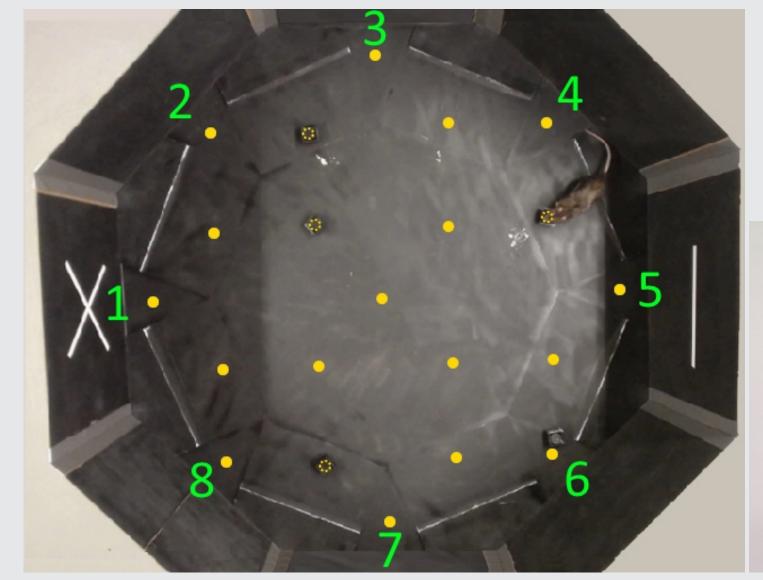


## 1. Introduction

The Traveling Salesperson Problem (TSP) involves planning a route between a fixed set of locations using the shortest possible path without re-visits. The TSP is a classical artificial intelligence problem that combines dynamic planning, working memory, and spatial navigation. In Rat TSP, animals navigate for rewards in multiple cups in a small environment (Watkins de Jong et al. 2011) and for the first time in a much larger environment.

## Traveling Salesperson task for Rodents



Environment Size = 150 cm 21 possible cup locations

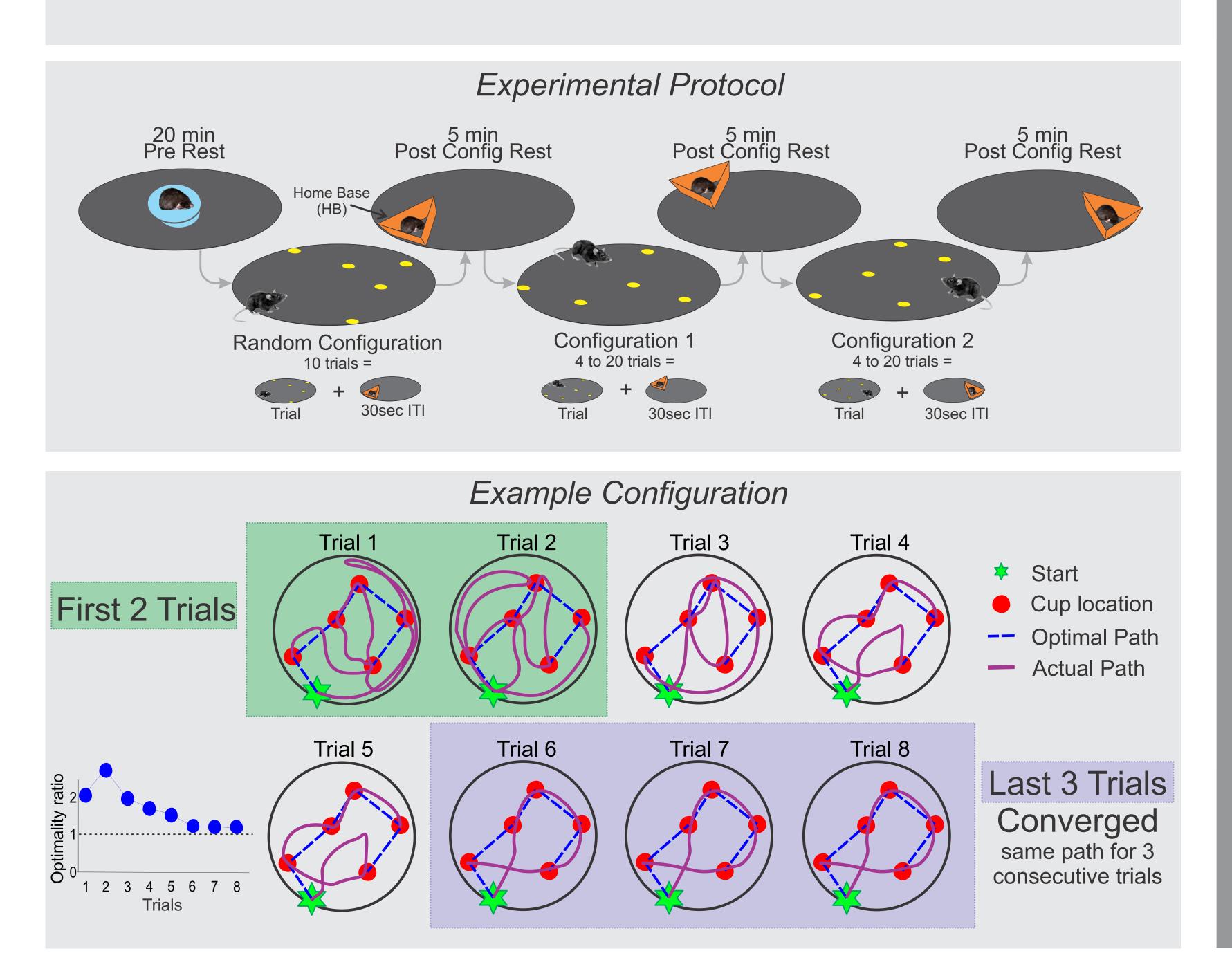
- **1-8** 8 possible start locations

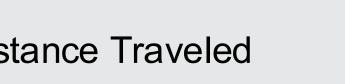


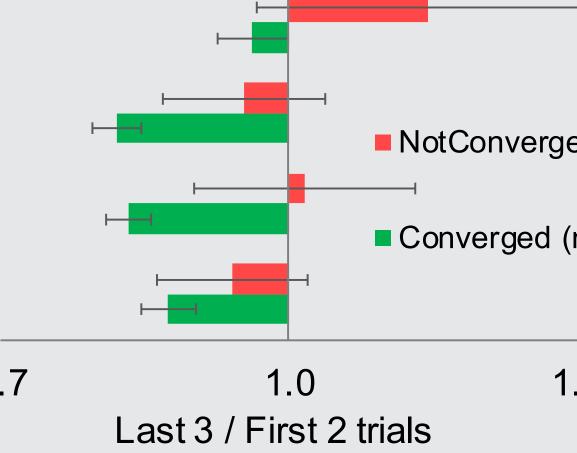
- What are the behavioral strategies in TSP? How does a rat's behavior change from the first to later trials?
- Are the rate and spatial distributions of Sharp Wave Ripples (SPWs) in the dorsal hippocampus correlated with the convergence onto a specific route?
- Are SPWs produced at the reward locations related to the rats convergence?

# 2. Methods

- Random Configuration different configuration of 5 cups, as well as different start position each trial for 10 trials. No opportunity for optimization.
- Standard Configuration same 5 cup locations and start position each trial until rat takes same path for 3 trials in a row = 'converged'. After 20 trials without converging the configuration ends = '**not converged**'.
- Wired and Wireless Multi-tetrode recordings from dorsal CA1. SPWs filtered (100-300 Hz) and extracted: Post-Configurations, Between Trials, at Reward Locations.



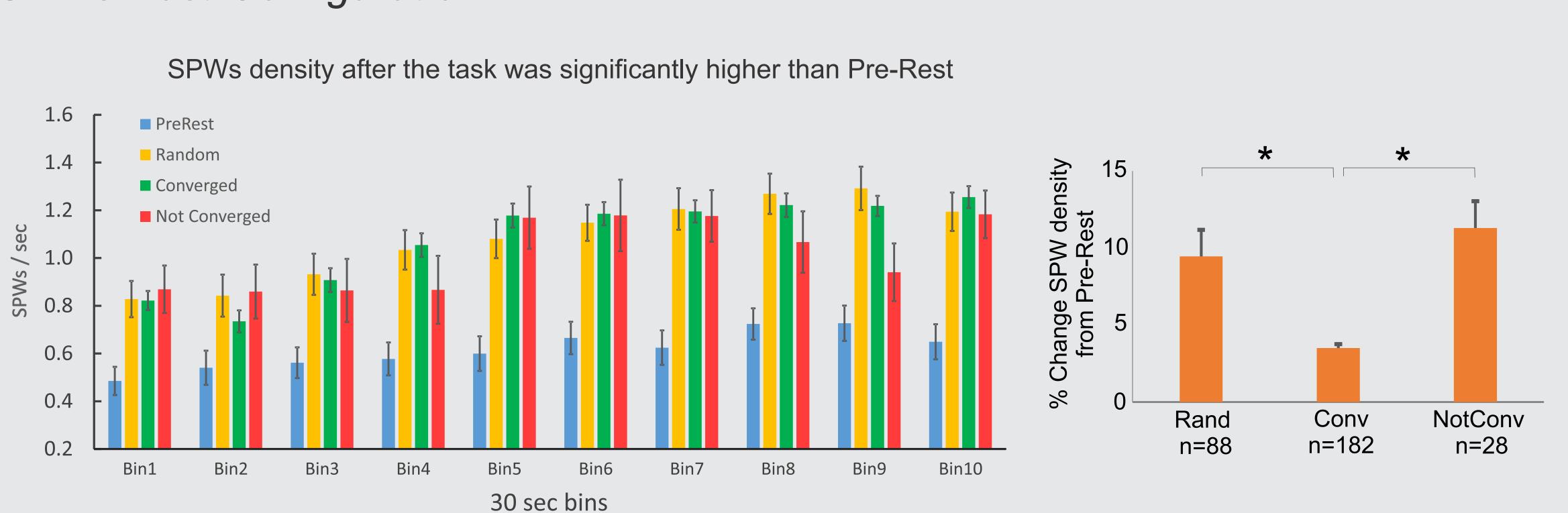




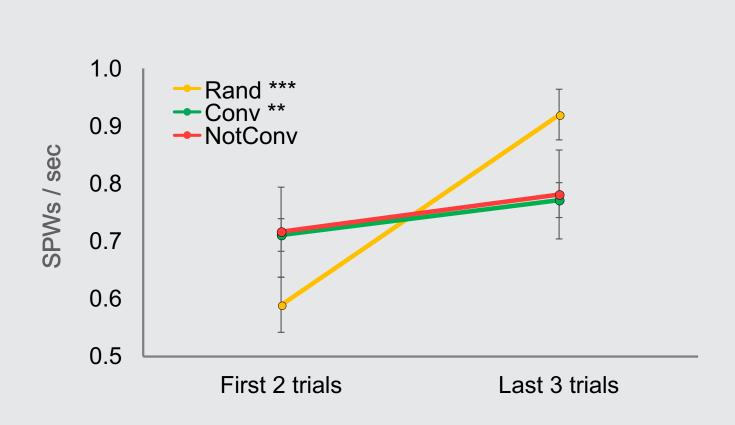
When rats converged, optimization was reflected in the decrease in distance traveled, trial completion time, movement time, and number of visited reward locations.

## SPWs Post-Configuration





## SPWs Between Trials

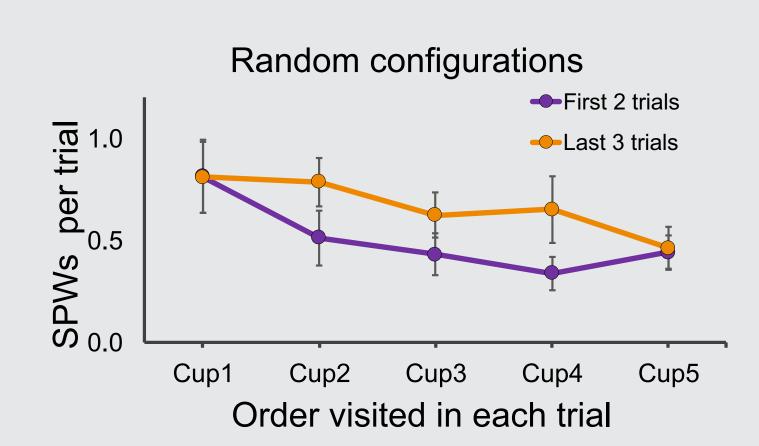


SPWs density increased significantly across trials for random and converged configurations.

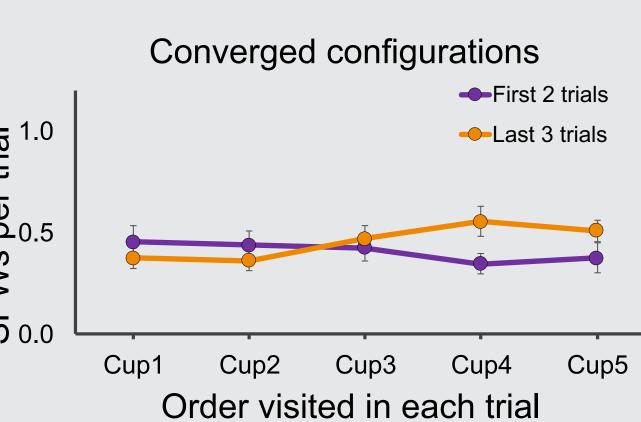
# Post-Trial SPW Density (SPWs/sec)

Rand r\*
Conv r\*
NotConv

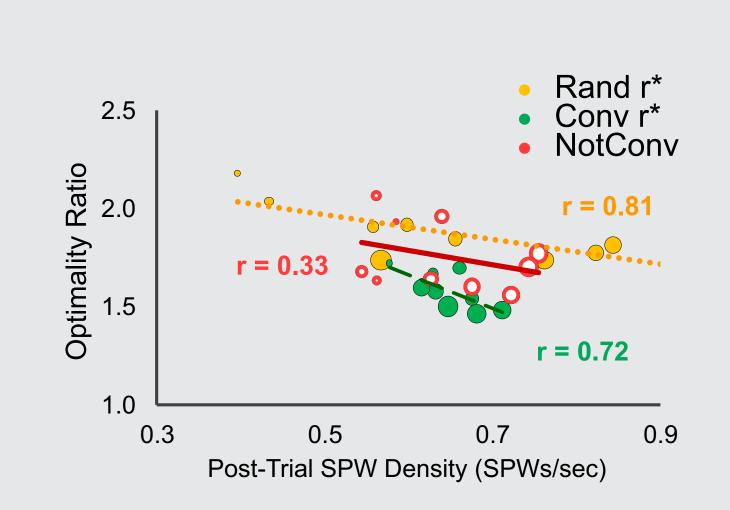
SPWs at Reward Locations



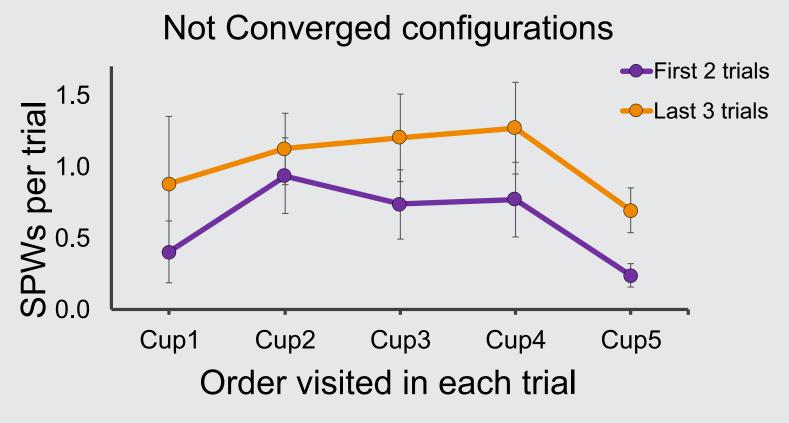
In random configurations the number of SPWs at reward locations decreased from first cup to last cup for both the first 2 and last 3 trials (Main Effect of Cups, F=3.41, p<0.01). In **converged configurations** the number of SPWs at reward locations decreased from first cup to last visited cup for the first 2 trials, but increased from first to last visited cup for the last 3 trials (First2/Last3\*Cups Interaction, F=3.22, p<0.05).

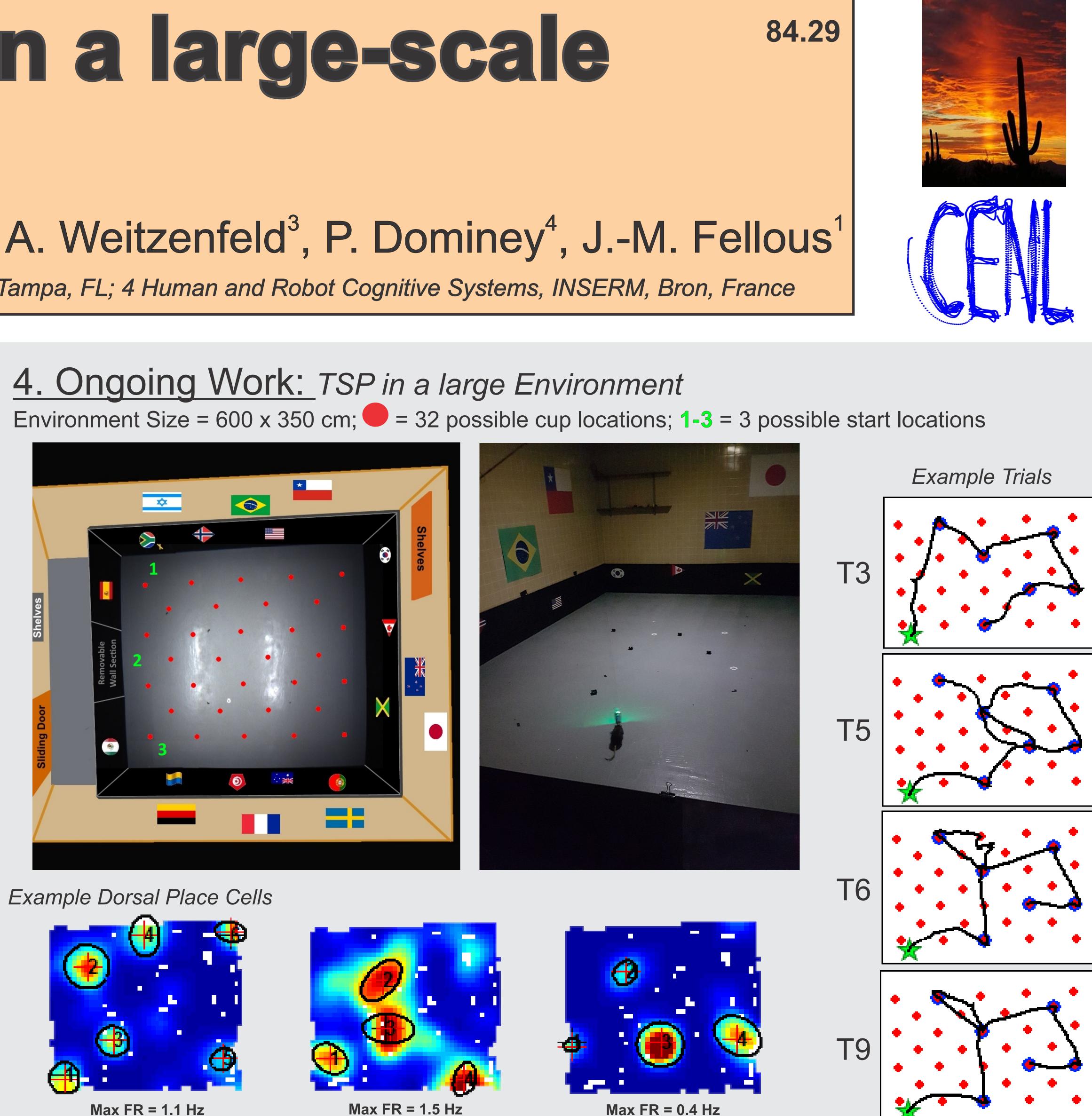


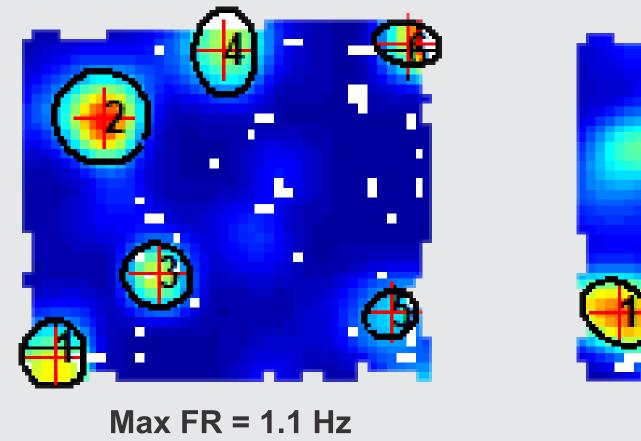
First trials of the converged configurations were more associated with local strategies, last trials were associated with local and global strategies.



Post-Trial SPWs density was correlated with trial completion time and optimality ratio in the random and converged conditions.







## Robot-guided TSP

Rats can be trained to follow a small robot between rewarded cups (Gianelli et al., 2017).

Can this method be used to bias or teach the rat to converge on optimal or sub-optimal trajectories?

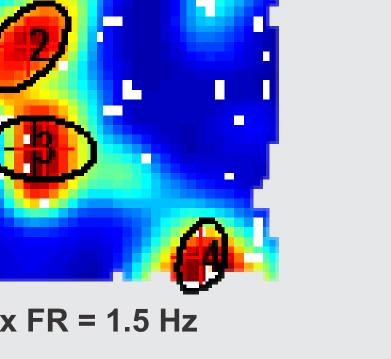
## 5. Conclusions

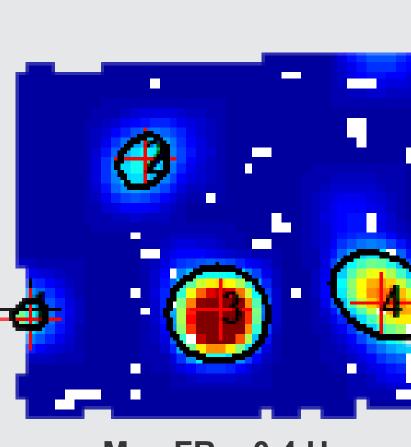
- optimization or not.
- irrespective of convergence.

References:

De Jong, L. W. Gereke, B. Martin, G. M. Fellous, J-M (2011) The traveling salesrat: insights into the dynamics of efficient spatial navigation in the rodent J. Neural Eng. doi: 10.1088/1741-2560/8/6/065010 Gianelli S, Harland B, Fellous J-M. (2017) A rat-compatible robotic framework for behavioural neuroscience experiments. Journal of Neuroscience Methods, https://doi.org/10.1016/j.jneumeth.2017.10.021

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. Optimization in the TSP task may be the result of an increase in both local and global strategies, as a subject becomes more familiar with the reward locations.

2. SPWs density increased between configurations, whether the task involved

3. SPWs density between trials was positively correlated with performance

4. For converged configurations, the number of SPWs at target locations decreased from cup to cup for the first 2 trials, but increased for the last 3 trials which could represent a neural correlate of optimization in terms of population activity.