The Traveling sales*rat*: Insights into optimal spatial navigation and the role of the dopaminergic system.

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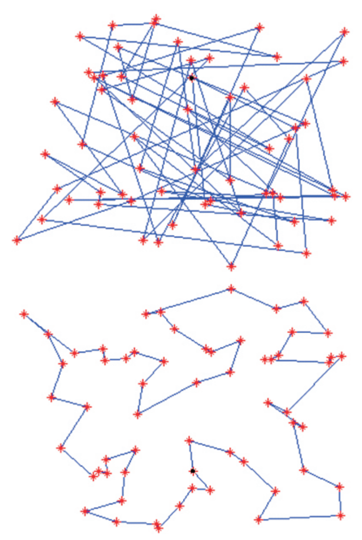
Introduction



• The *traveling salesman problem* is a classic problem in artificial intelligence and theoretical computer science in which an agent has to plan visits to a fixed set of cities. It can be solved by calculating the total distance traveled for every possible tour and sorting the solutions. Finding the best solution is computationally expensive (NP-complete problem) because each city added increases the complexity of the problem exponentially.

• Heuristic methods allow humans to find near optimal solutions.

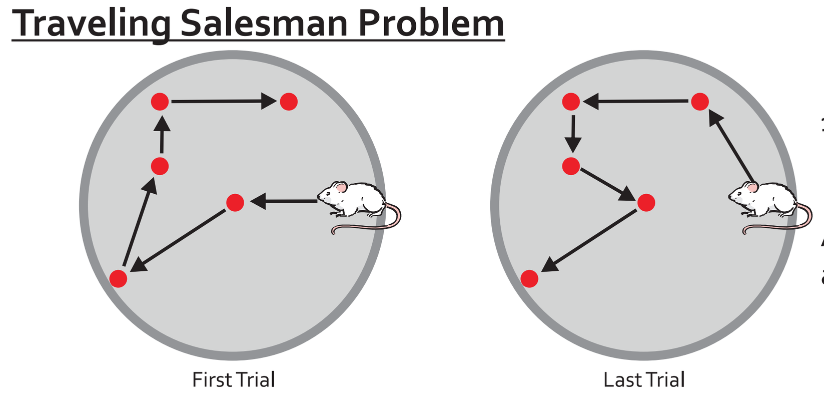
• Understanding the neural mechanisms underlying these heuristic processes can give insights into how complex choices are made.

• We propose a rodent model to investigate problem solving strategies at both behavioral and neural levels.

• We study how rats use a combination of spatial and reward information to optimize their decisions.

Methods

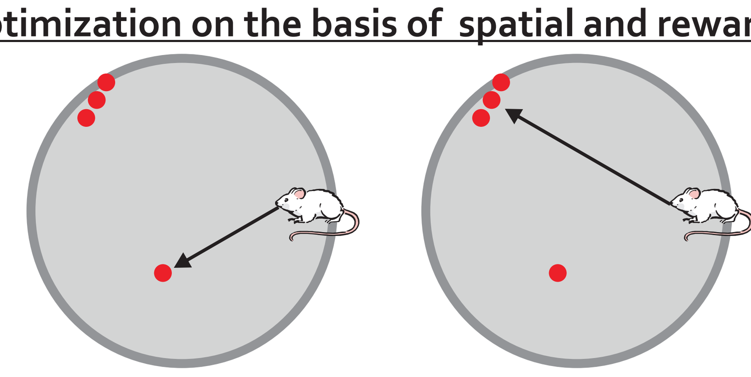
Traveling Salesman Problem



10 trials to find the optimal path for a given configuration

A total of 24 configurations over a six day period were used.

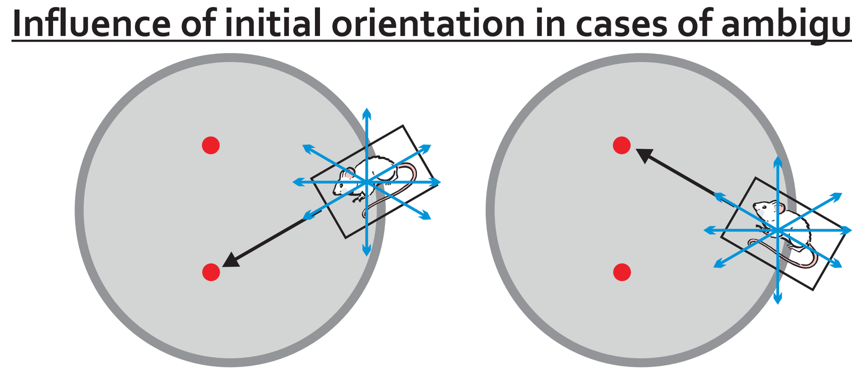
Optimization on the basis of spatial and reward information



Spatially optimal, reward optimal, or ambiguous configurations were presented.

Each configurations: Exploration trial+ 3 decision trials.

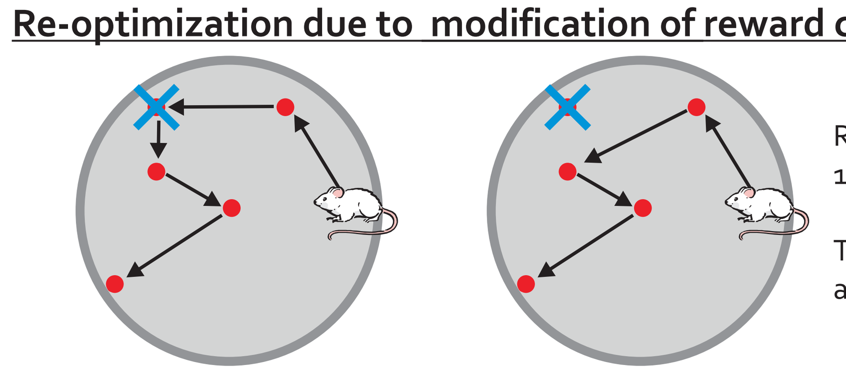
Influence of initial orientation in cases of ambiguous choices



Rats were randomly started at eight angles (0, 30, 90, 120, 180, 210, 270, 330) relative to center of arena.

Rats were allowed to visit only one city.

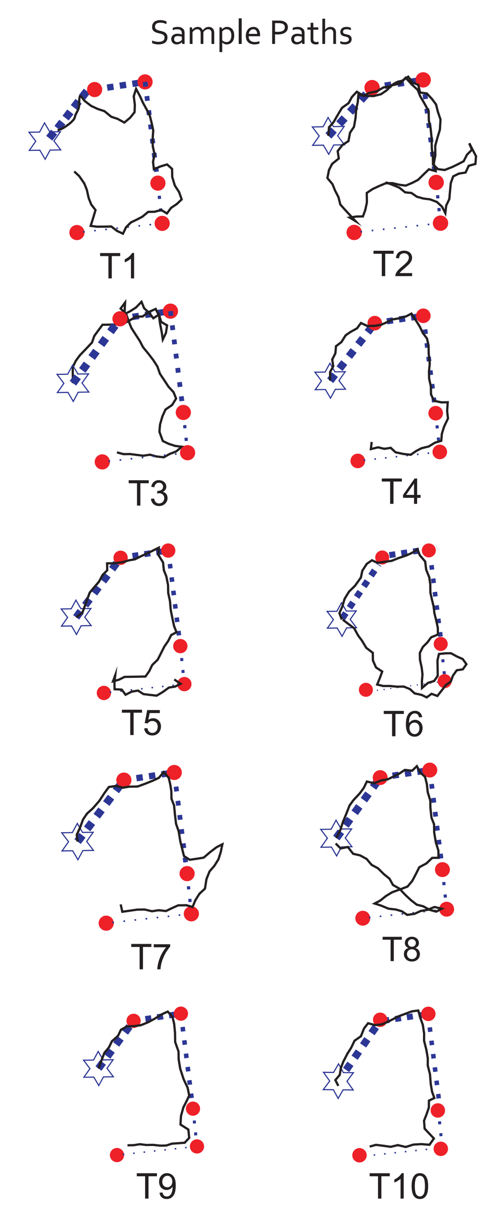
Re-optimization due to modification of reward contingencies

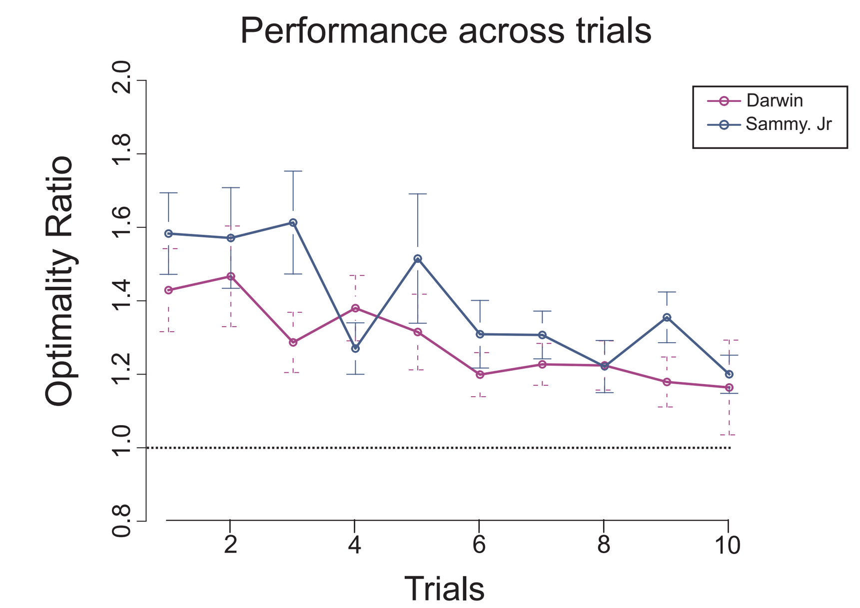


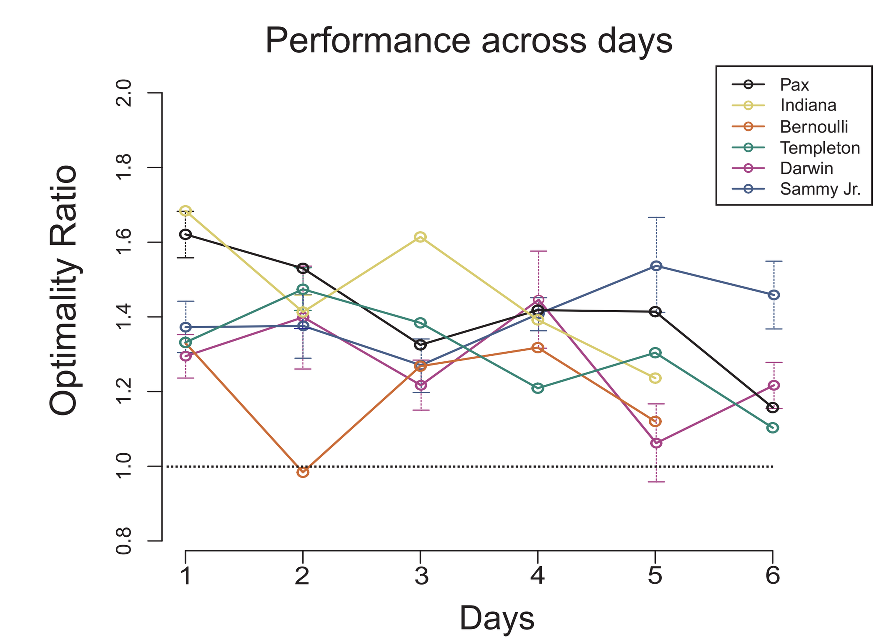
Reward removed from city after 10 trials.

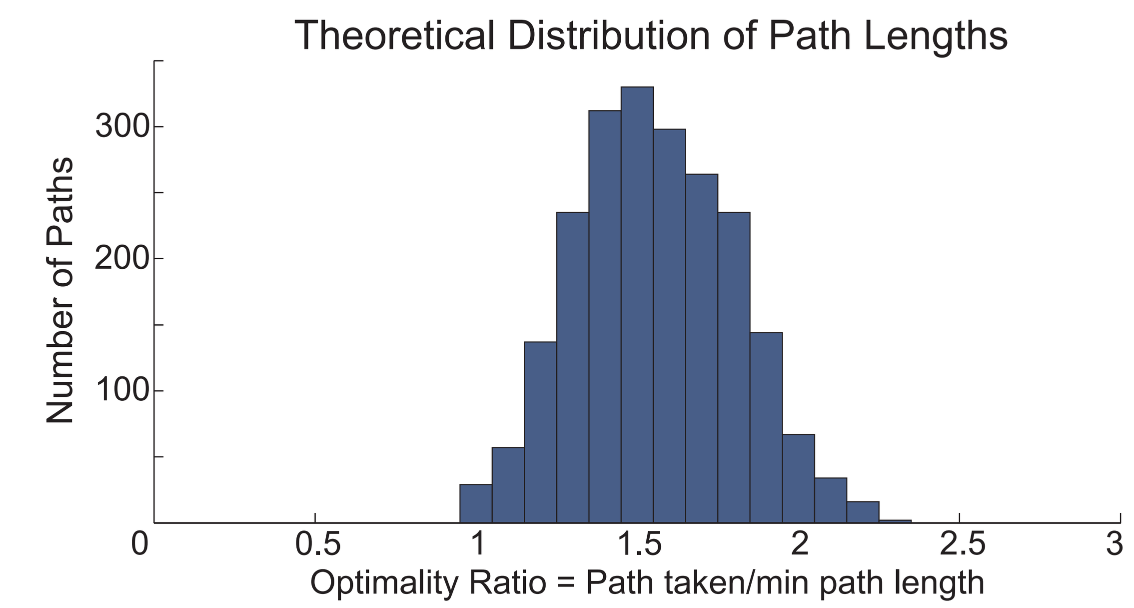
Trials continued until rat was able to re-optimize its path.

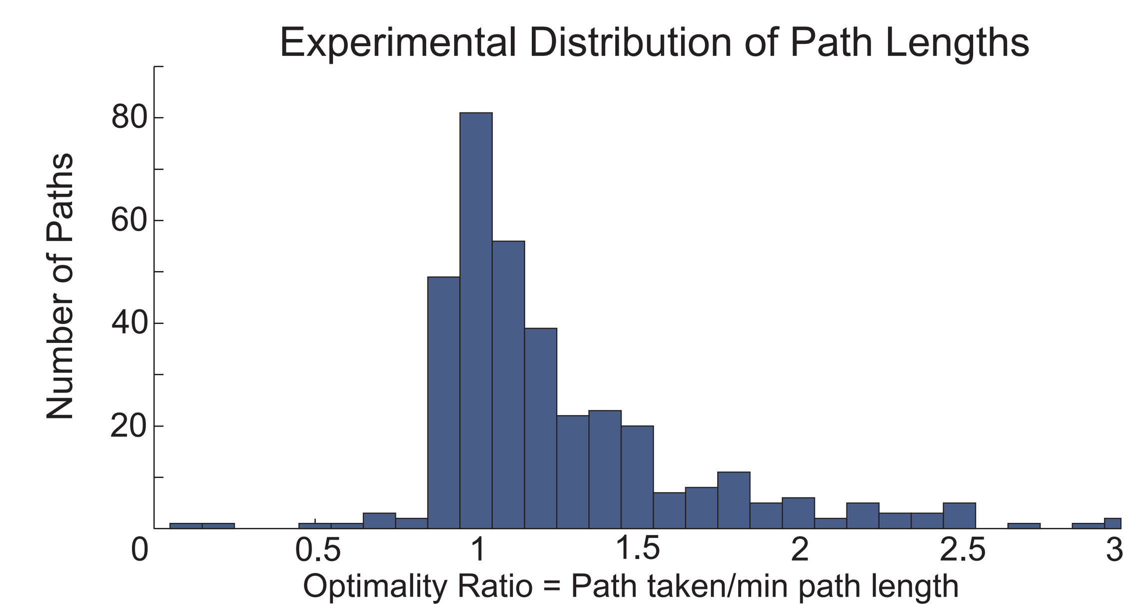
Traveling Salesman Problem



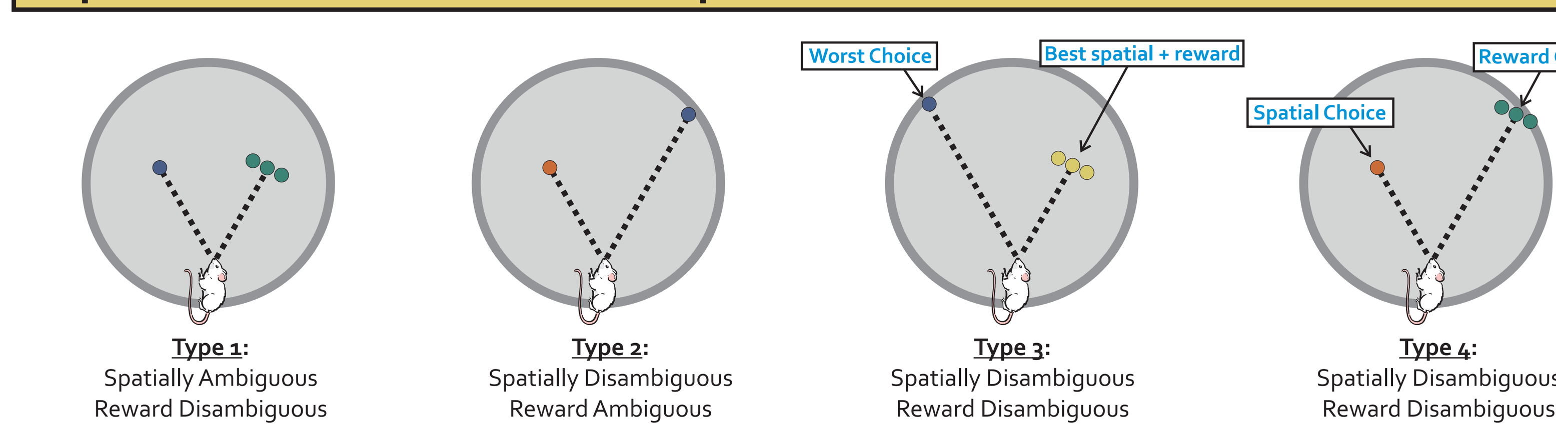


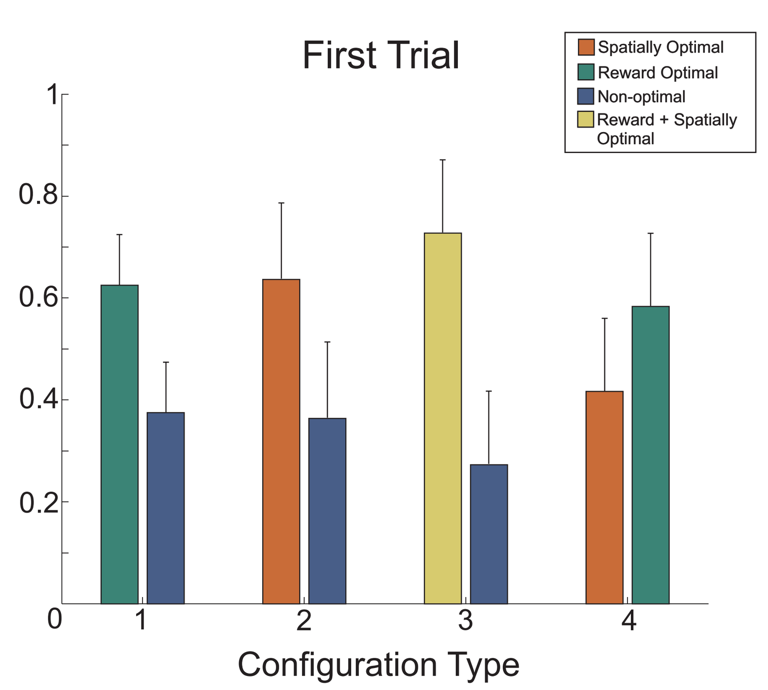


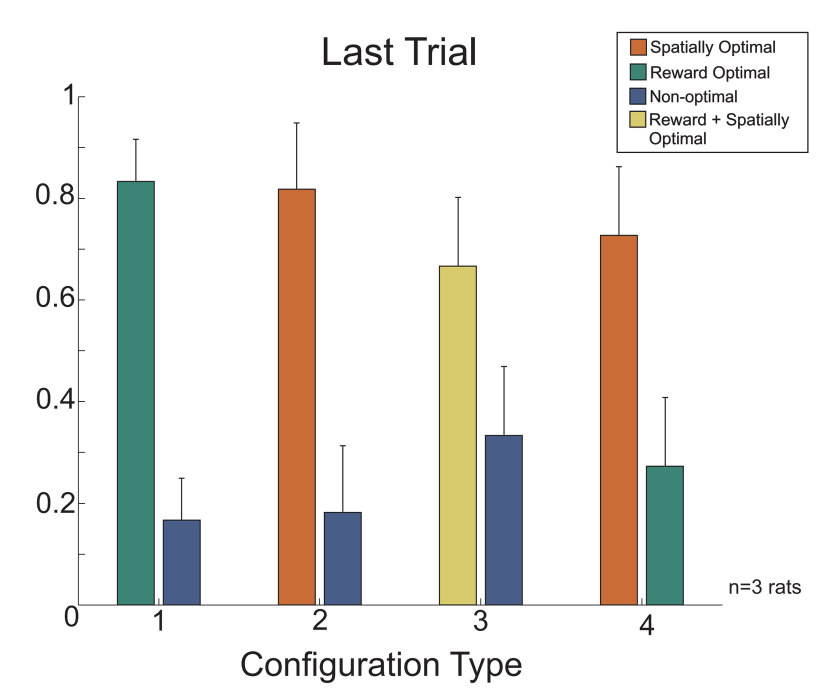




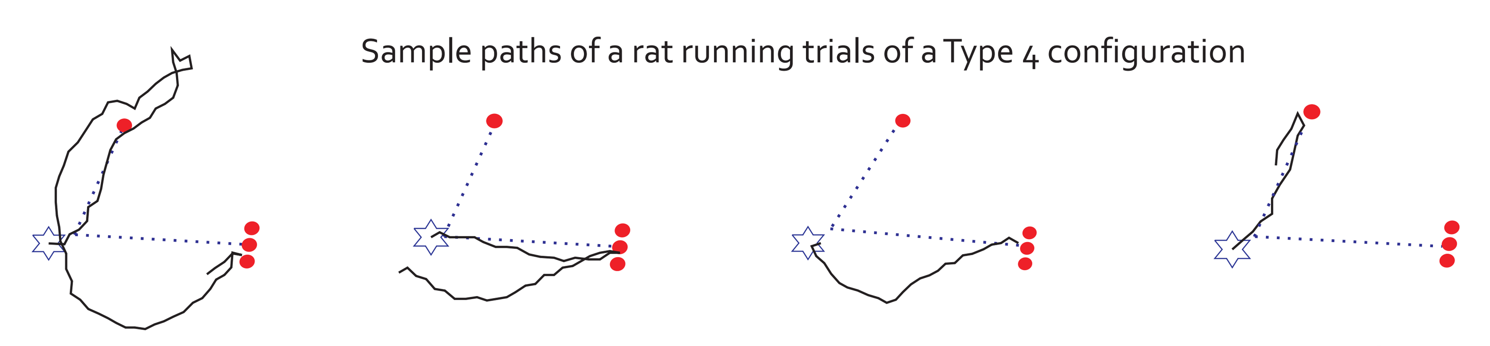
Optimization on the basis of spatial and reward information



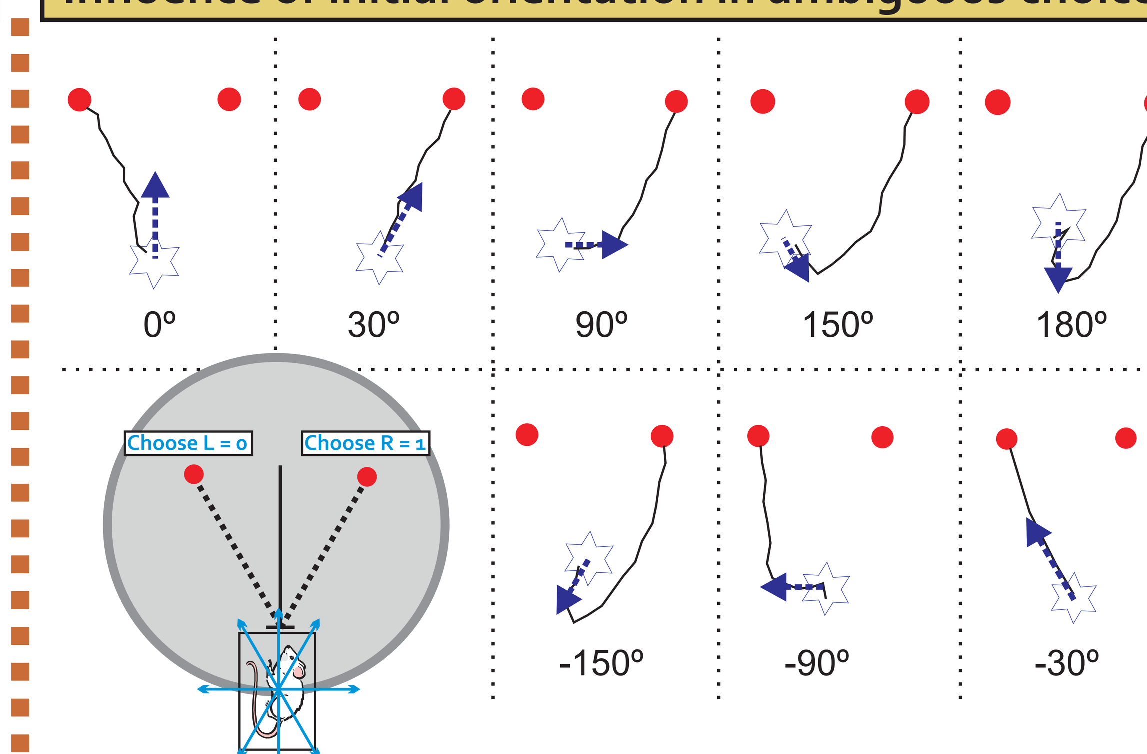




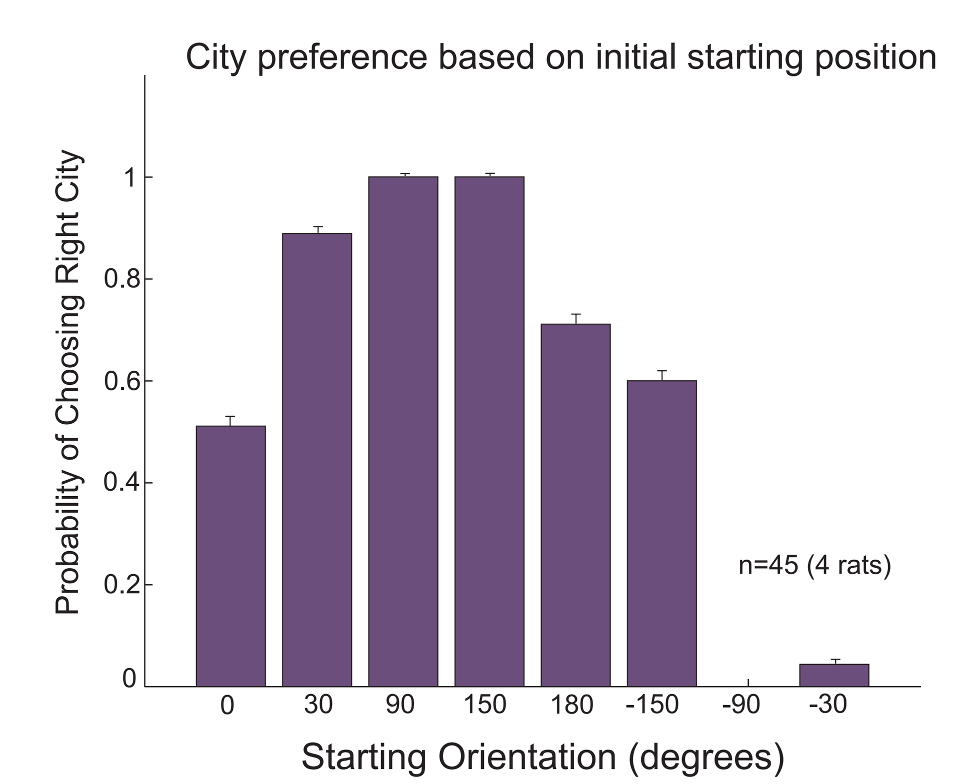
Sample paths of a rat running trials of a Type 4 configuration



Influence of initial orientation in ambiguous choices

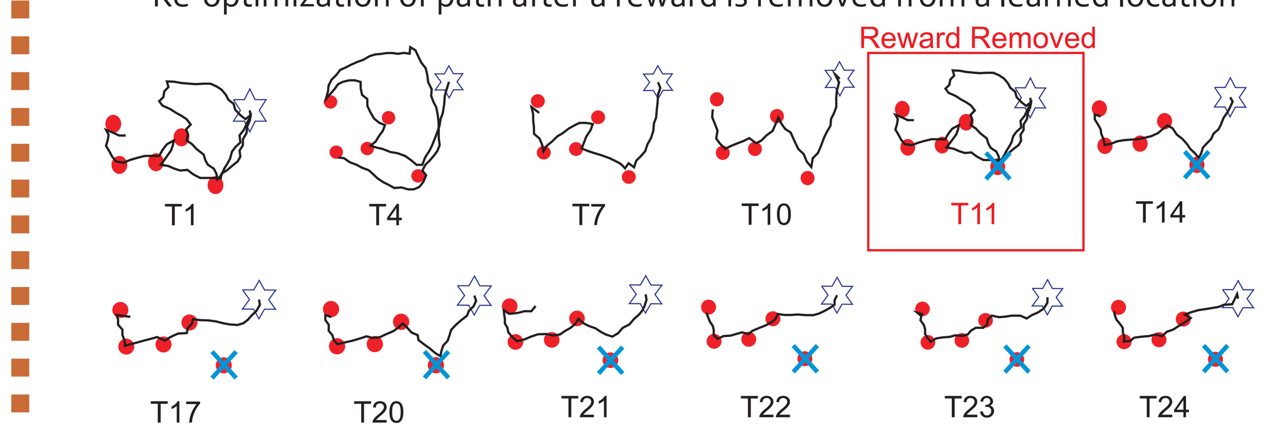


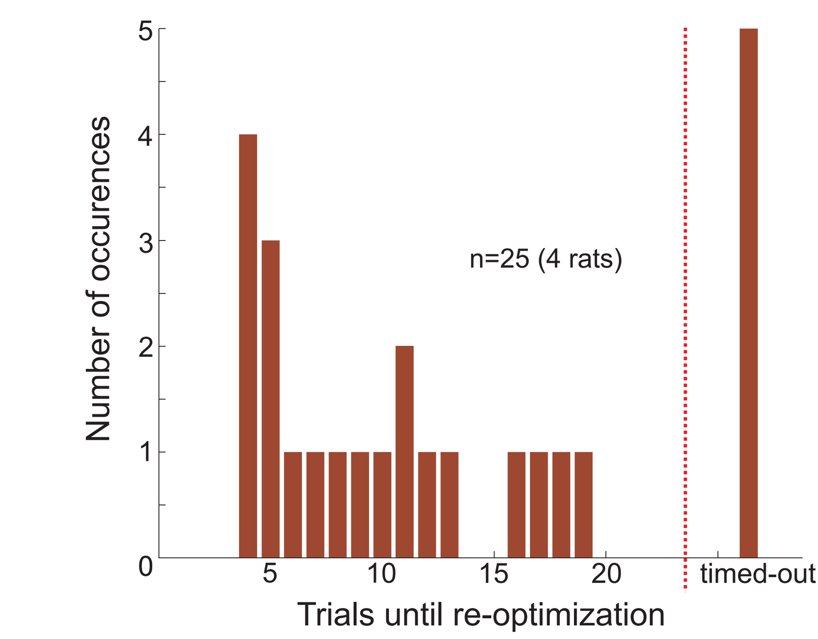
City preference based on initial starting position



Re-Optimization because of reward removal

Re-optimization of path after a reward is removed from a learned location





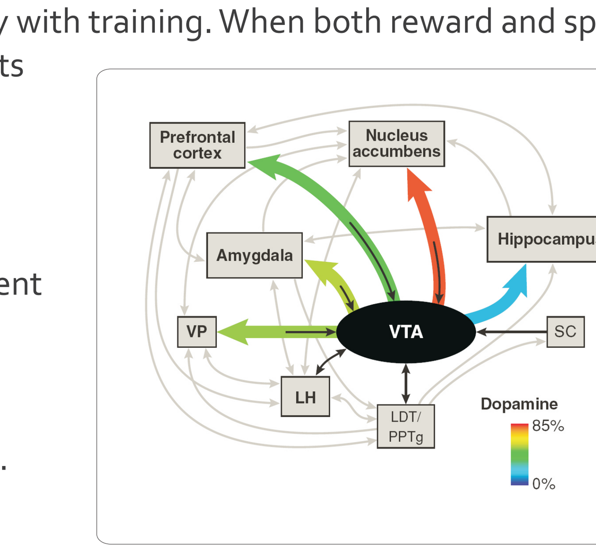
Conclusions

•The ability of rats to optimize their path based on reward contingencies suggests that reinforcement may contribute to the rats' ability to shift their strategy towards the optimal path.

•This shift is likely to depend at least in part on the interaction between brain structures that are involved in reward processing (VTA), spatial navigation (hippocampus) and planning (prefrontal cortex).

•Route optimization occurs within a configuration, not over sessions, which suggests that this task involves planning and short term memory, not long term memory.

•Rats will choose the optimal spatial or reward solution if presented separately – this choice is made more decisively with training. When both reward and spatial options are presented together, rats will shift strategy from reward to spatial optimization with training.



(Fields et al., 2007)

•Unlike in most TSP problems, spatial choice is biased by the current position and orientation of the rat.

•Rats are able re-optimize when reward contingencies are changed.

•Optimization based on reward availability and quantity suggests the involvement of the dopaminegic system of the ventral tegmental area (VTA).

References

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