behavioral experiments involving rewards and learning

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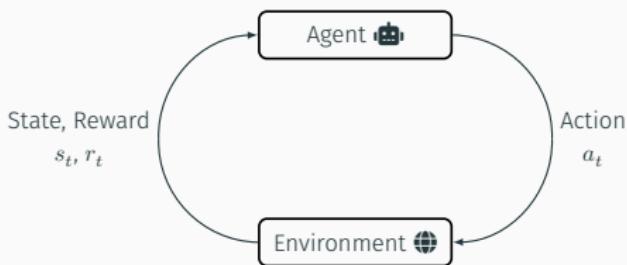
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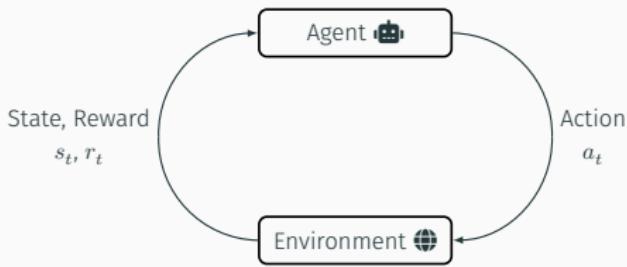
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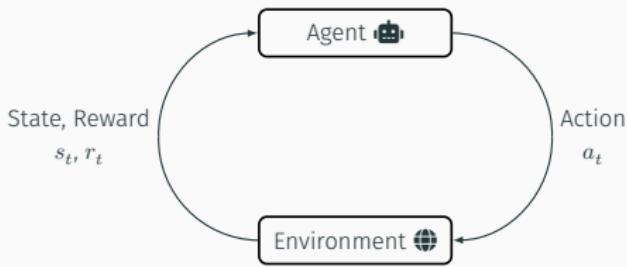
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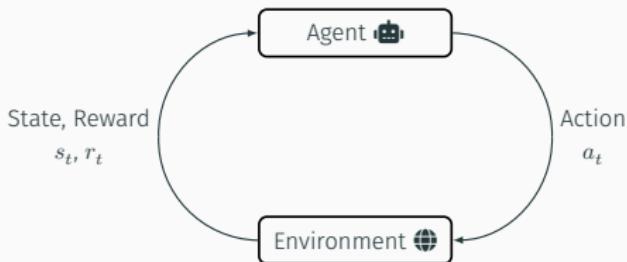
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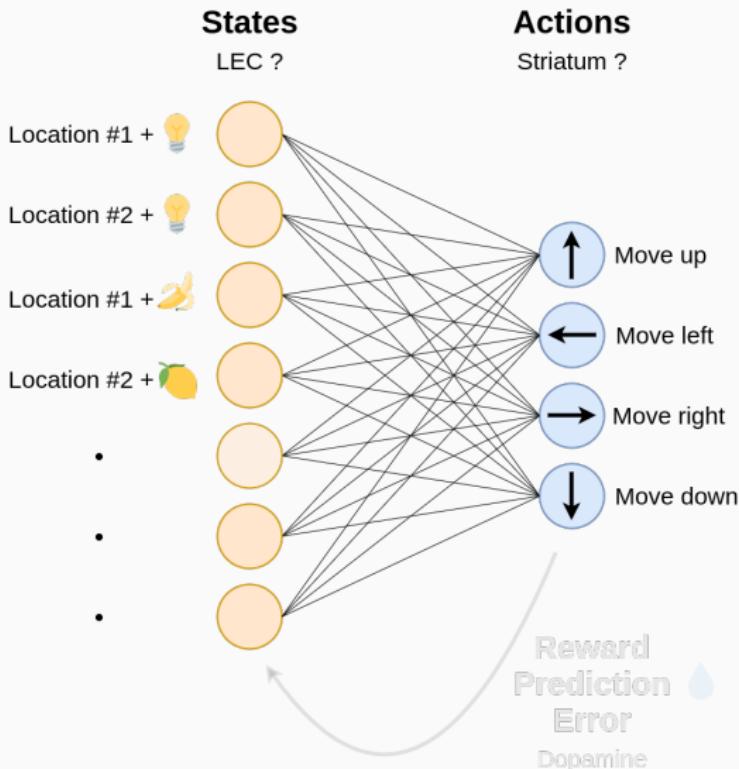
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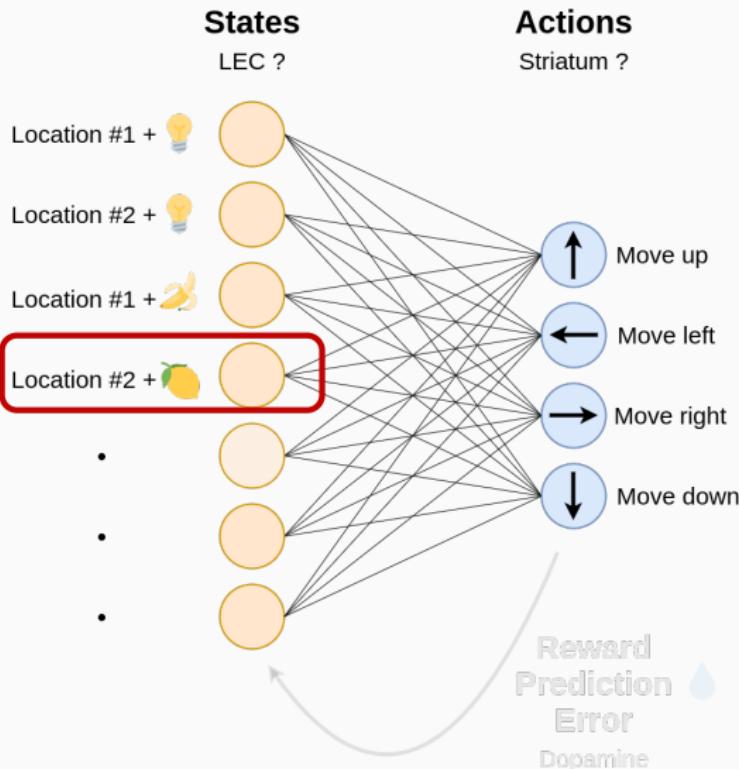


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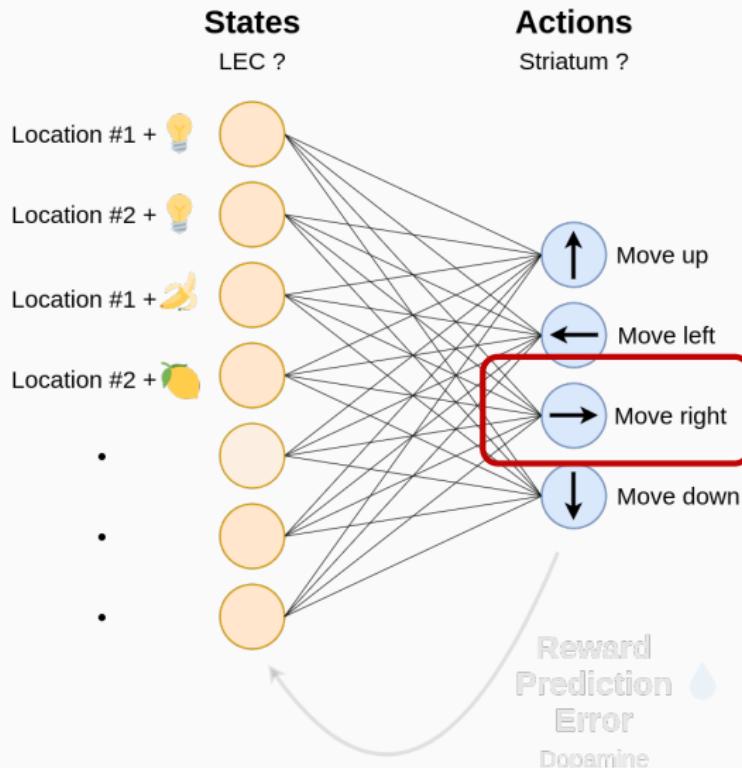
RL maps states to actions



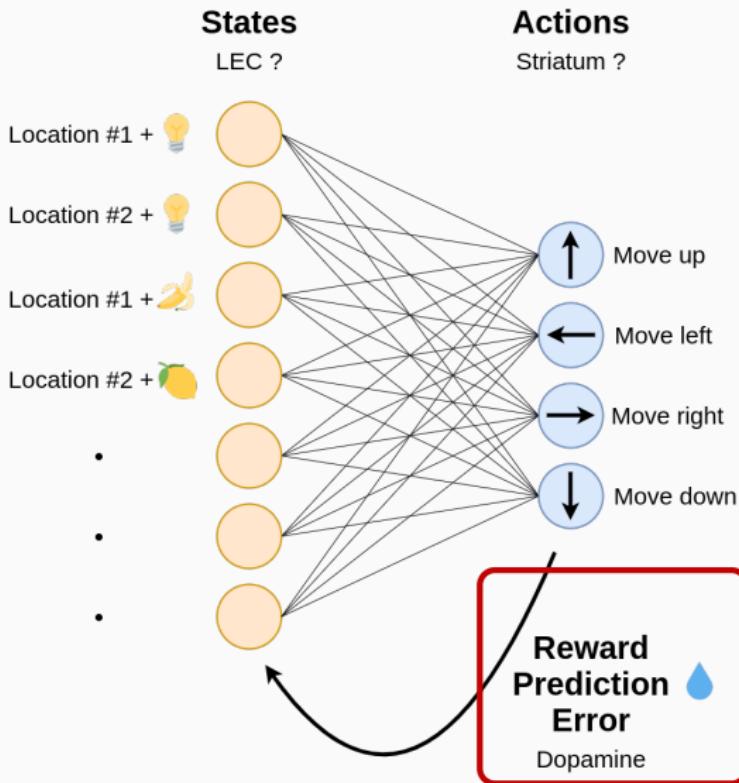
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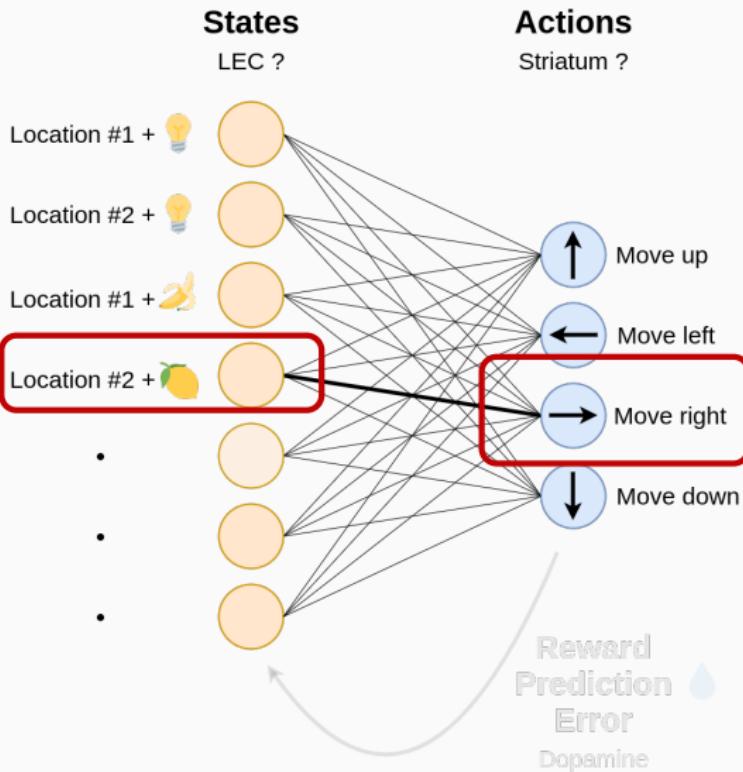
RL maps states to actions



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RL maps states to actions



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

The joint representation encodes odor + location

Location only



The joint representation encodes odor + location

Location only



Odor only



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Location only



Odor only

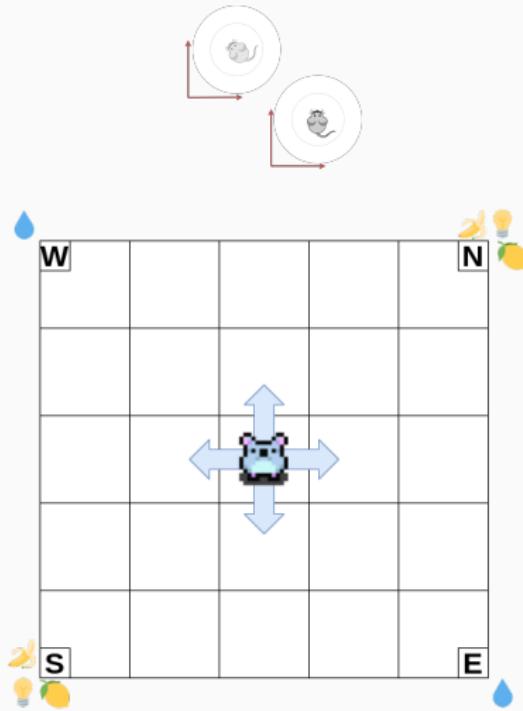


Joint



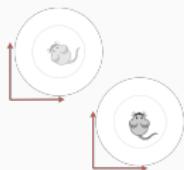
The model

Allocentric

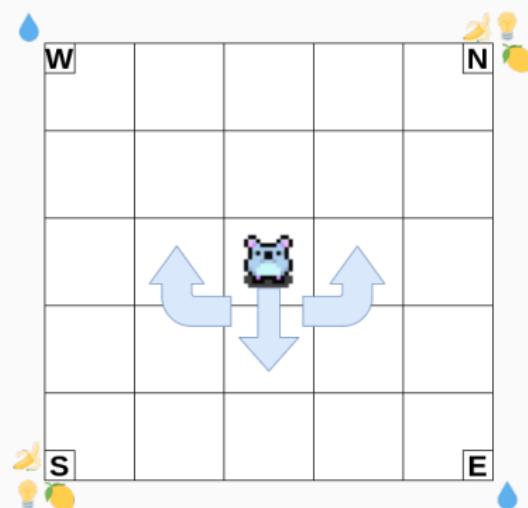
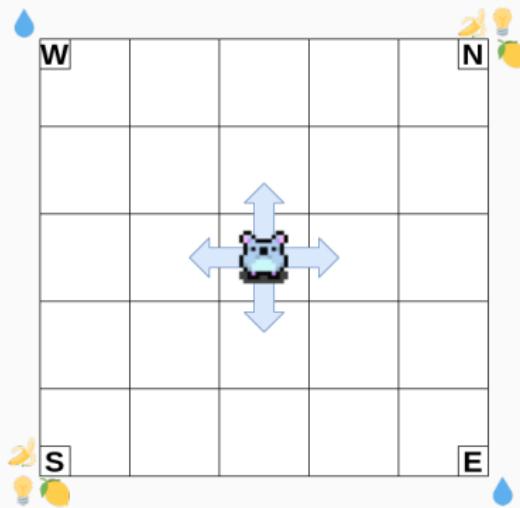
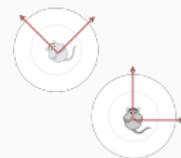


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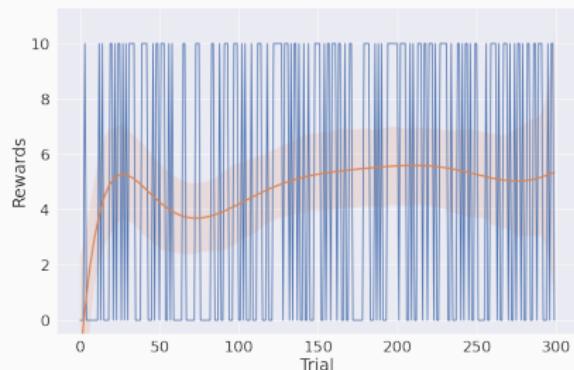


Egocentric

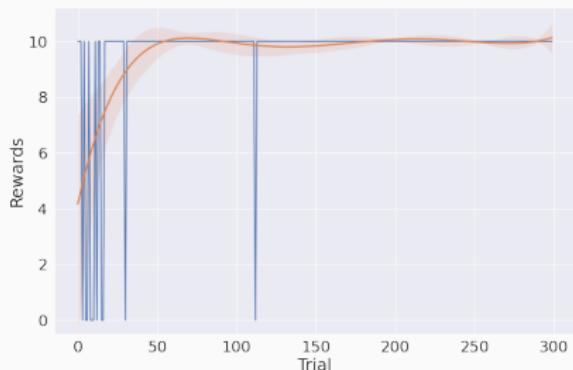


Maximizing rewards

Without joint representation



With joint representation

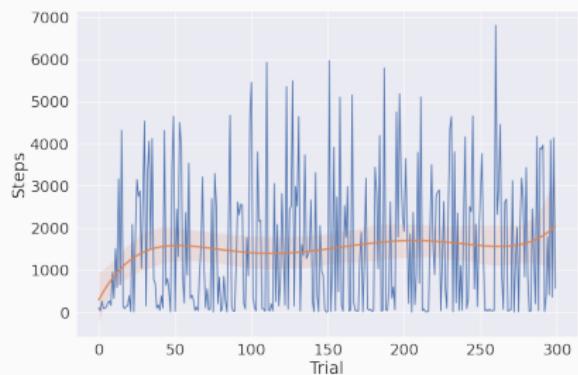


→ The agent doesn't learn

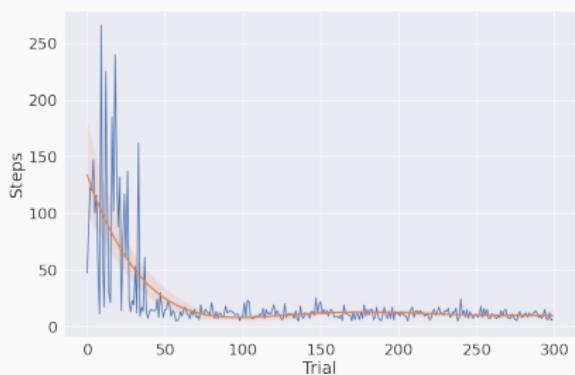
→ The agent learns to solve the task

Minimizing the number of steps to solve the task

Without joint representation



With joint representation

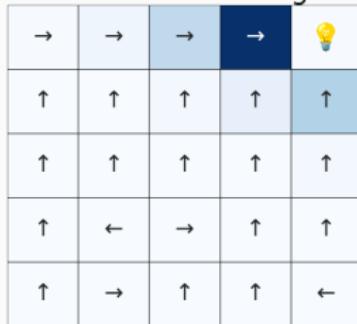


→ The agent doesn't learn

→ The agent learns to solve the task

What policy did the agent learned ?

Pre odor - North light

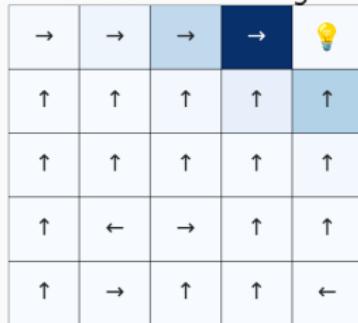


Pre odor - South light



What policy did the agent learned ?

Pre odor - North light



Pre odor - South light



Post odor



Post odor

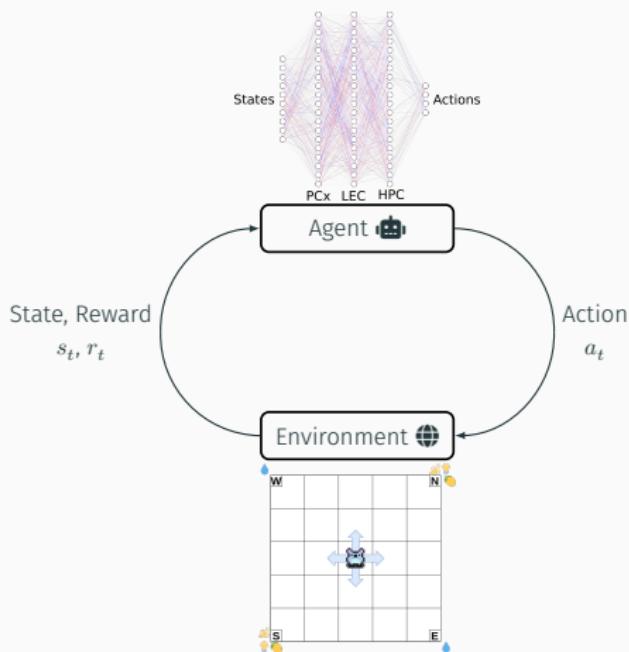


Our RL model so far



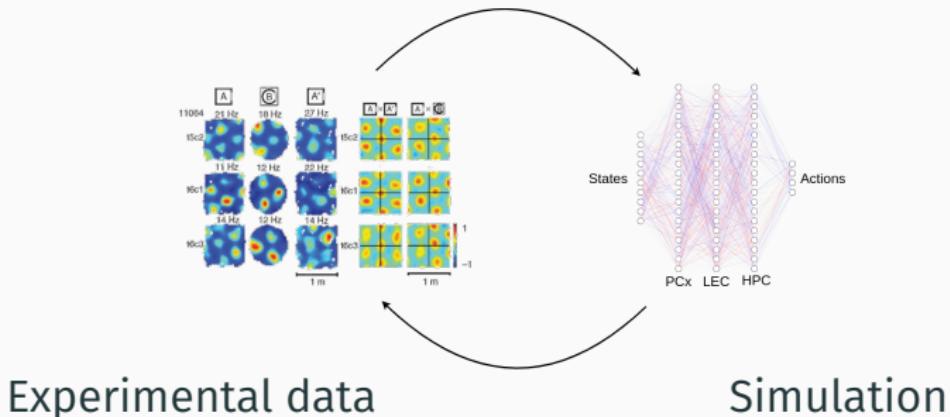
- Tabular model that maps states to actions
- No generalization
→ each state needs to be visited by the agent to compute a prediction of getting a future reward

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
→ 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 ?



→ 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

Fleischmann lab

- Alexander Fleischmann
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- Camille Donoho
- Timothy Pyon

Collaborations

- Matt Nassar
- Jason Ritt
- Niloufar Razmi



Policy learned in the egocentric version

