Learning useful representations to solve a place-odor association task

Andrea Pierré

April 4, 2023

Fleischmann Lab

Outline

1. Context of the project
2. Modeling & preliminary results
3. Next steps

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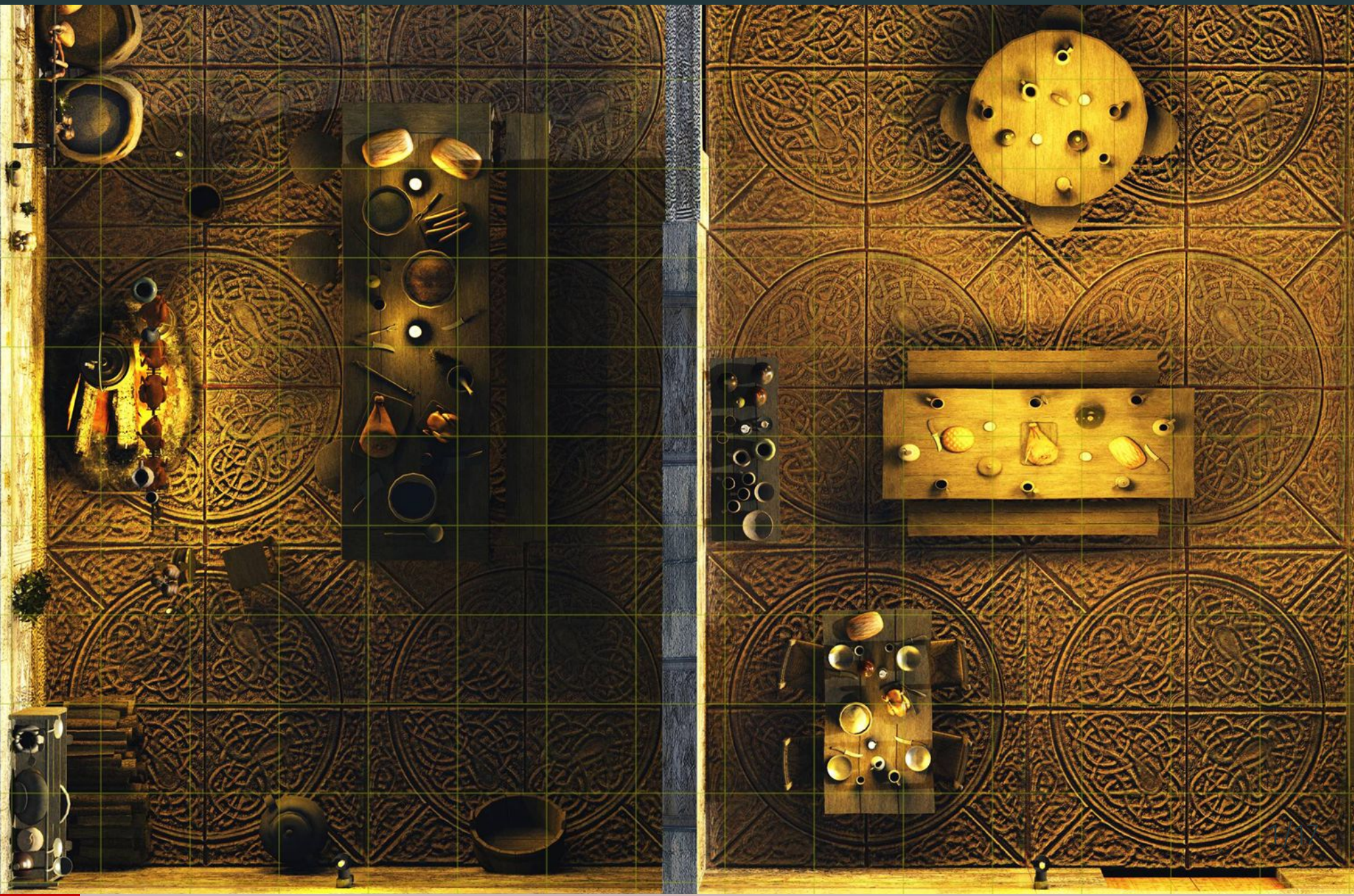
Odor-place association



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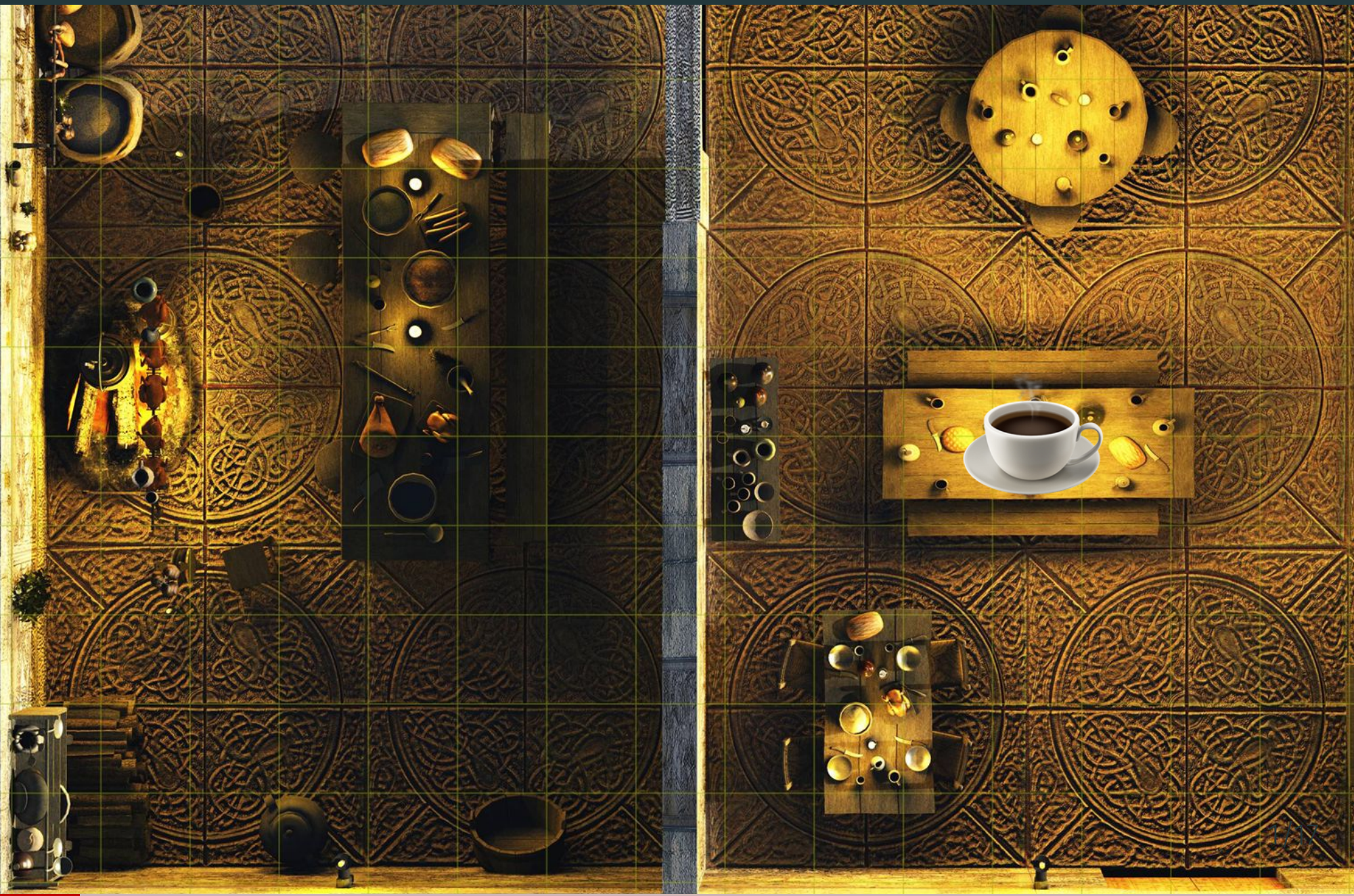

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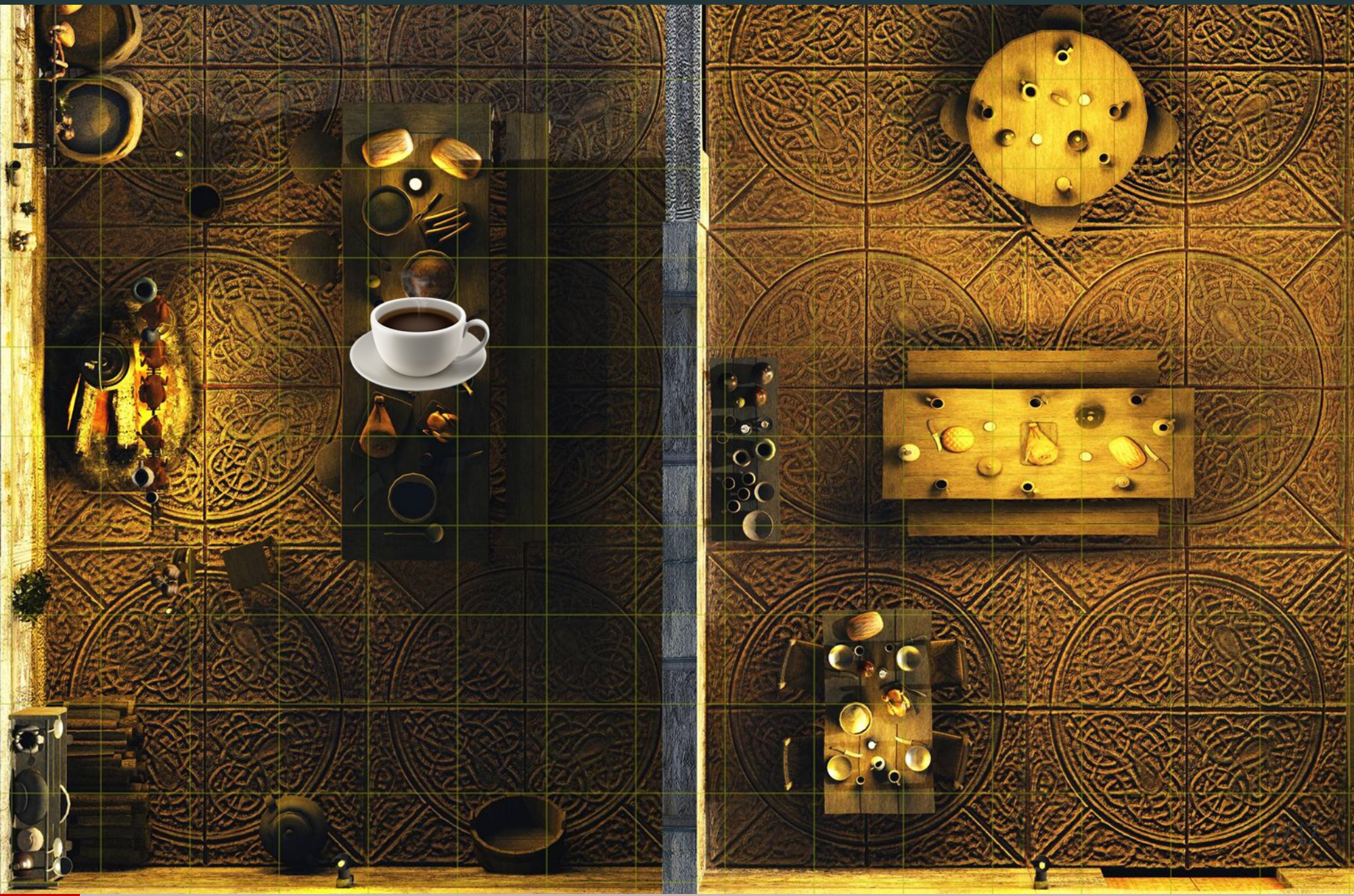
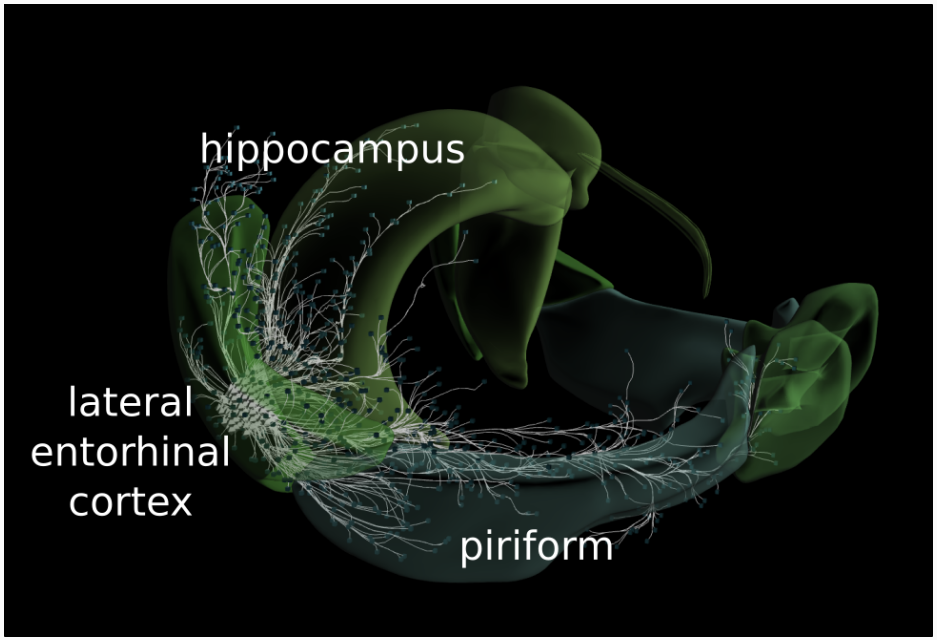


The LEC is key to sensory associations and spatial memory

- LEC is needed for learning sensory associations and certain spatial memory tasks
- LEC and hippocampus are strongly and reciprocally connected
- Direct olfactory connections from olfactory bulb and piriform



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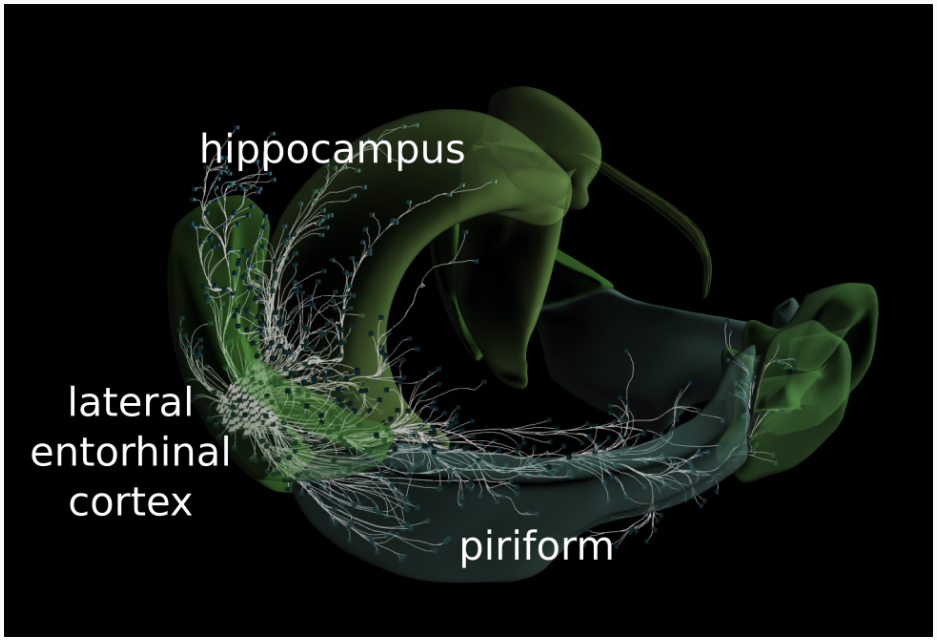

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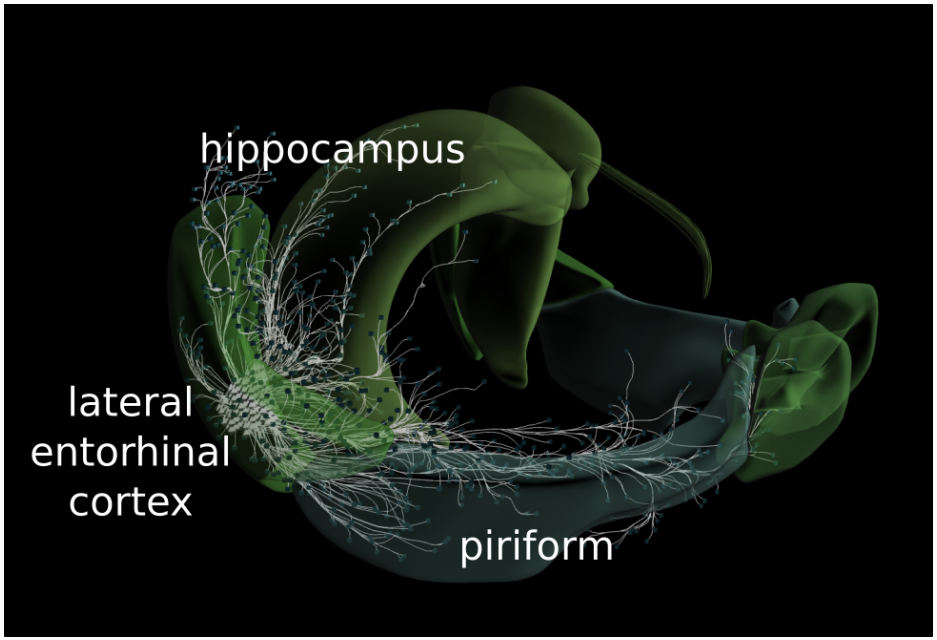

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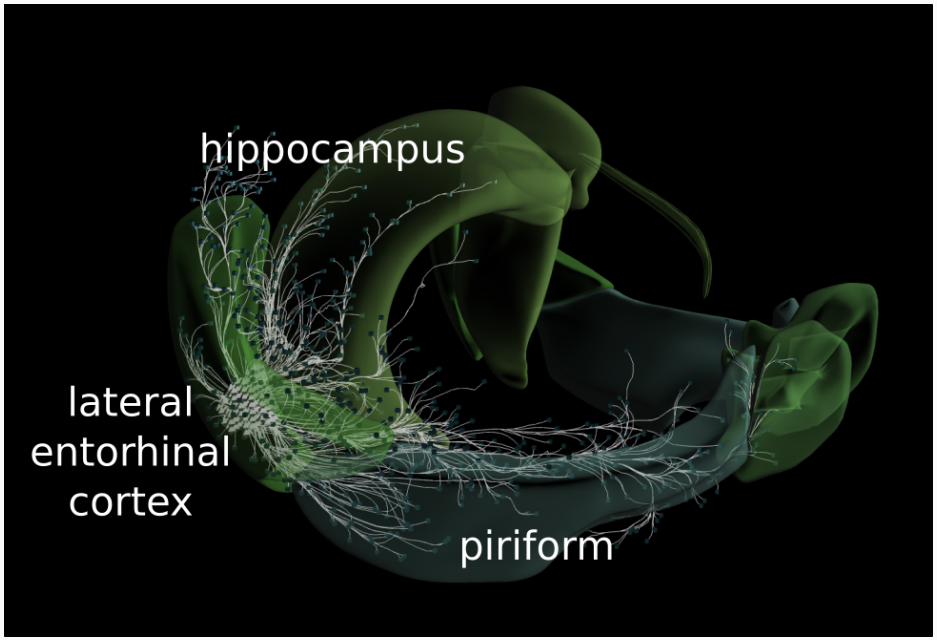

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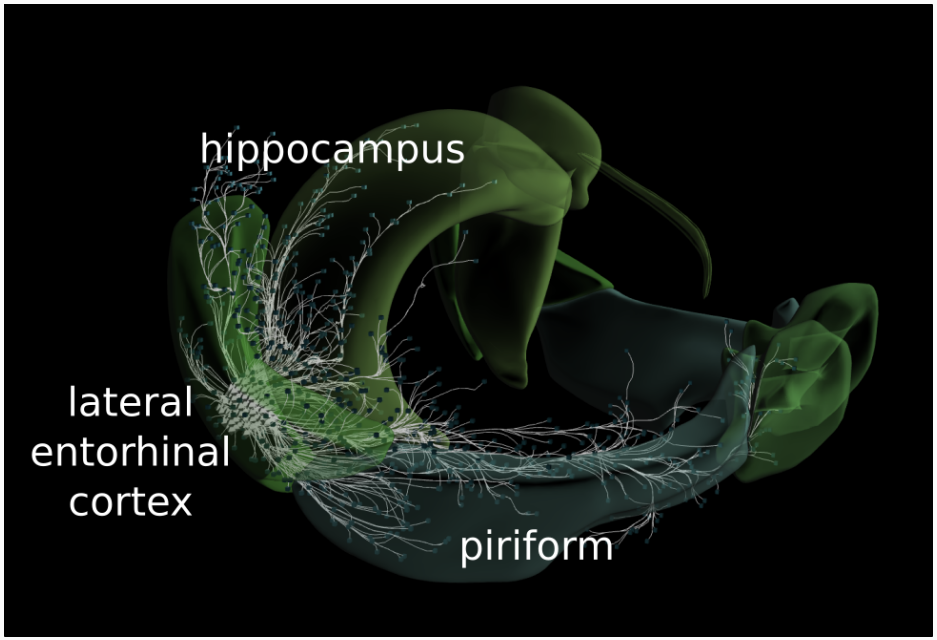

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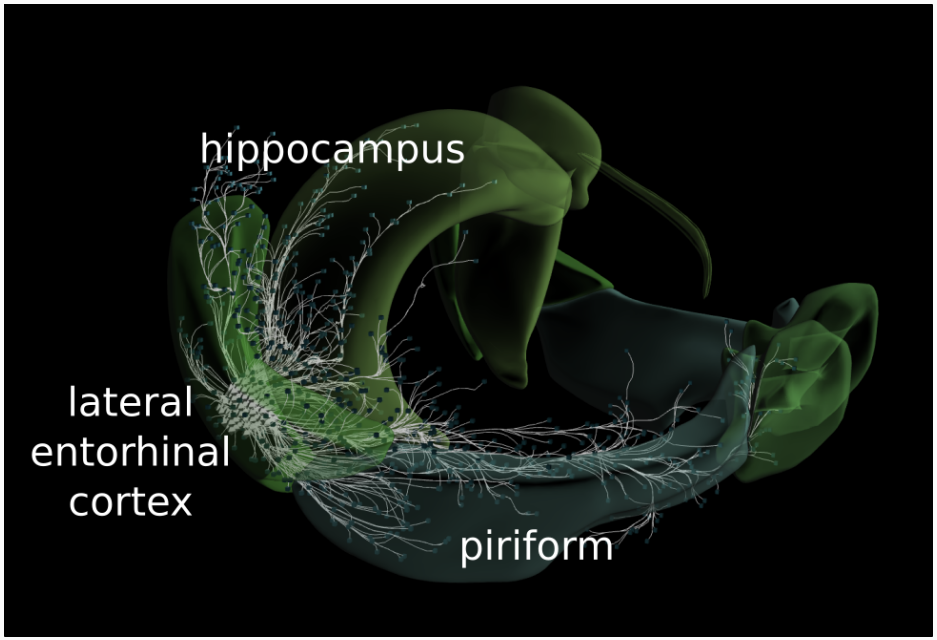
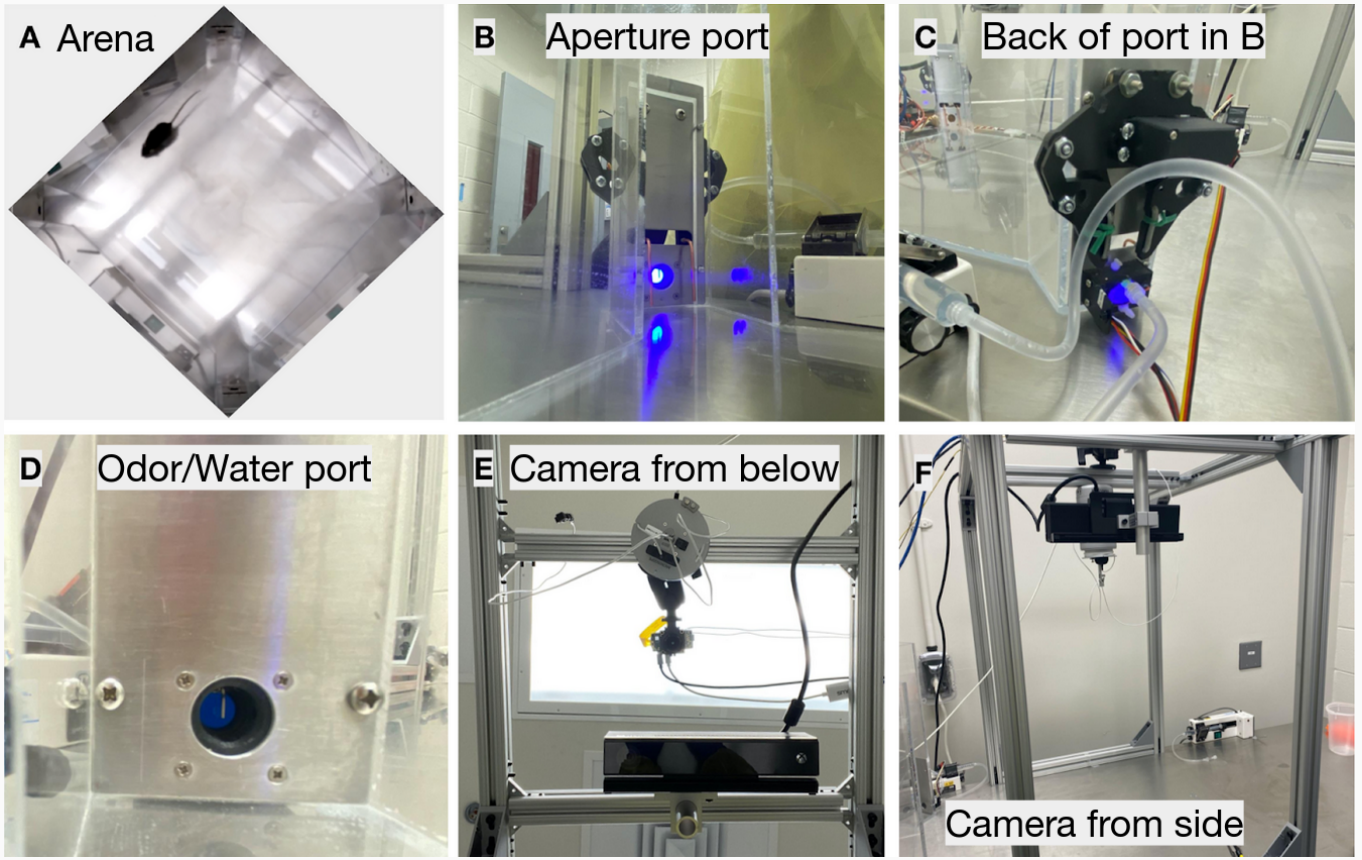


Diamond arena experimental setup

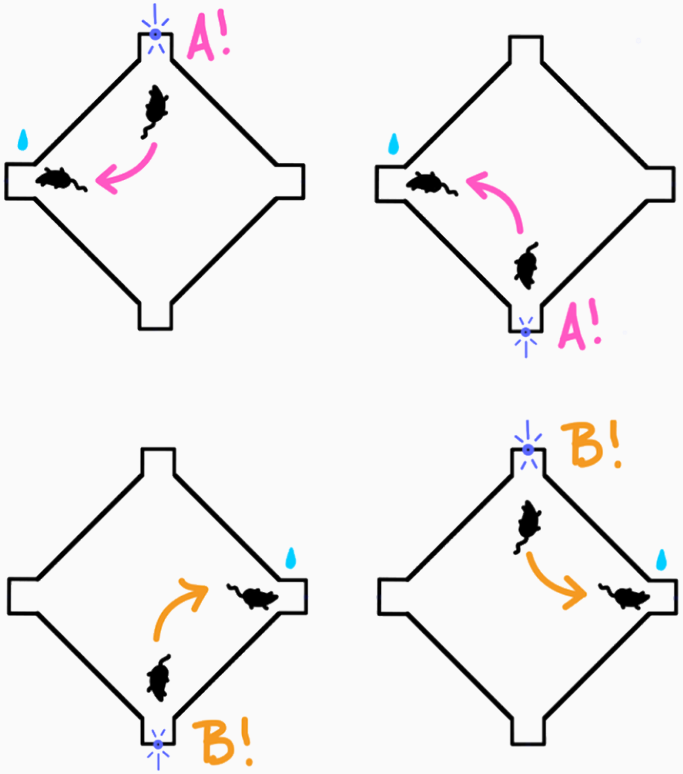
Olivia McKissick



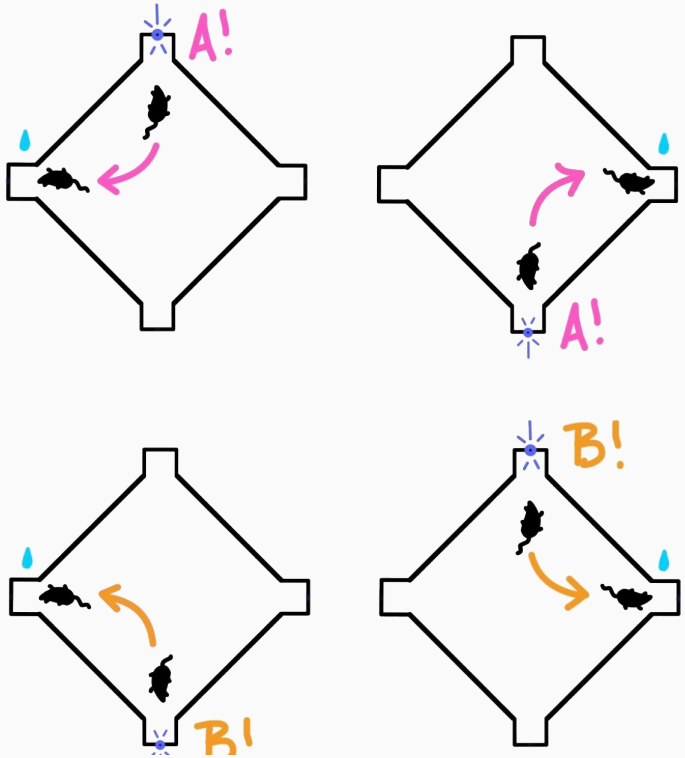
Diamond arena olfactory task

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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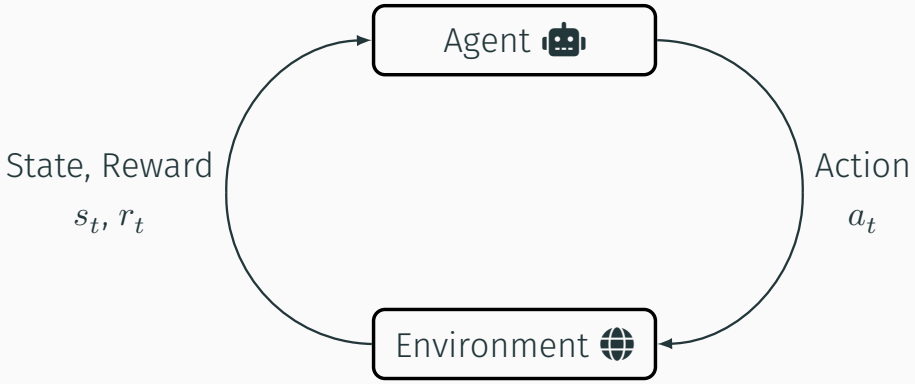

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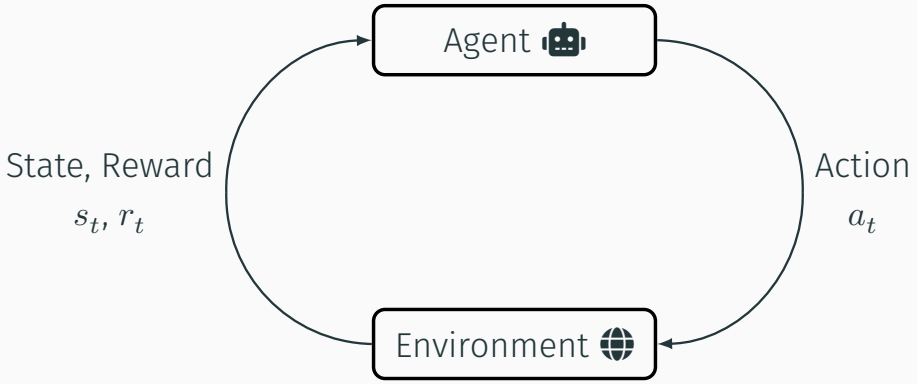

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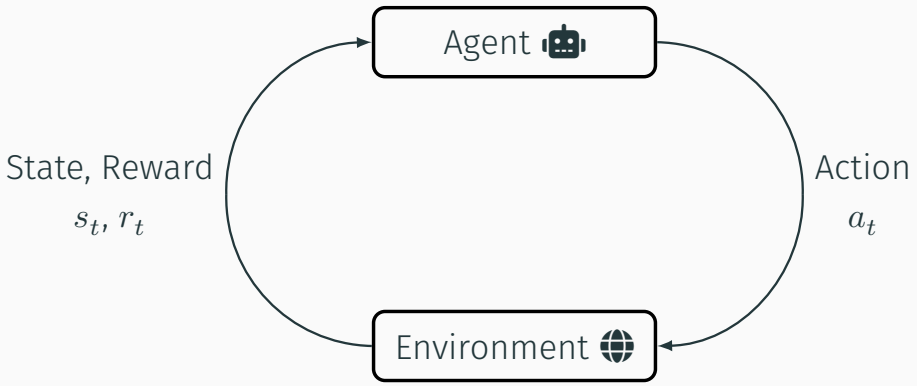

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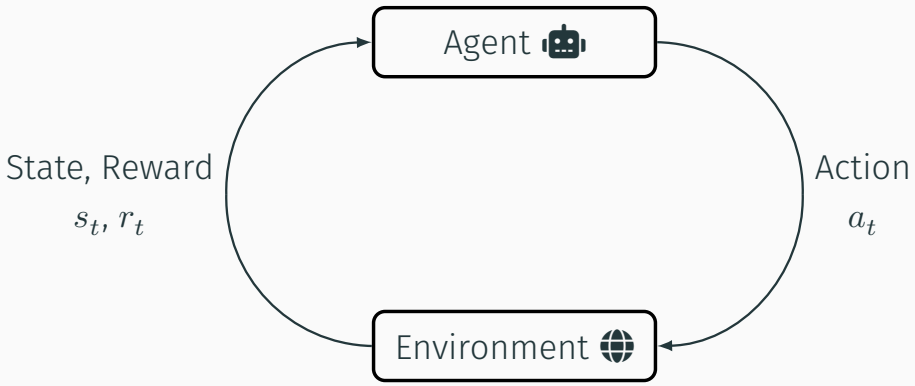

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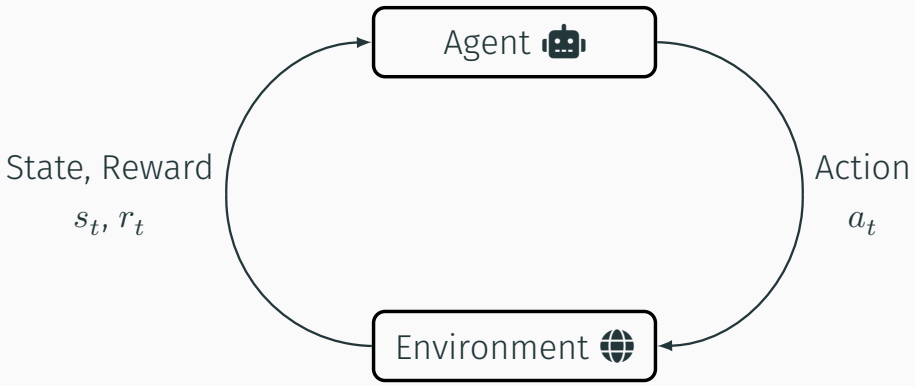

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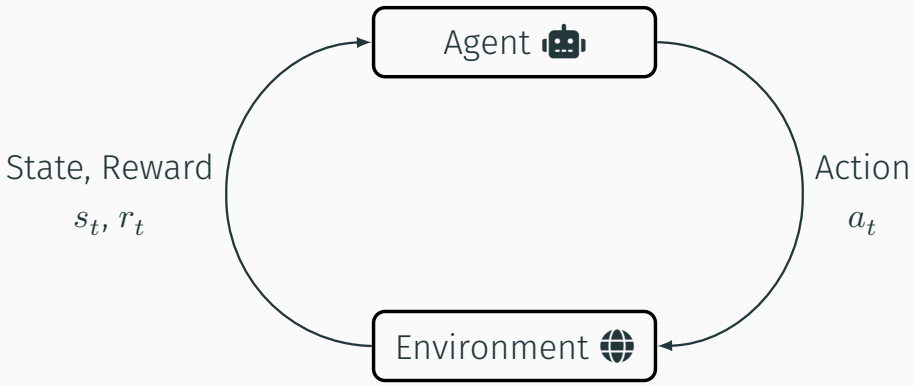

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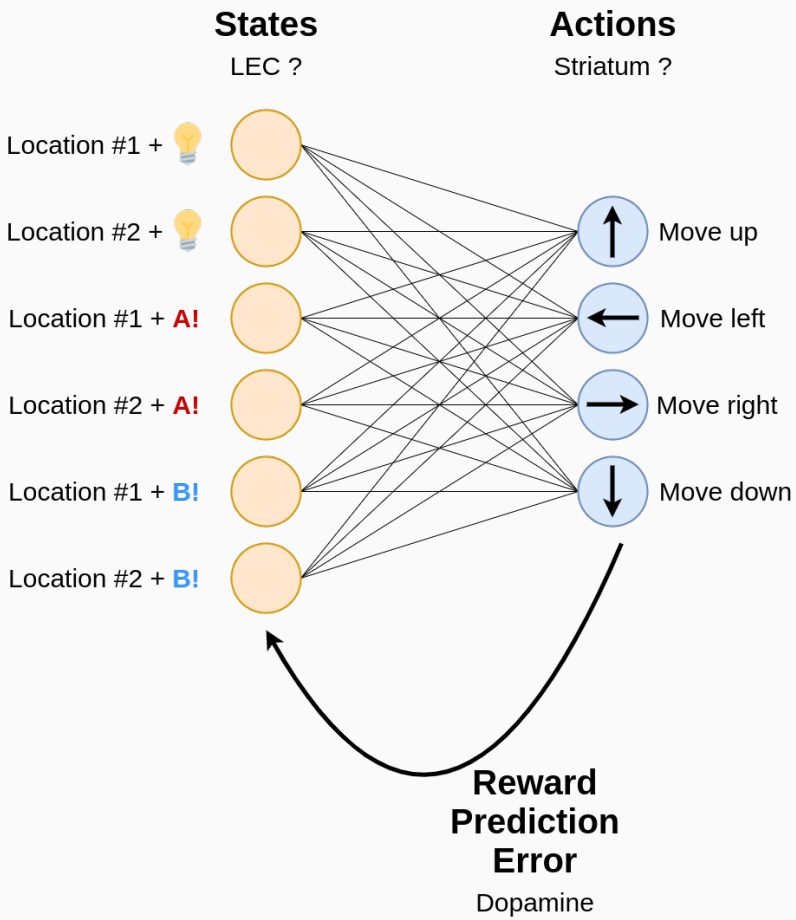
RL maps states to optimized actions



$$Q^{new}(s_t, a_t) \leftarrow Q(s_t, a_t) + \underbrace{\alpha}_{\text{learning rate}} \overbrace{(\underbrace{r_t}_{\text{reward}} + \gamma \max_a Q(s_{t+1,a}) - Q(s_t, a_t))}^{\text{temporal difference}}$$

$$\mathbf{Q} = \mathbf{x} \cdot \mathbf{W}$$

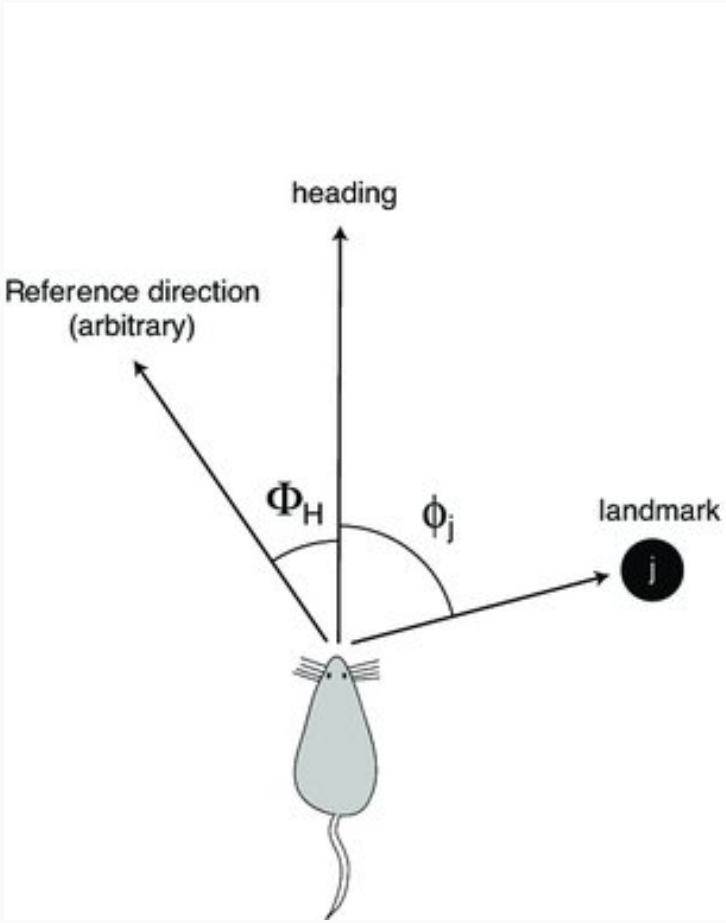
Question

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

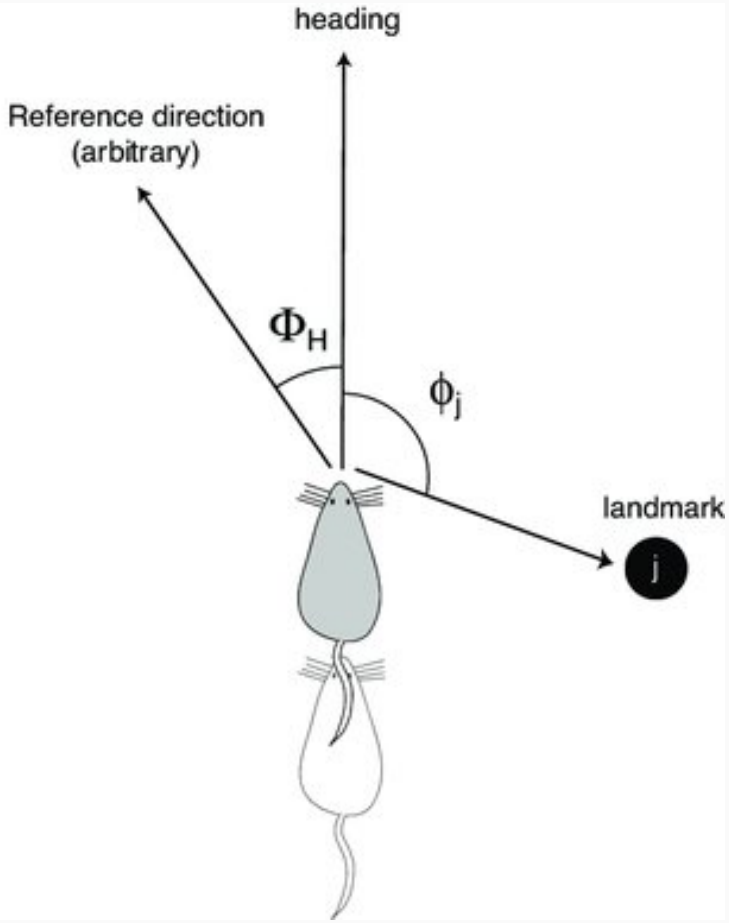
Outline

Allocentric vs. Egocentric

Allocentric

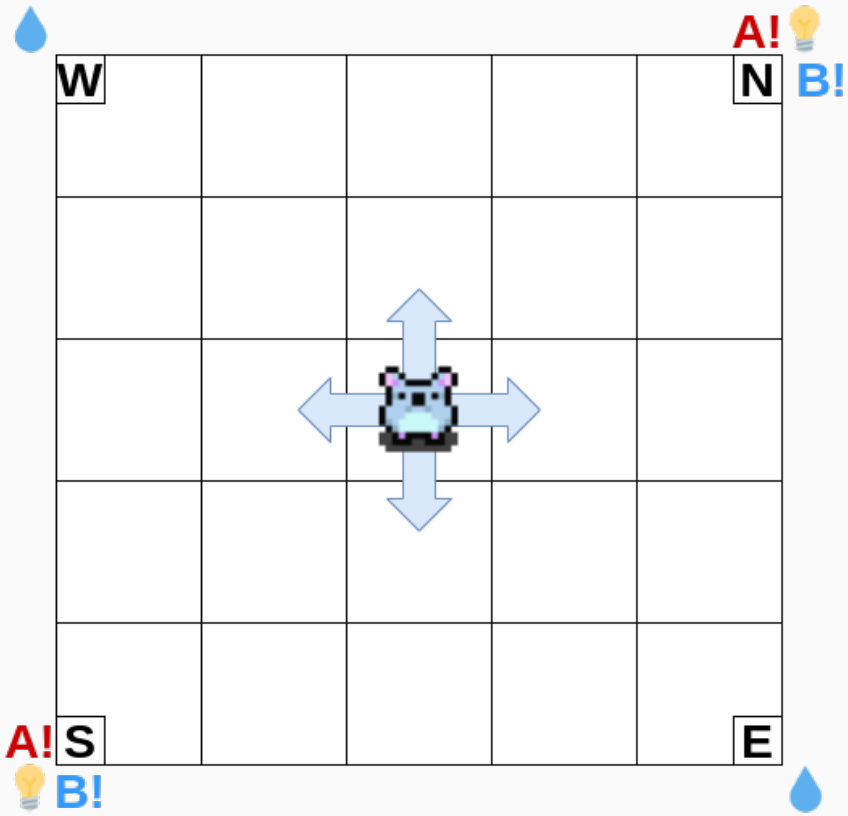


Egocentric



The model

Allocentric



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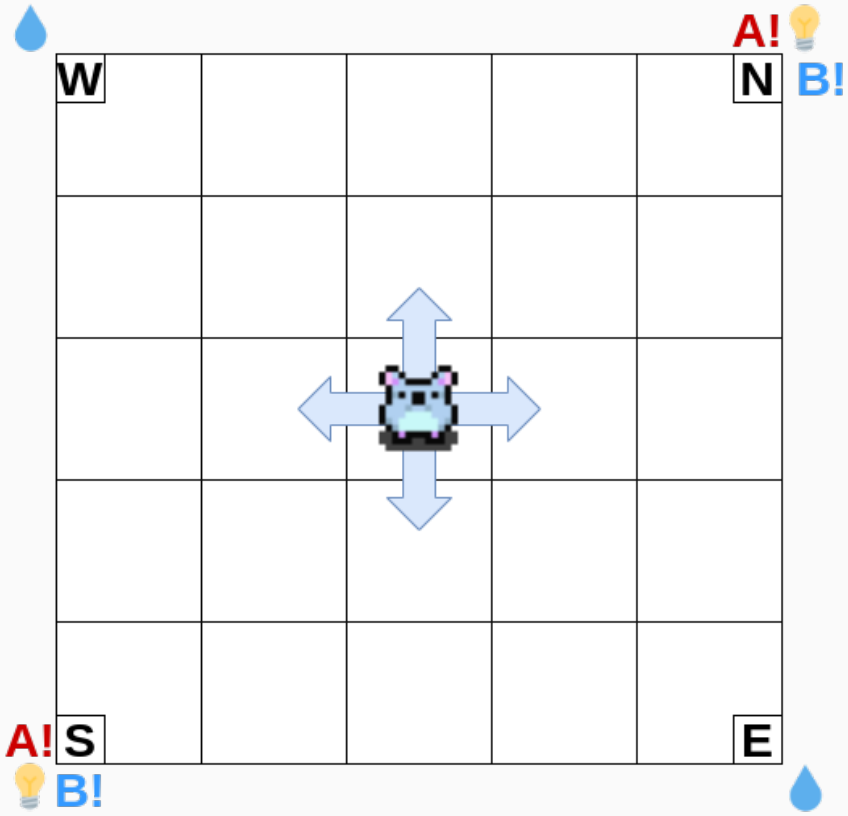

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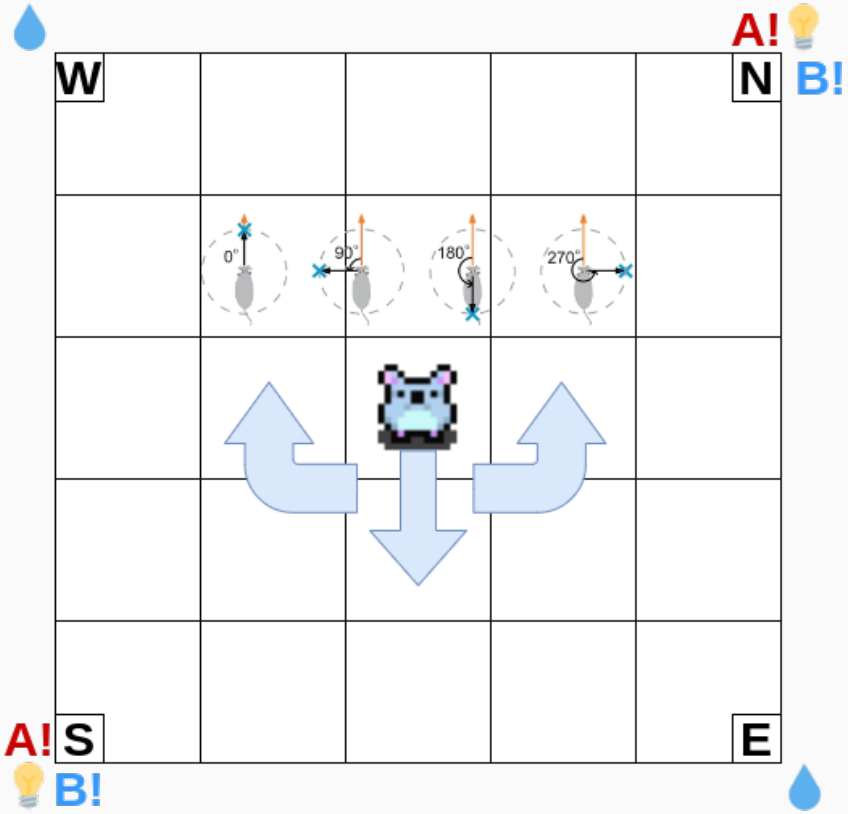
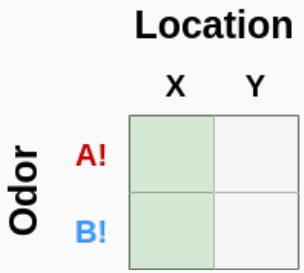
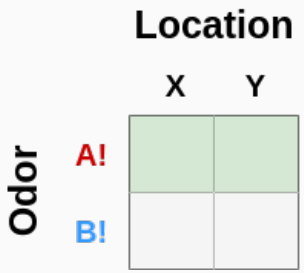


The joint representation encodes odor + location

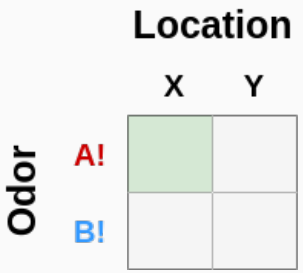
Location only



Odor only

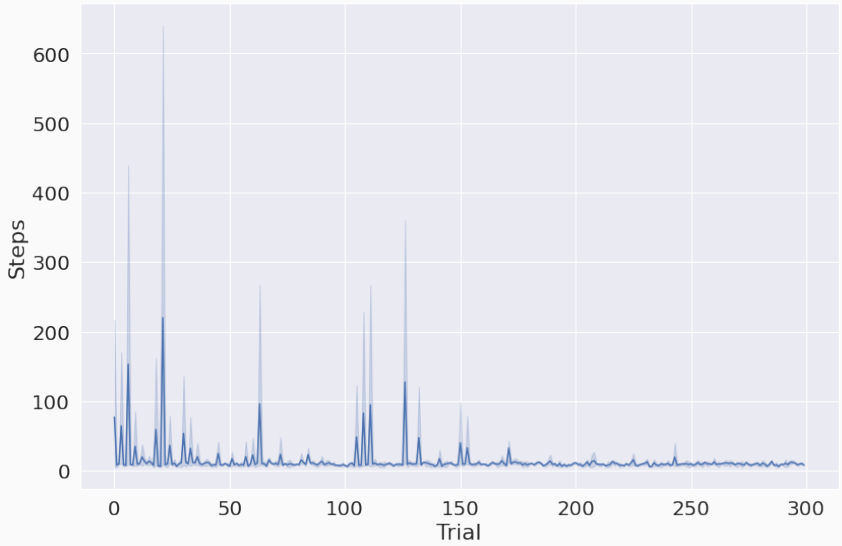


Joint



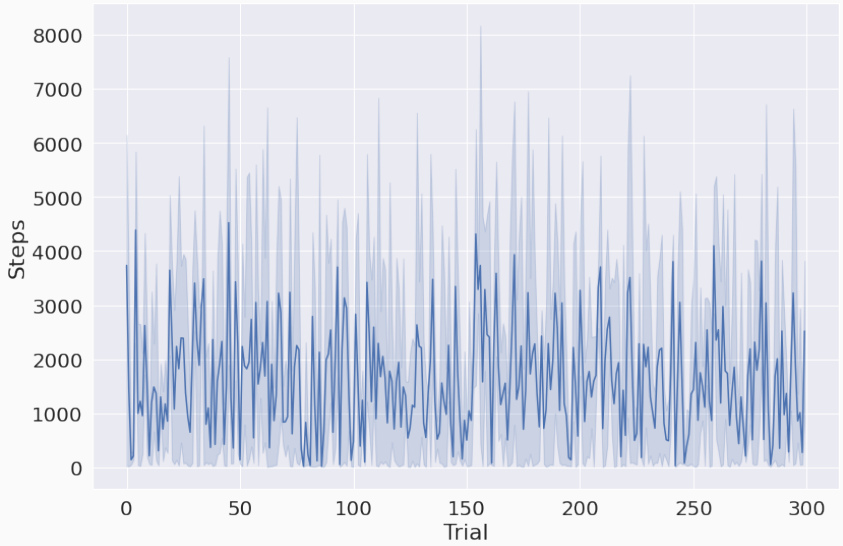
Minimizing the number of steps to solve the task

With joint representation



→ The agent learns to solve the task

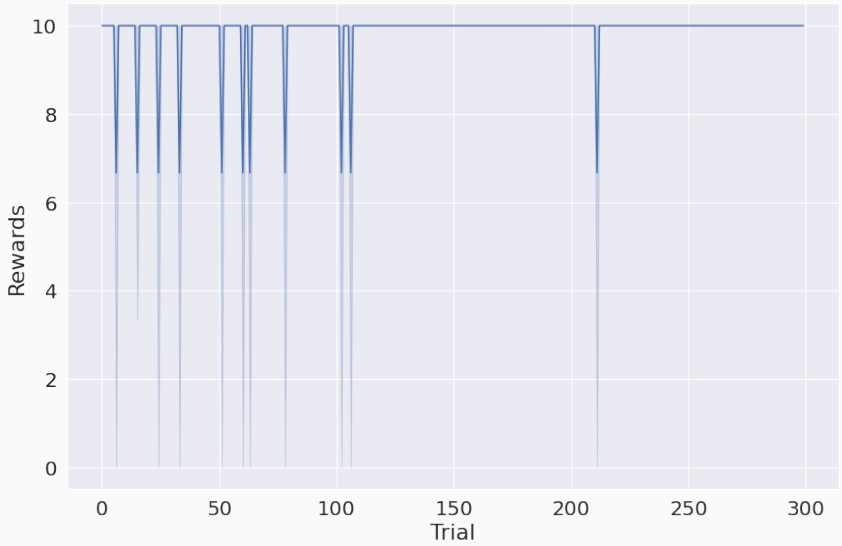
Without joint representation



→ The agent doesn't learn

Maximizing rewards

With joint representation



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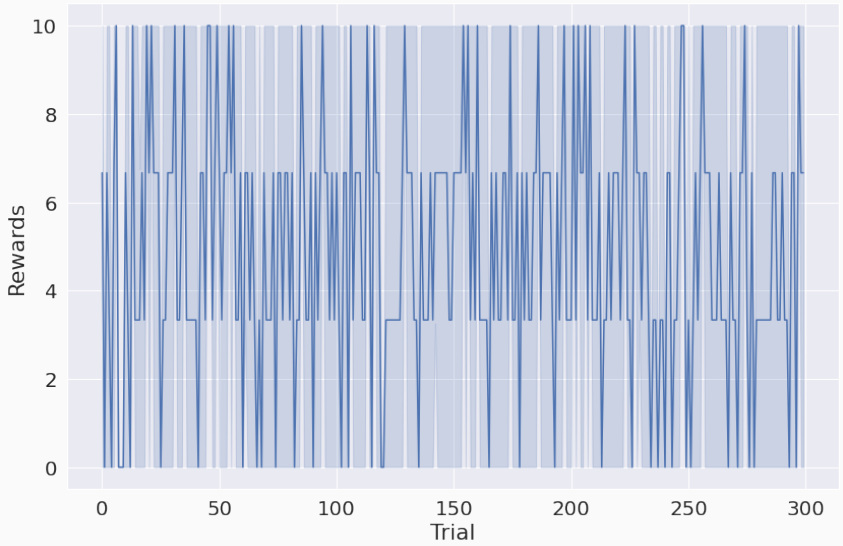
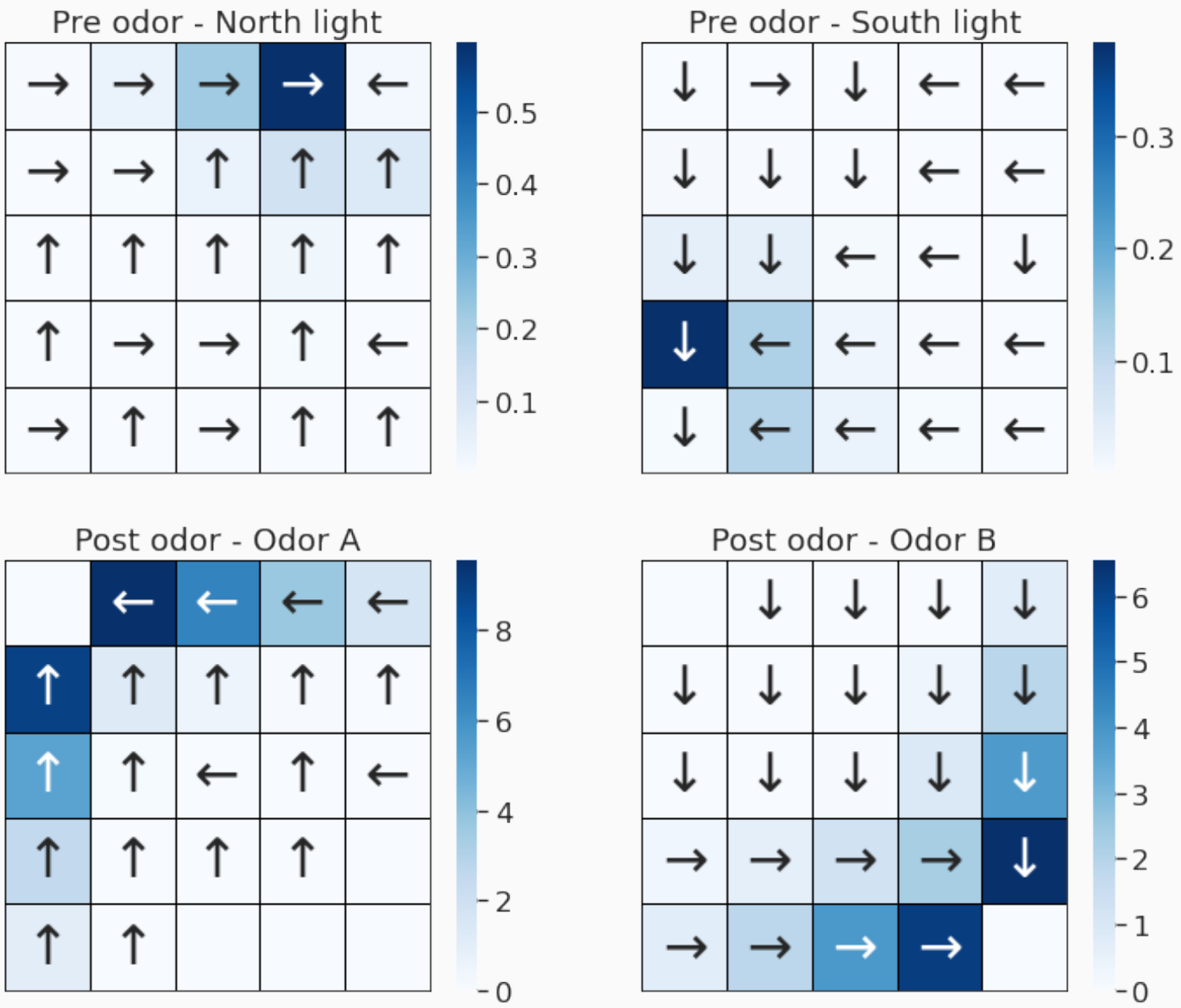
Without joint representation



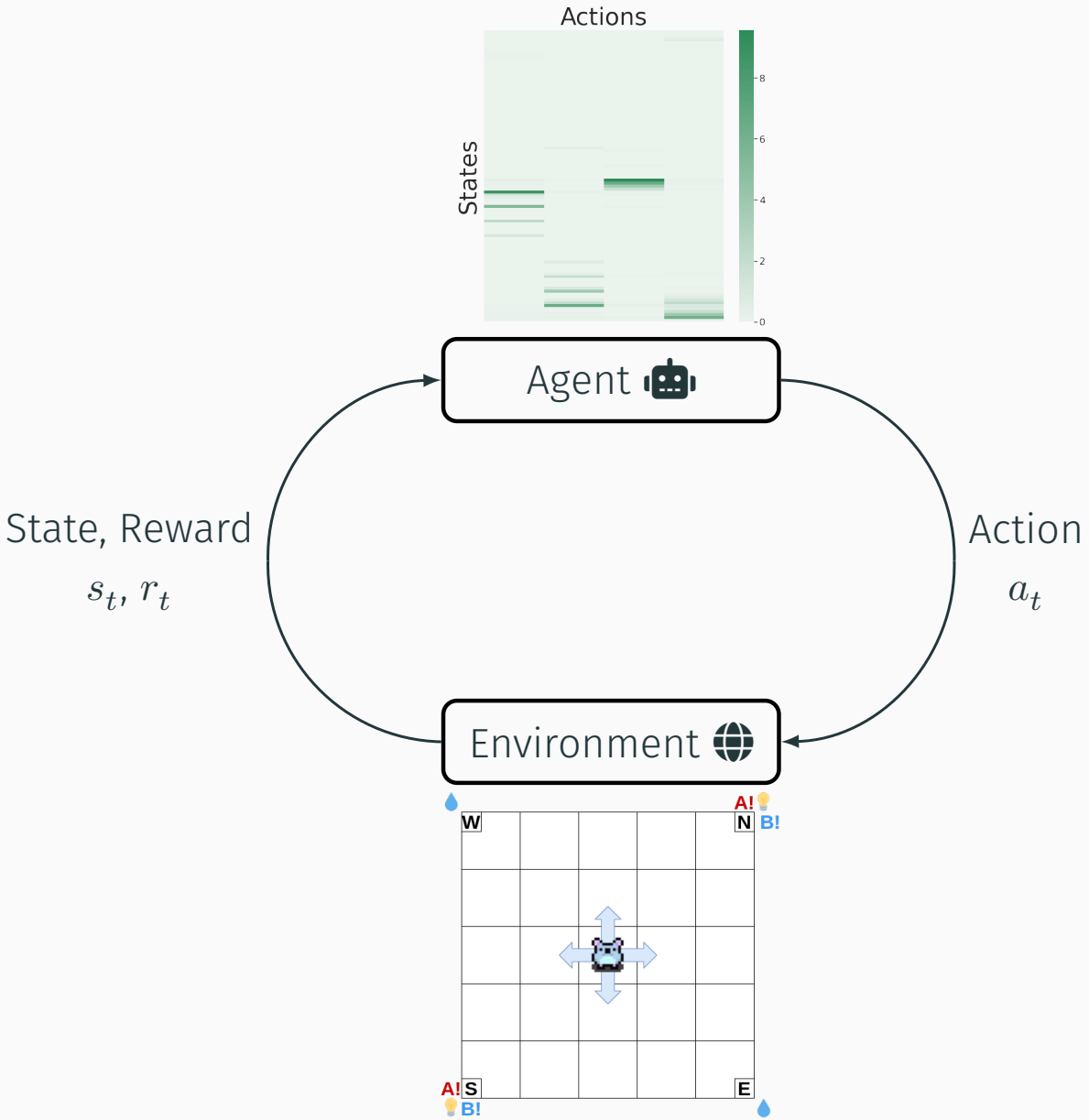
→ The agent doesn't learn

What policy did the agent learned ?



Outline

From tabular RL to deep RL



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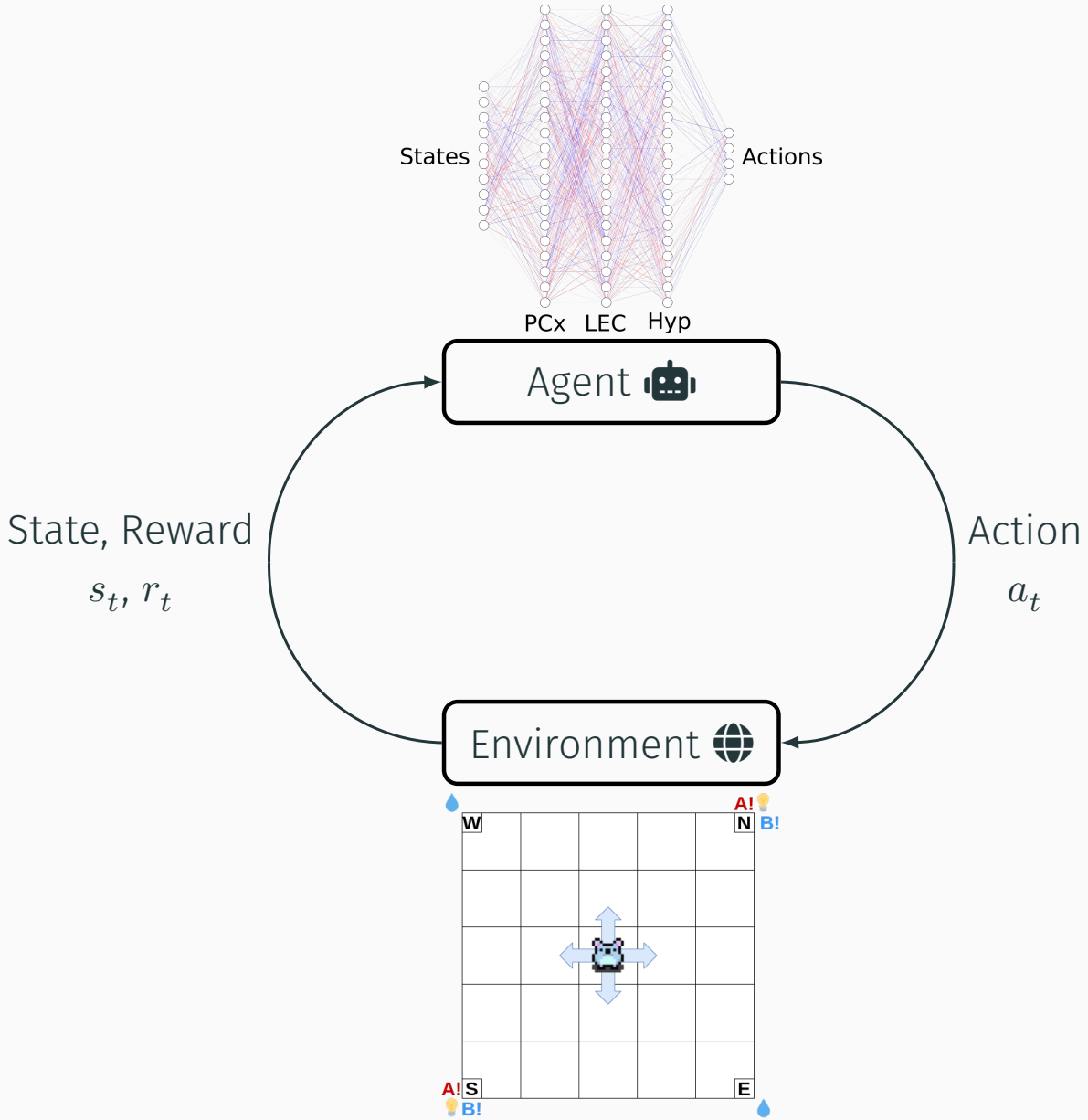
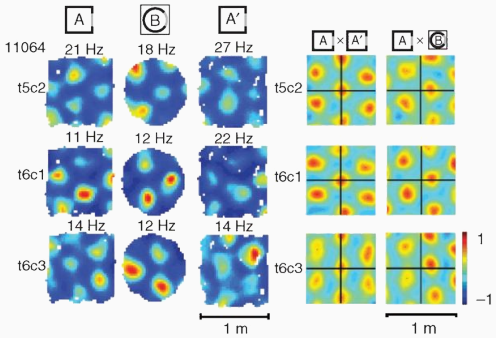


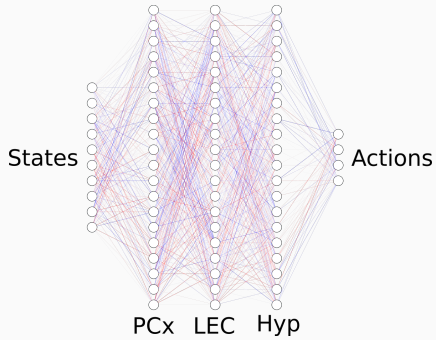
What types of representations are in use to solve the odor-place association task ?

Experiment



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

Simulation



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


Summary

- The LEC is key to sensory associations and spatial memory
- Reinforcement Learning can be a useful tool to model behavior involving rewards
- The joint representation is needed to solve an odor-place location task

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Acknowledgments

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  - Keeley Baker
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  - Tuan Pham
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  - Timothy Pyon
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  - Matt Nassar
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