Lab meeting

Robust representations for olfactory-spatial association learning

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Andrea Pierré

March 11, 2025

Outline

1. Project recap
2. Modeling & Simulation
3. What does the network learn?
4. Conclusion

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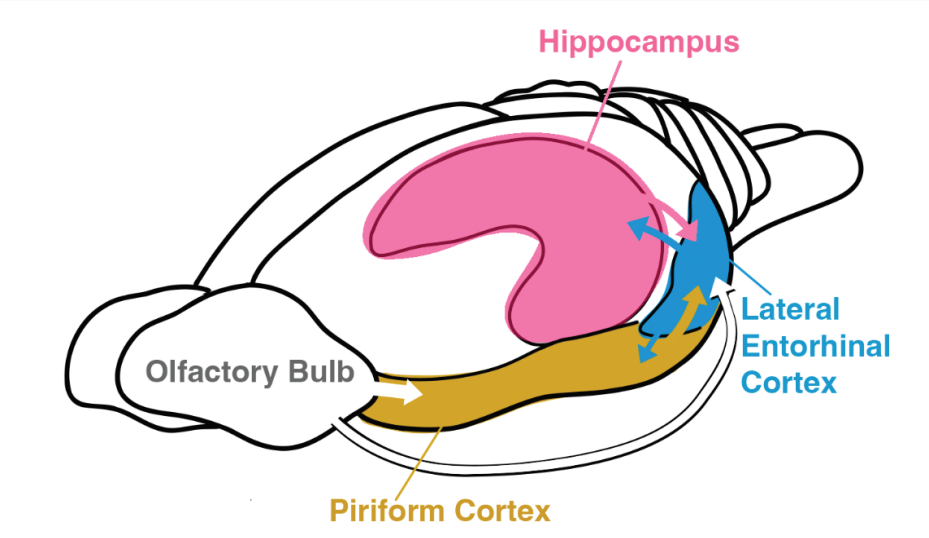
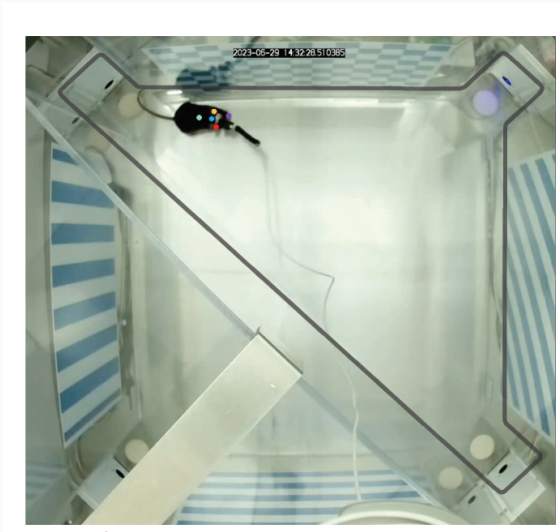
The LEC is key to sensory associations and spatial memory

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

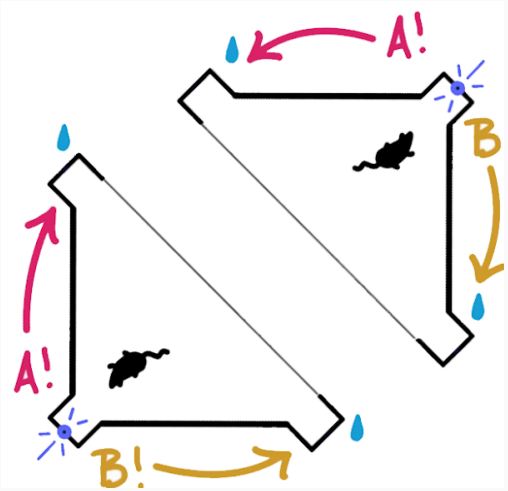


Poo et al., 2022
Bitzenhofer et al., 2022
Lee et al., 2021

Half triangle task for olfactory-spatial association learning



East/West task



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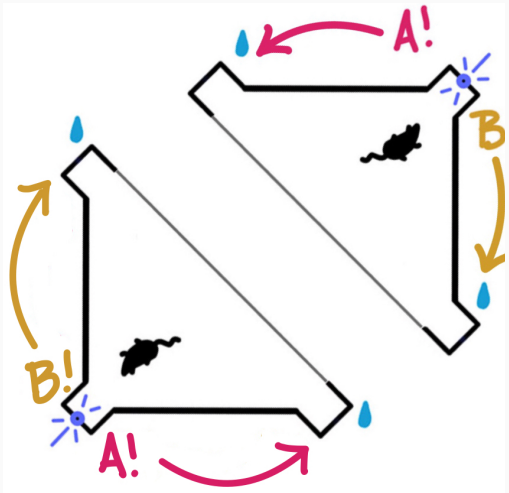
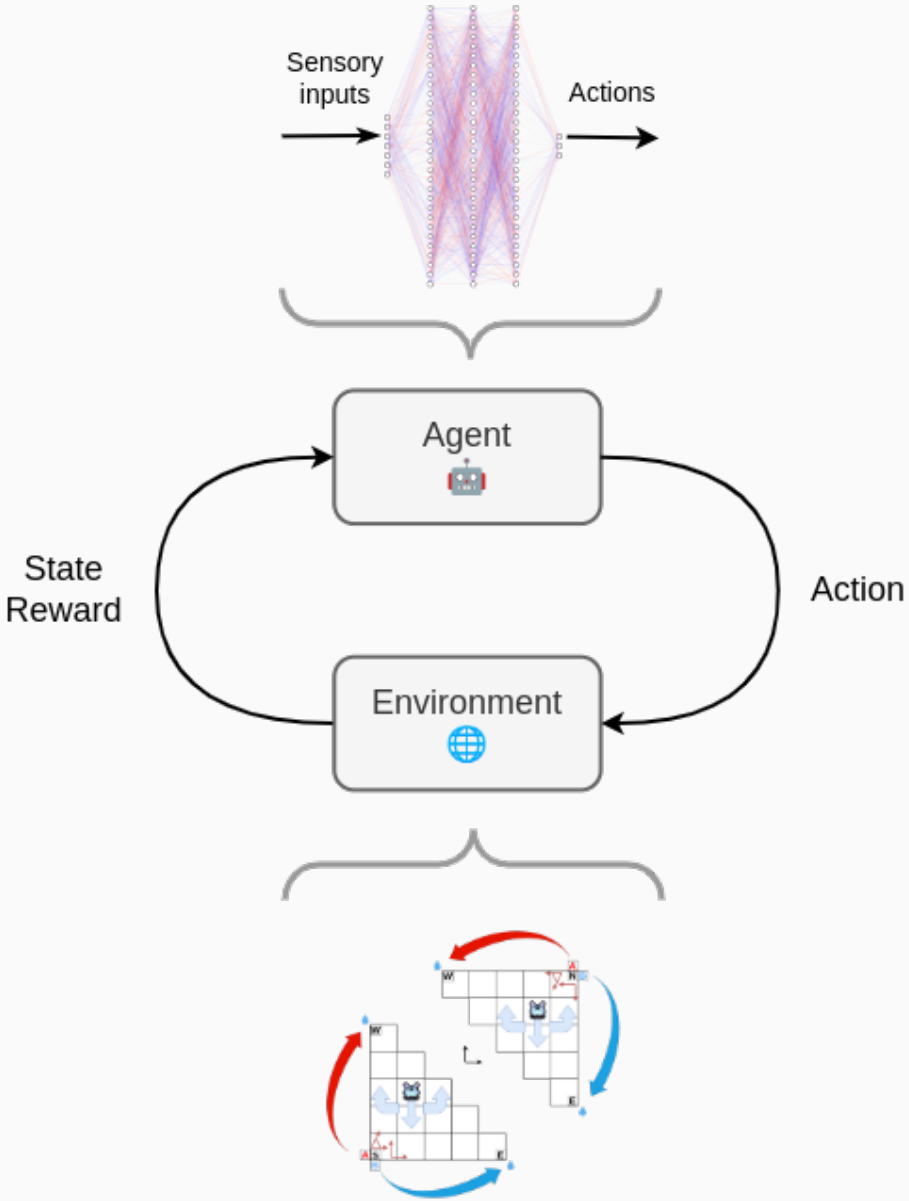
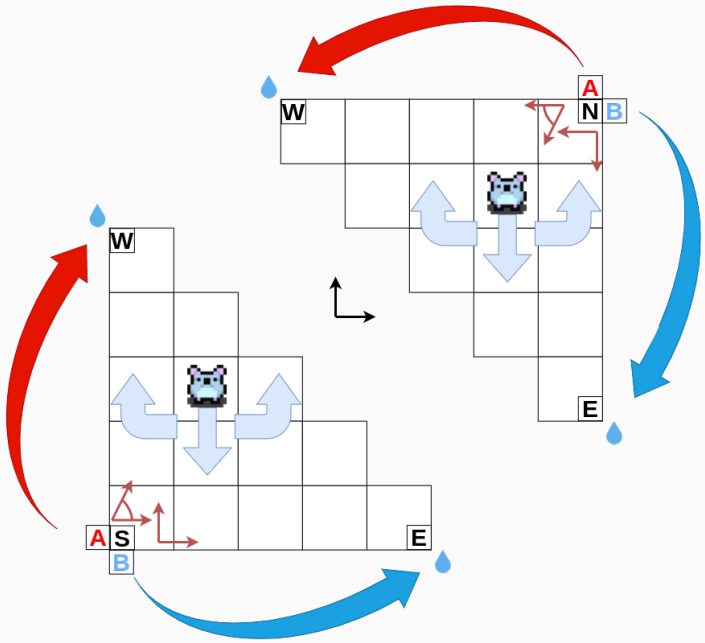


Deep Reinforcement Learning model



The environment



- 3 actions: $\Leftarrow$ $\Uparrow$ $\Rightarrow$
- Duplicated coordinates inputs:
  - Cartesian coordinates from north & south port
  - Polar coordinates from north & south port

Questions & Hypothesis

Questions

- What function does the network learn?
- How the constrains of the task affect learning & the representations learned?
- How do the representations learned compare between the *in vivo* and the *in silico* neurons?

Hypothesis

- The network will use the most efficient coordinate information based on the task
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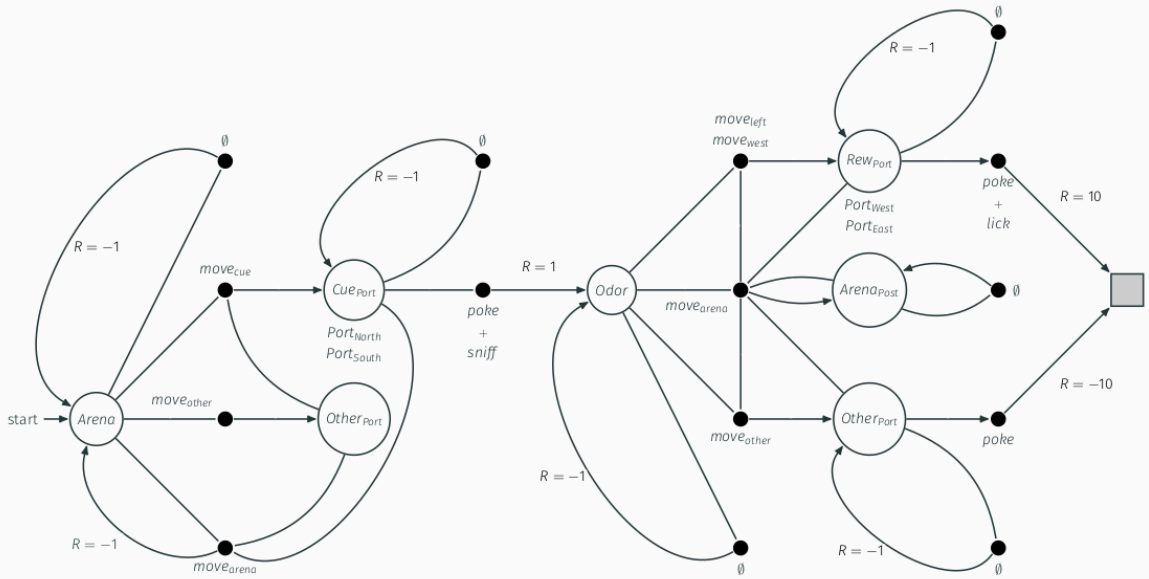
Looking back. . .



1. First step trying to define Olivia's experiment as a Markov Decision Process (MDP) in Julia
2. 2D tiles with tabular RL & function approximation in Python/NumPy
3. 2D coordinate system in Python/PyTorch
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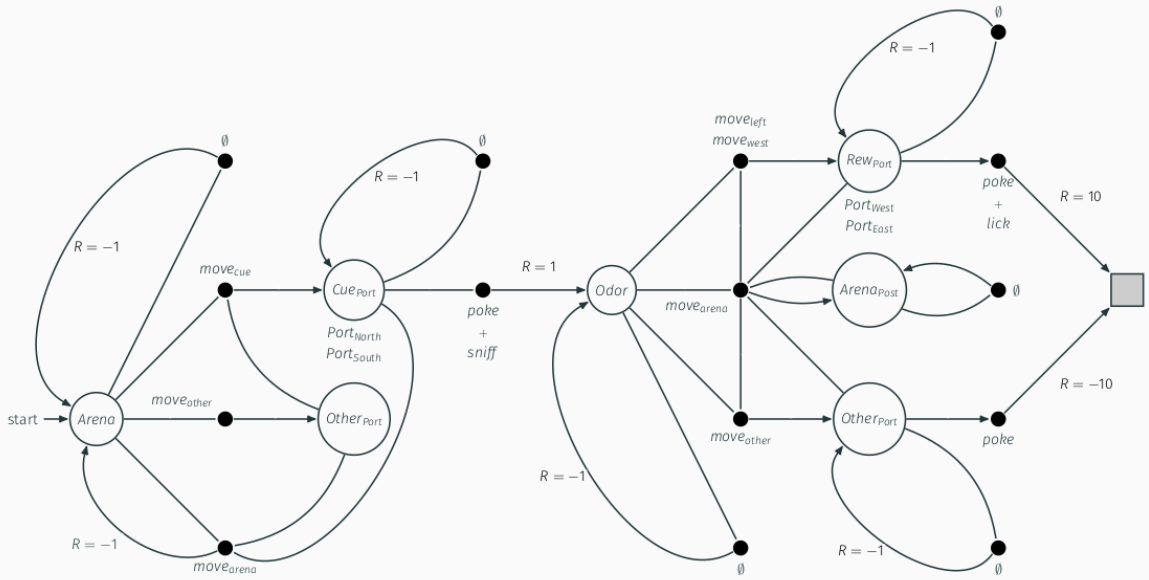

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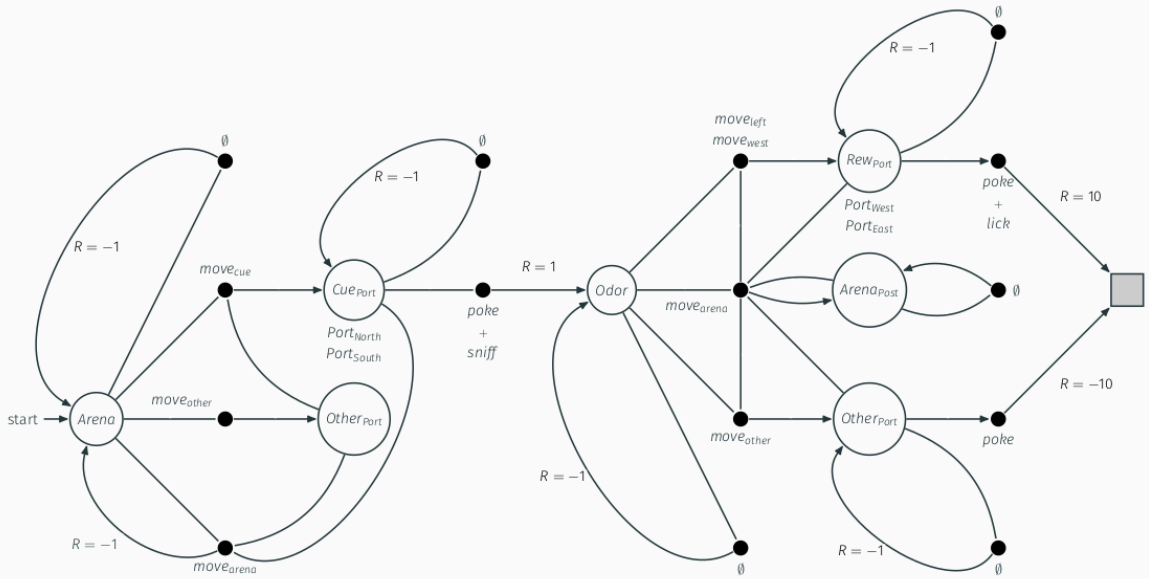

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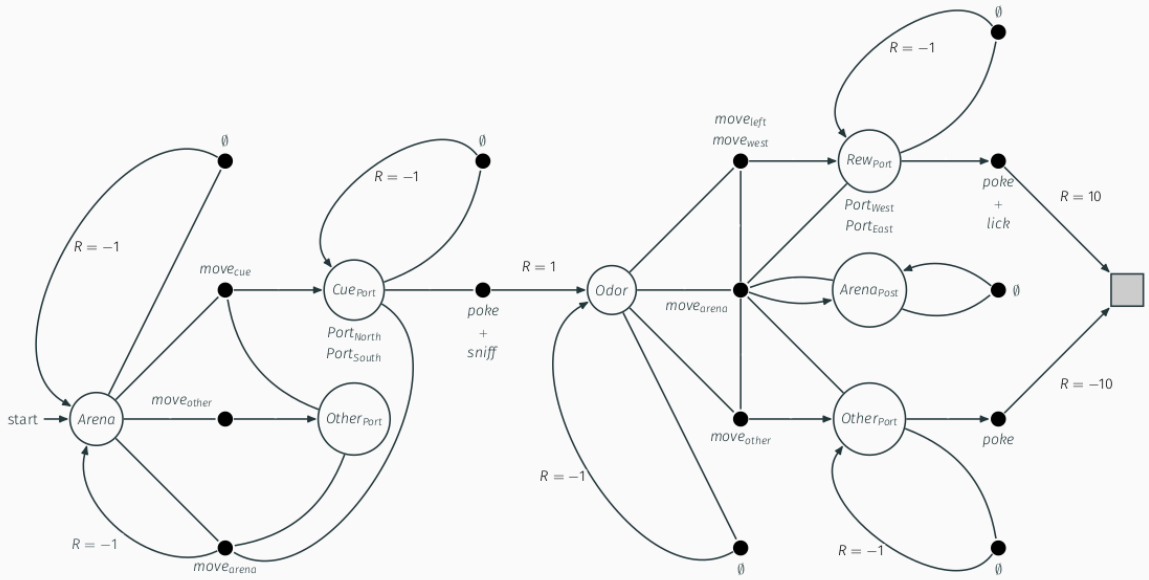

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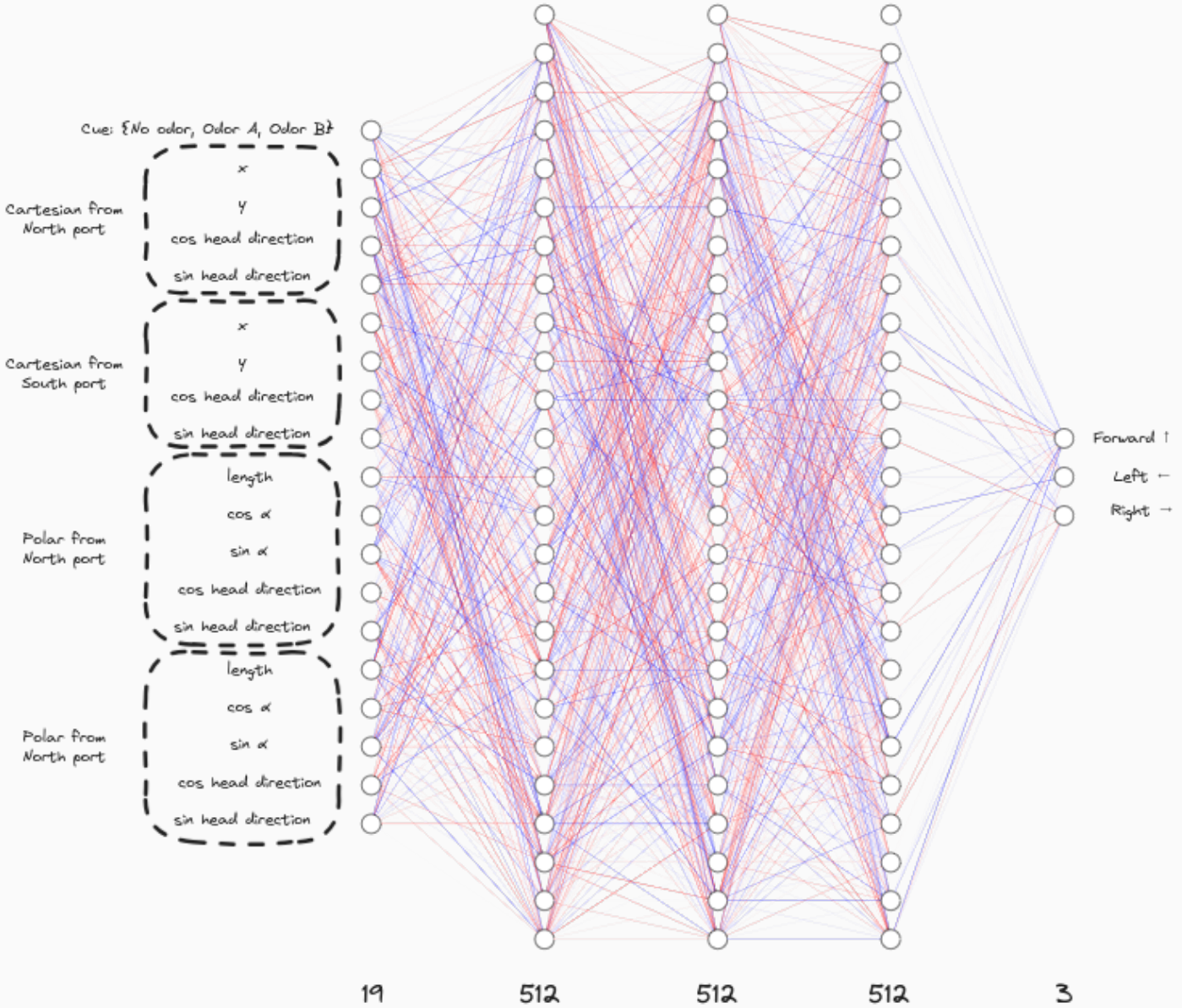
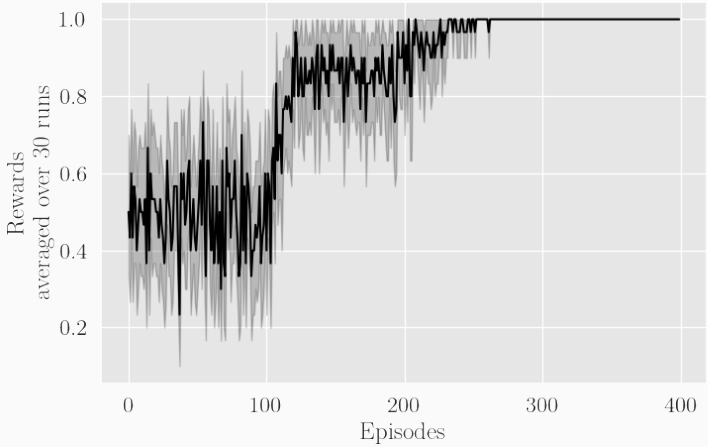
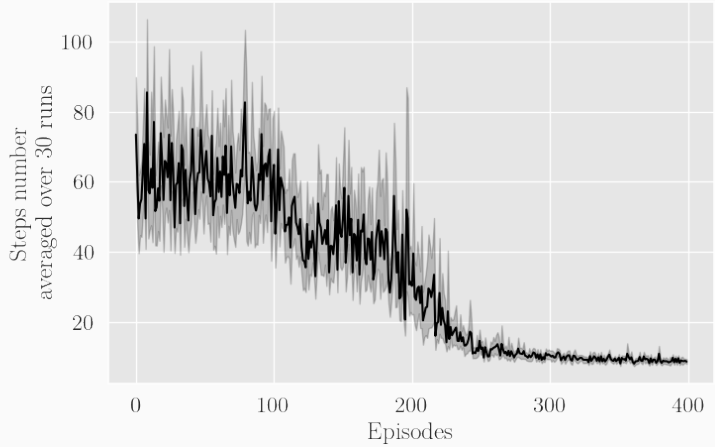
State space & network architecture



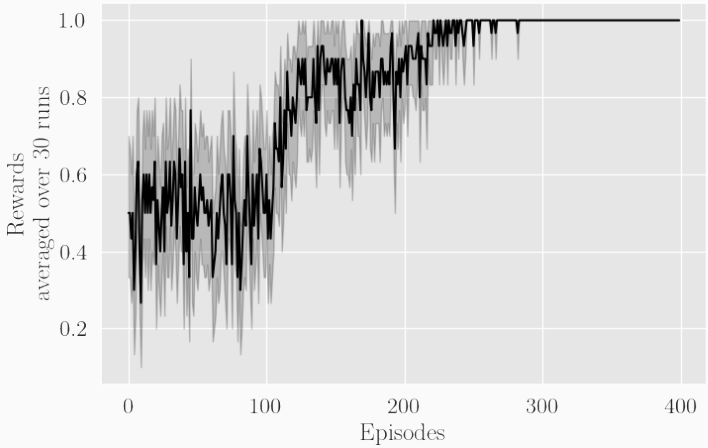
Training

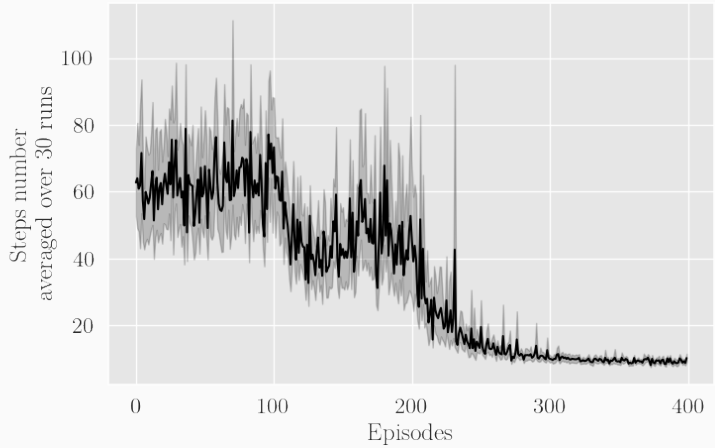
East/West



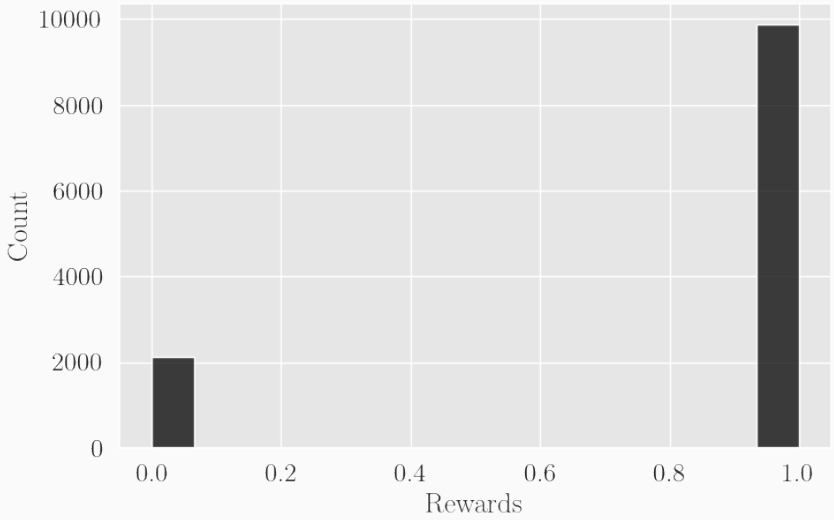


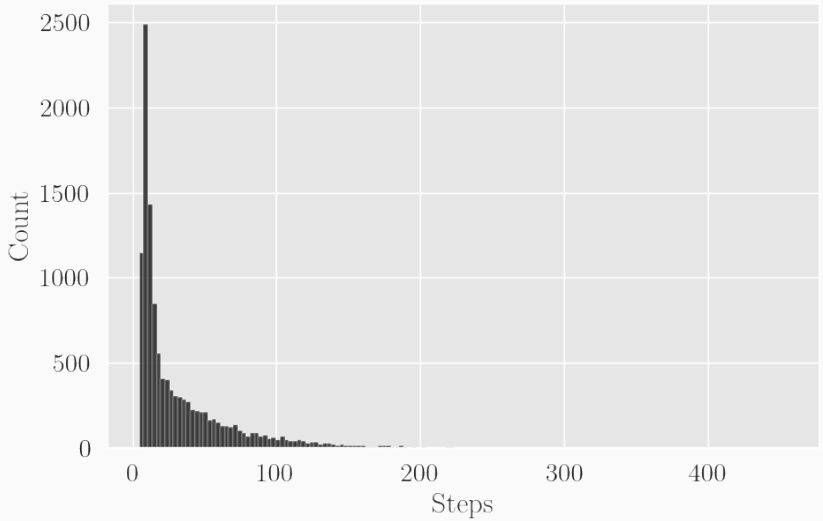
Left/Right

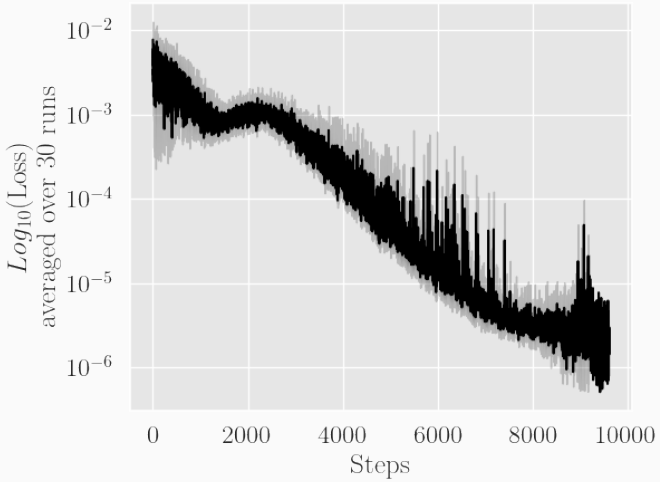


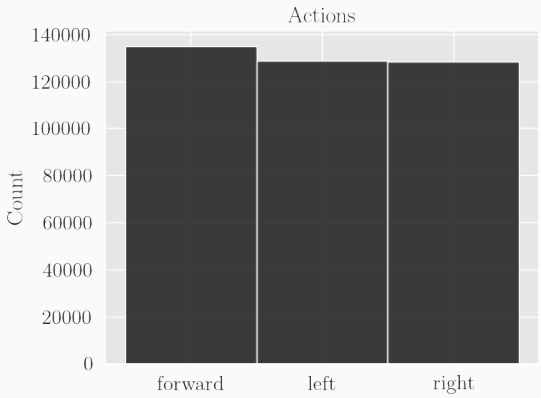


Training checks – East/West

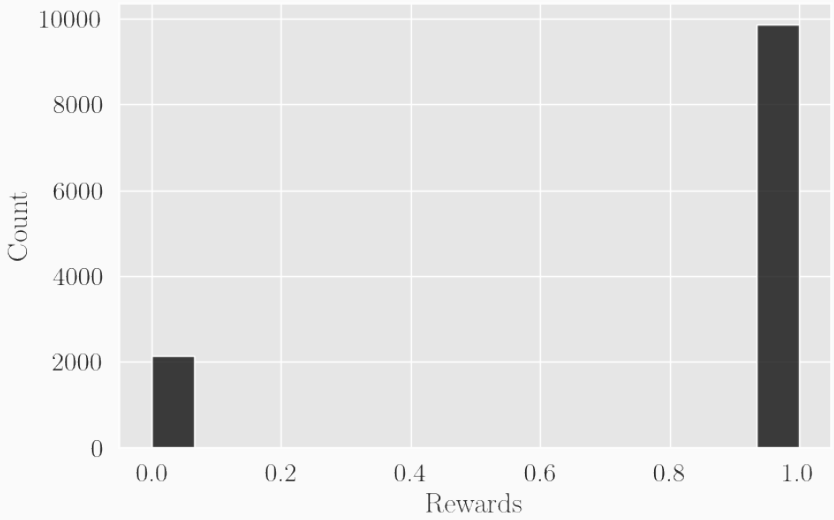


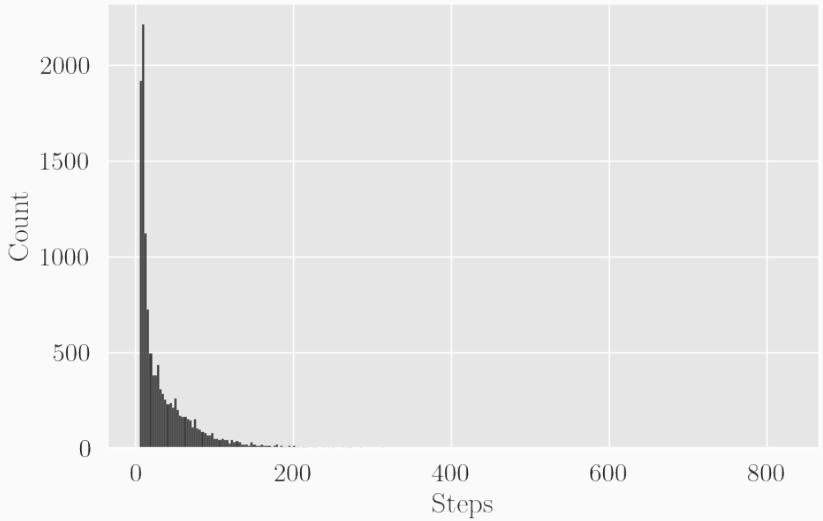


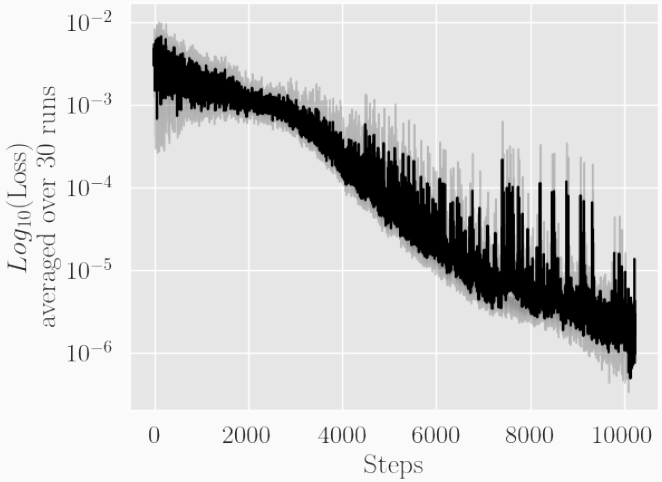


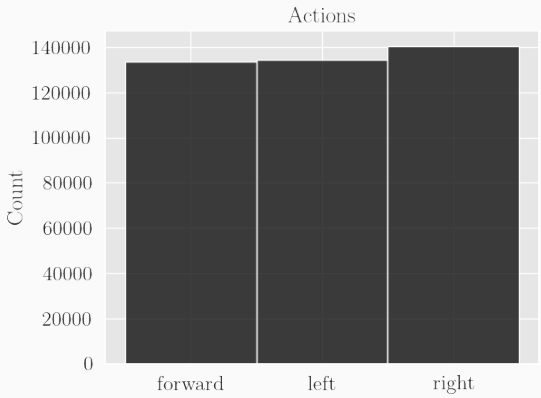


Training checks – Left/Right

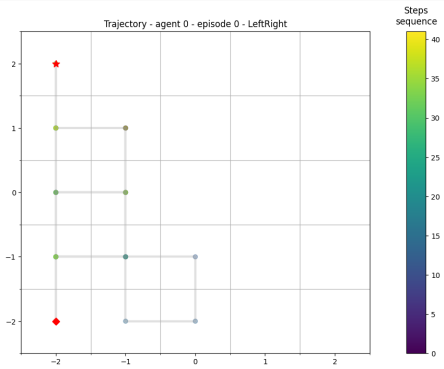


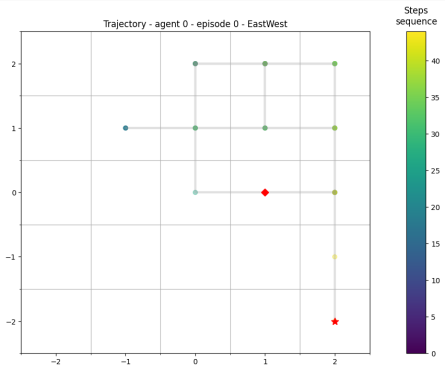


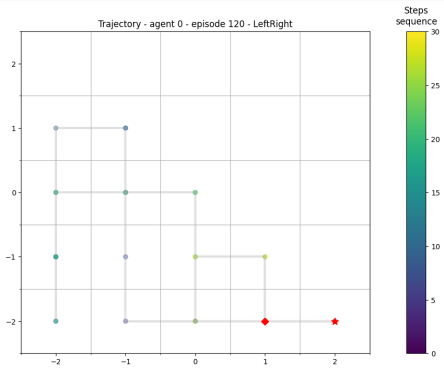


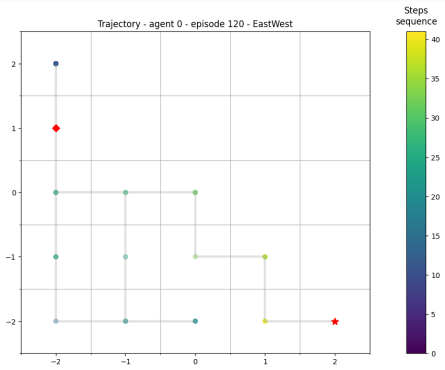


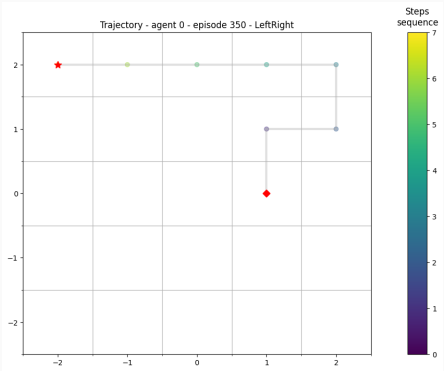
Agent behavior

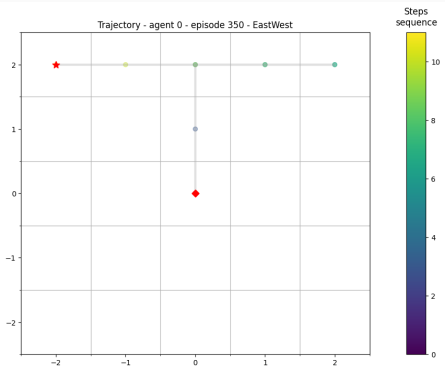












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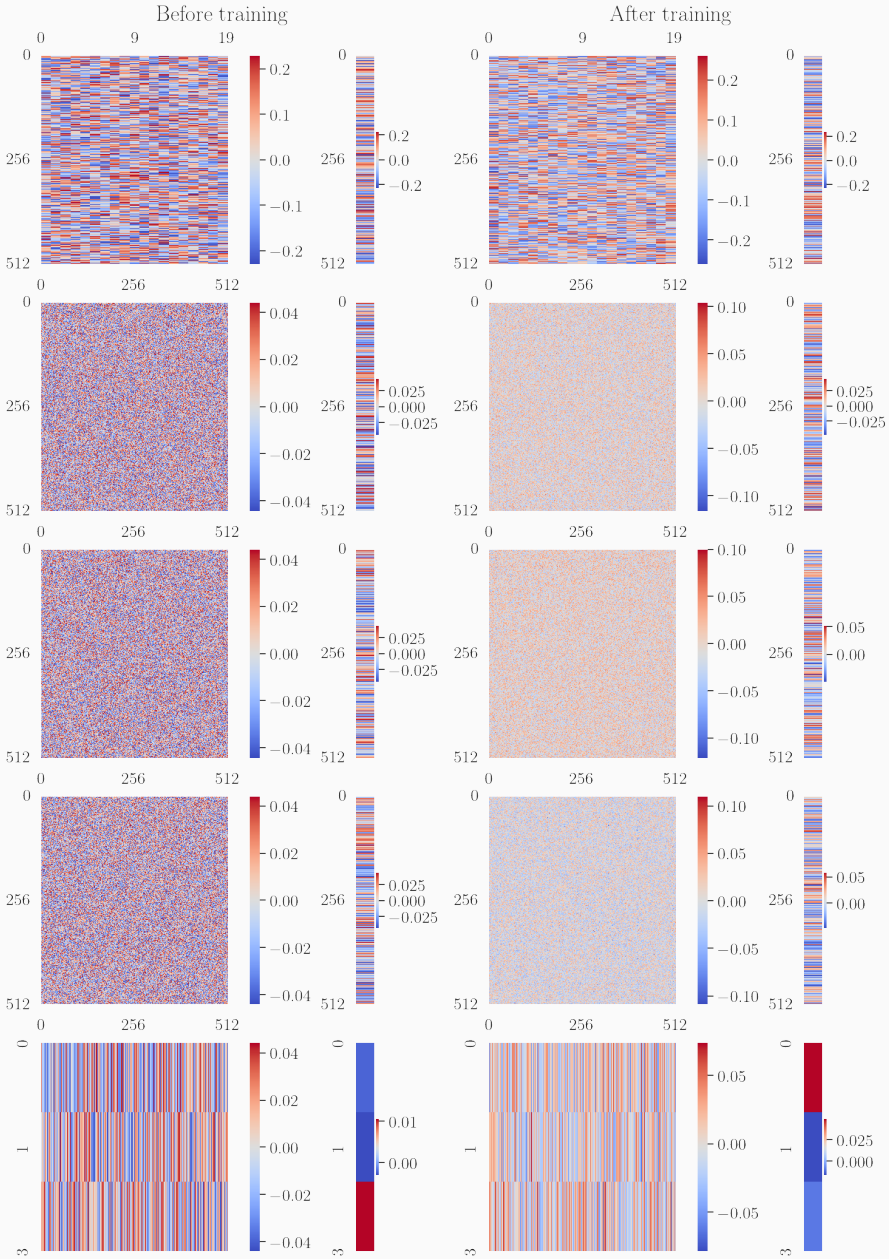
Weights structure – East/West



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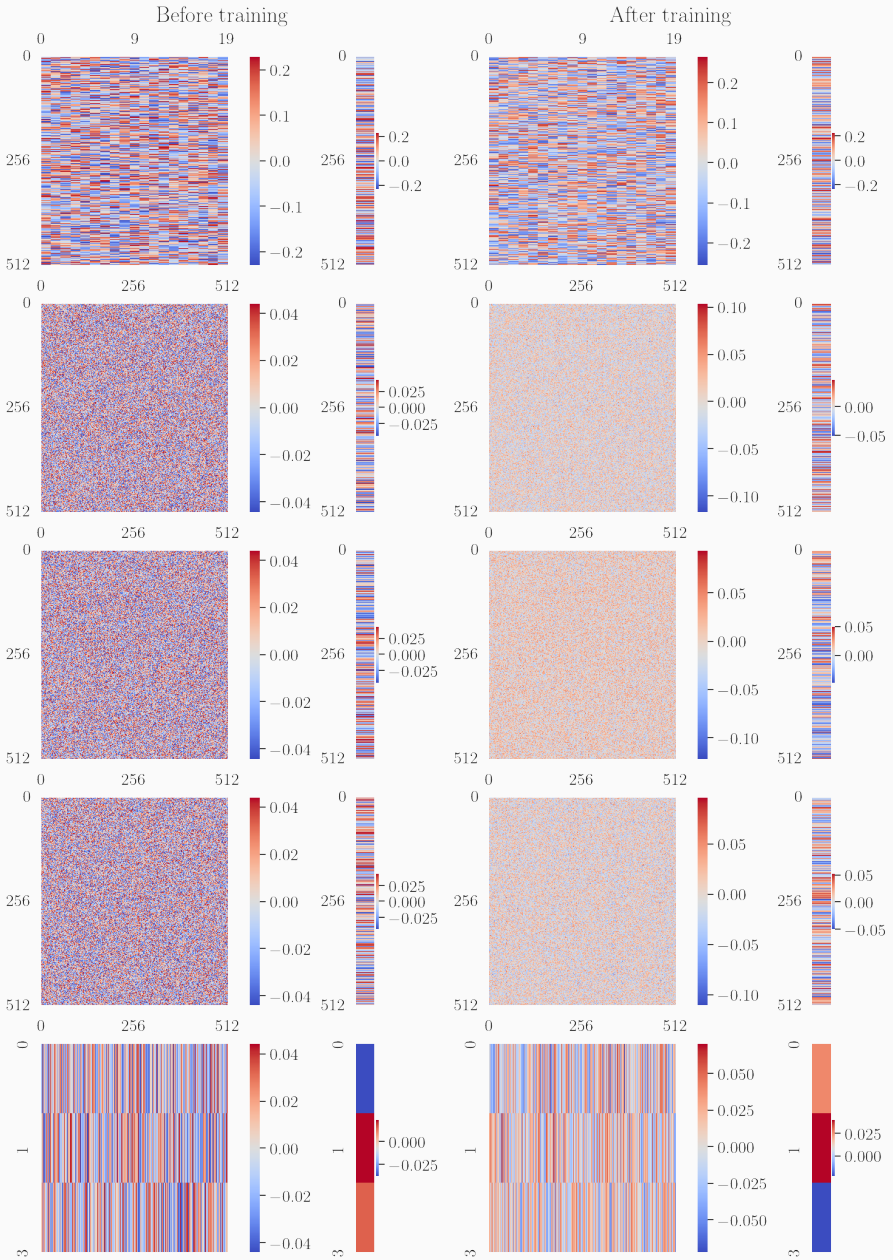
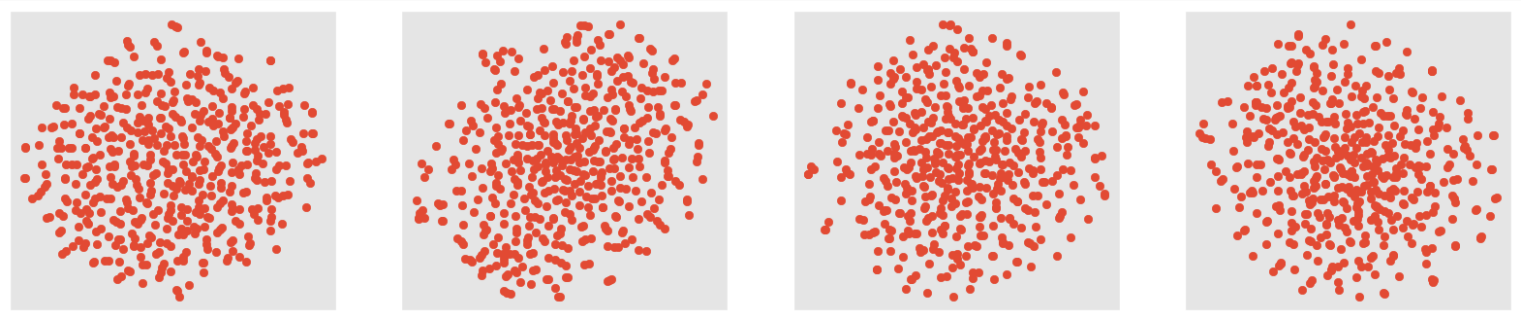


Weights clustering

East/West



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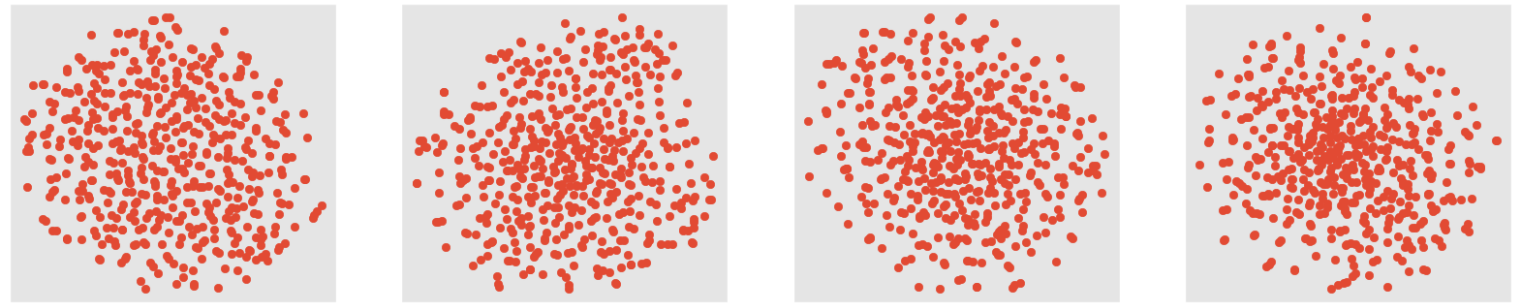
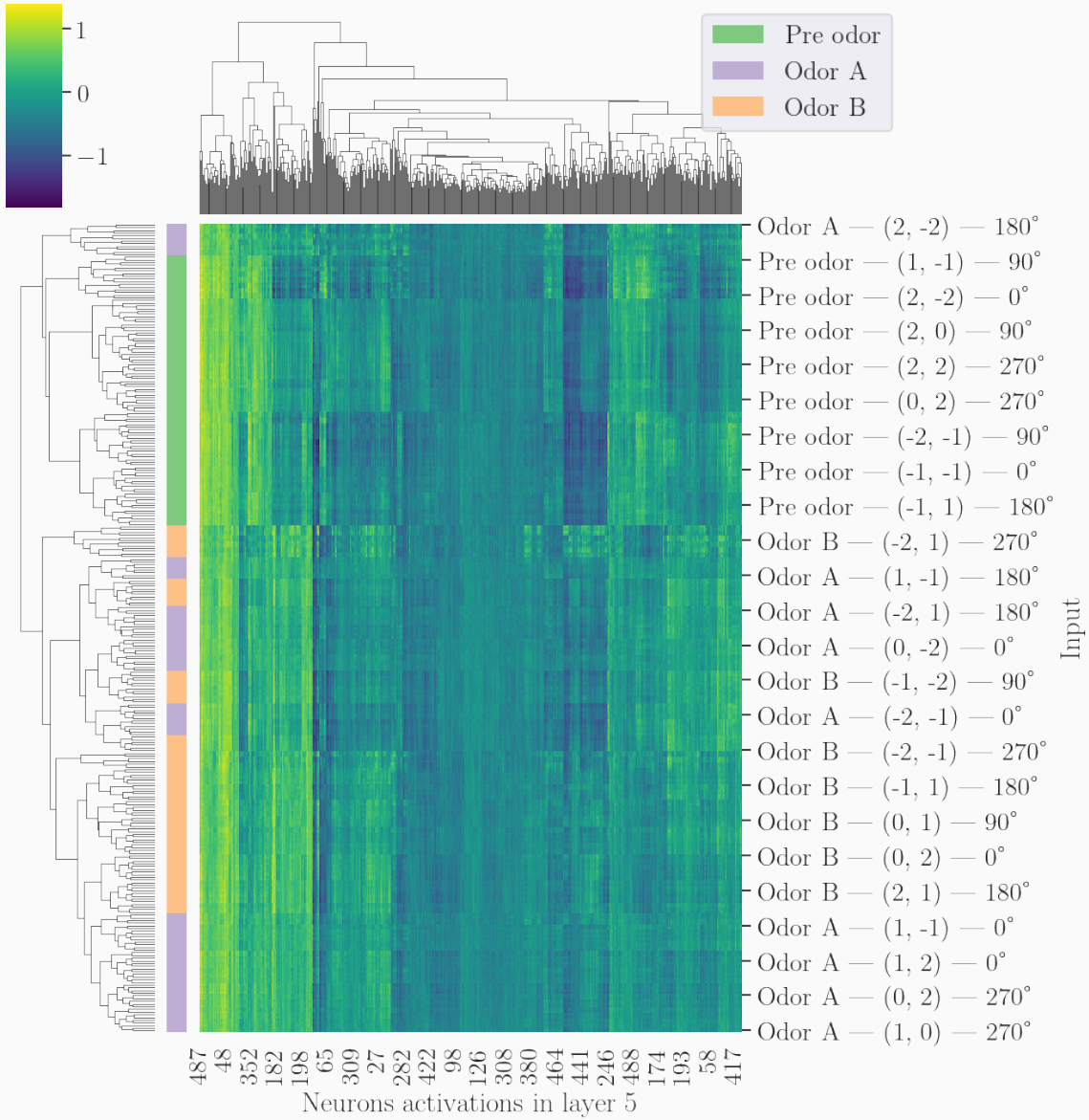


Activations learned – East/West



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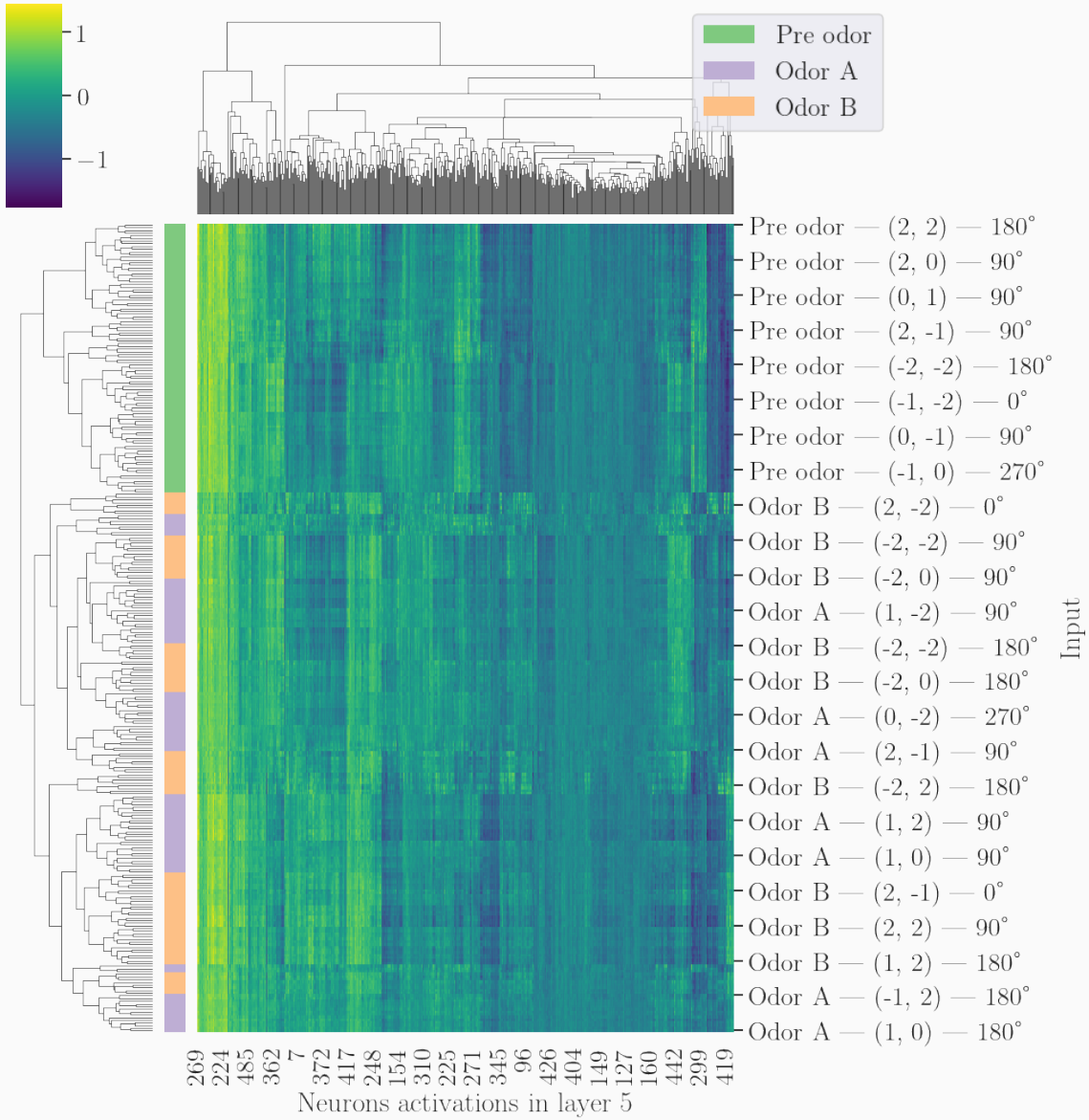

Use the behavior as proxy – Perturbation experiment

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- Expectation:
  - Left/right task:
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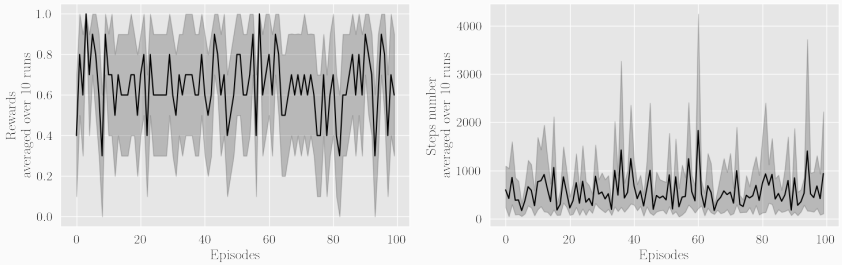
Cartesian inputs unchanged – polar inputs perturbed

East/West

Silencing inputs



Left/Right

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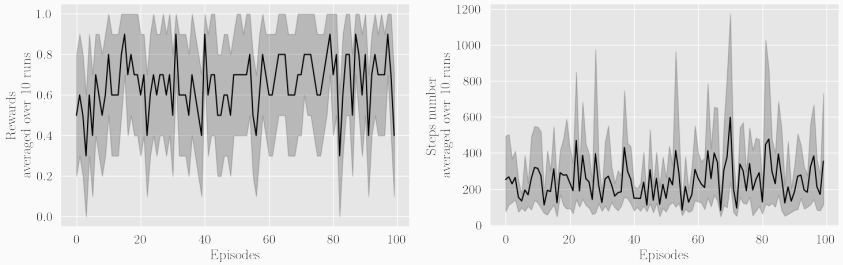
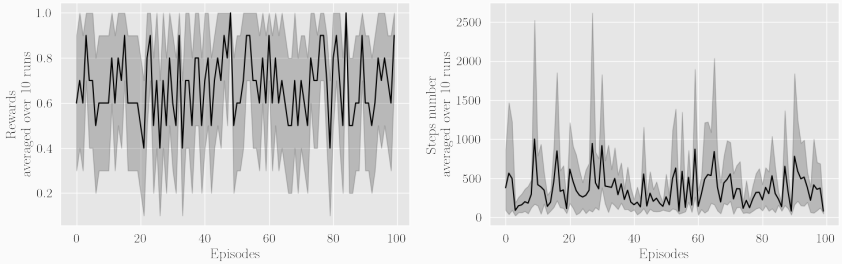


Randomizing inputs



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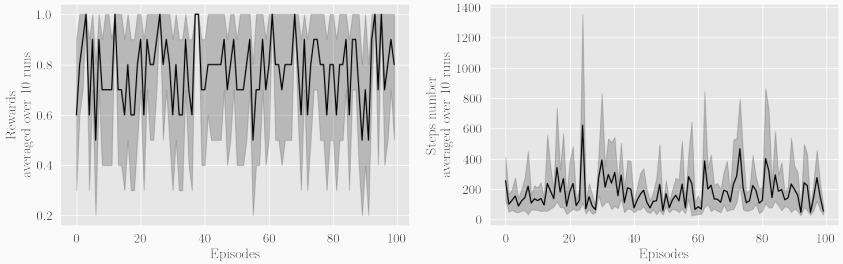

Polar inputs unchanged – Cartesian inputs perturbed

- Simulation does not end
  $\rightarrow$ couldn't figure out why yet...

Outline

Partial conclusions so far

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- The pre-odor activations cluster together, but no other clear pattern seems to emerge
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  - Fix issue on Cartesian inputs
  - Setup more metrics for the study: performance histogram, % correct, etc.
- Need for some causal inference framework?
- Use of techniques from explainable AI?
- Study of the derivative of the output w.r.t. the inputs?
- Timeline: wrap the project by end of August

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