Navigation and decision making in tactile VR

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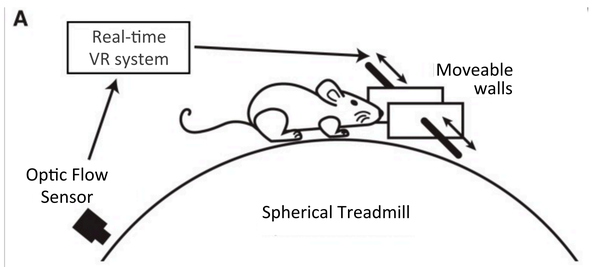
abstract

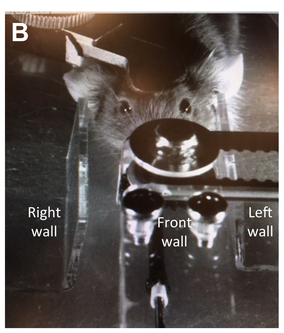
The aim of the study is to investigate goal-directed navigation and its neural correlates in the rodent cortex, using virtual reality tools to simulate foraging environments. Furthermore, these experiments attempt to elucidate real-time behavioral and neural characteristics of *vicarious trial-and-error* behavior (VTE). VTE is defined as search-and-evaluate behavior displayed upon imagination of future trajectories and subsequent decision-making[1]. Prior studies exploring navigation and VTE have traditionally employed freely-moving rodents running through mazes. By contrast, the experiments presented here take advantage of a new head-fixed tactile virtual system, which has been recently equipped to create not only tactile corridors, but also choice points and dead ends. This capability allows us to construct simpler single-choice point Y-mazes, as well as more complex maze schemes.

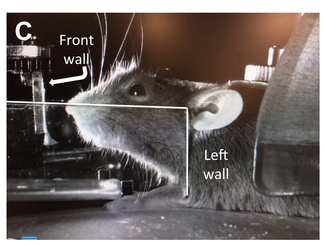
Two sets of head-fixed behavioral experiments were run in a tactile virtual reality setup in which rodents employed whisker-guided navigation to run through a series of repeatable single-choice point mazes to locate reward.

methods

The tactile virtual reality setup readily mimics corridor and dead-end environments. The virtual reality single-choice point maze was constructed using three moveable walls (two on either side and one directly in front of the animal), controlled in real-time by running speed and direction. The walls move around the mouse running on an air-supported spherical treadmill. Subject mice, while head fixed, continue to display natural movements, including whisking, licking and running[2]. All experiments performed on the rig are conducted in the dark in order to isolate tactile cues.







Data analysis was performed using standard SciPy toolkits and Jupyter notebooks.

references

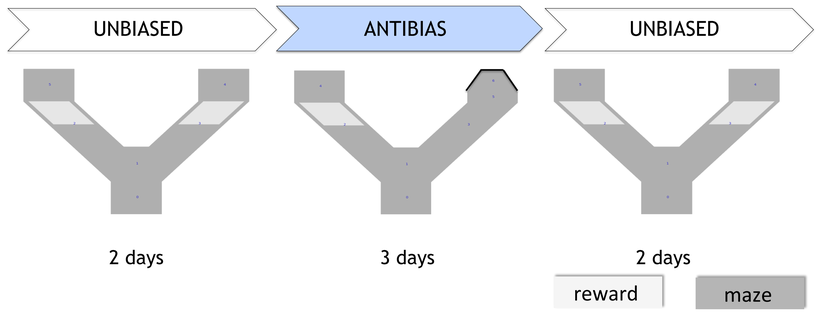
1. Redish, A. D. (2016). Vicarious trial and error. *Nature Reviews Neuroscience*, *17*(3), 147-159.

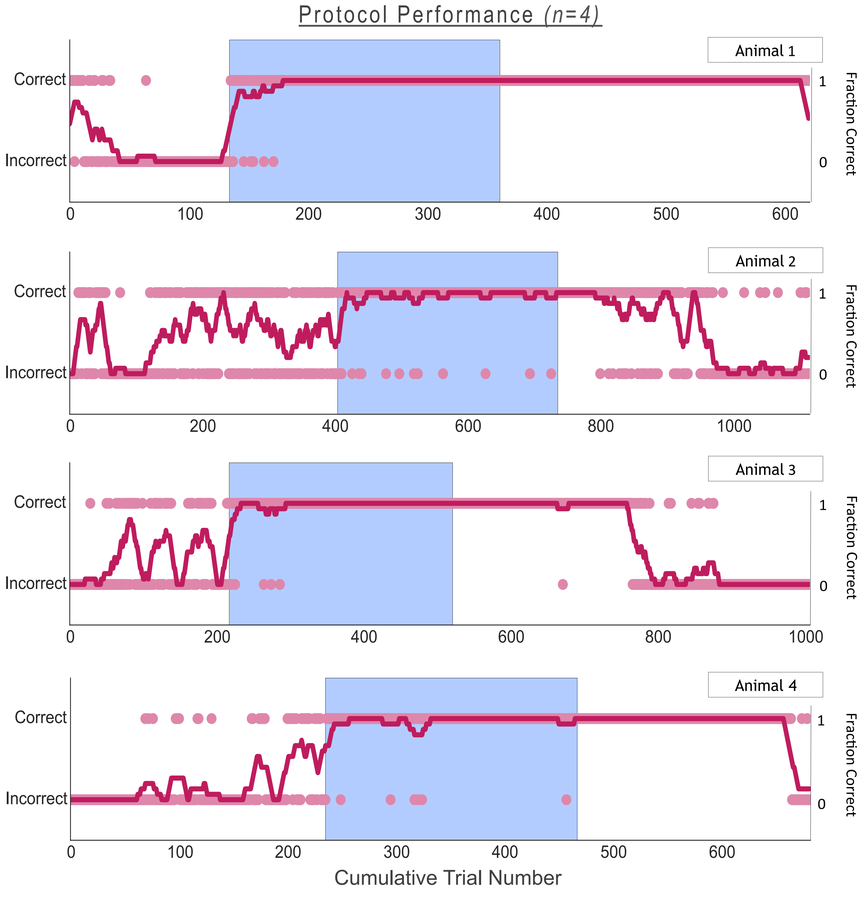
2. Sofroniew, N. J., Lee, A. K., & Svoboda, K. (2014). Natural whisker-guided behavior by head-fixed mice in tactile virtual reality. *Journal of Neuroscience*, *34*(29).

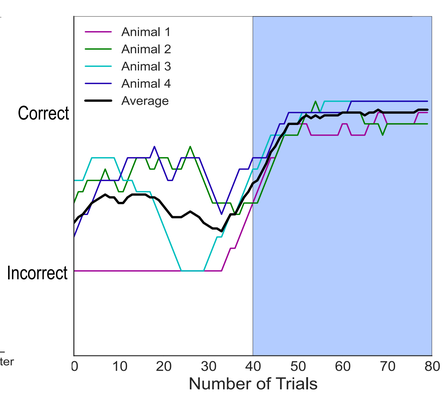
experimental design & results

Anti-Bias Task : *(n=4)*

- Goal: Use tactile VR to reverse animals' innate directional biases
- Determined biases in open Y-maze, blocked bias side ("antibias" maze), returned to open maze to test bias shift
- 20 minute sessions (~100 trials each); 7 day protocol below:

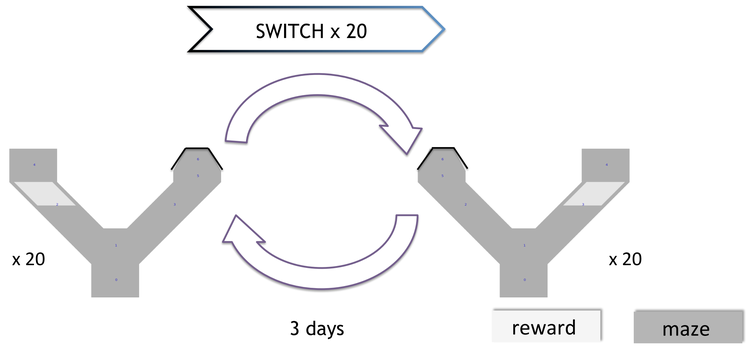


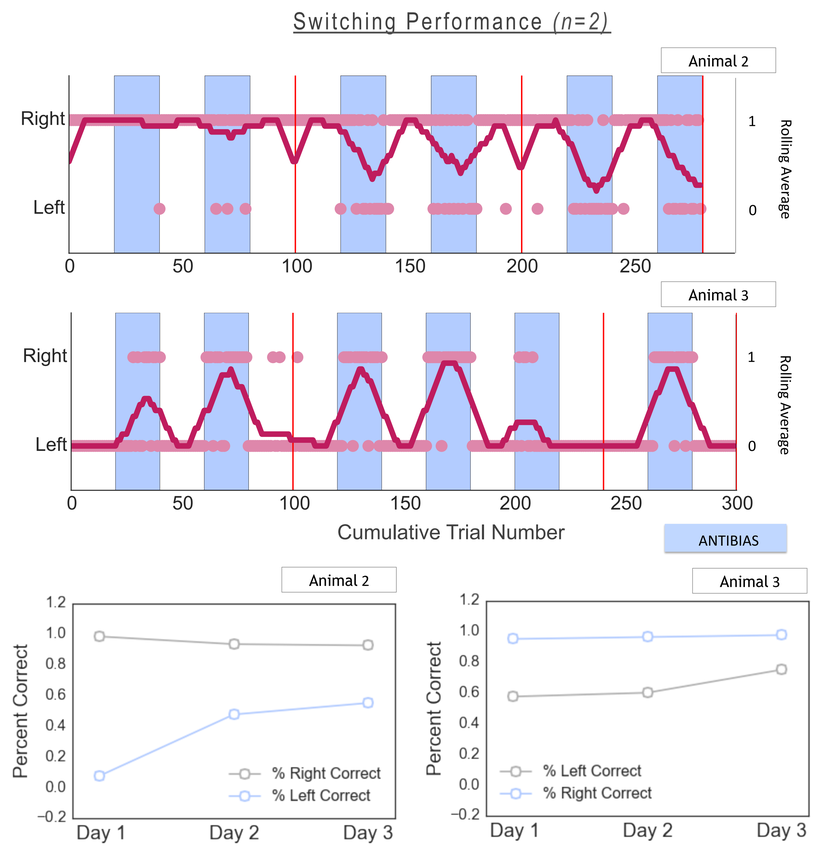




Intra-Session Switching Task: *(n=2)*

- Goal: Investigate VTE by employing maze branch switching within a session
- Employed dead end and reward branch switches every 20 trials
- 30 minute sessions (~4-6 switches); 3 days; animals previously trained on anti-bias task





conclusions

- Mice displayed rich, **goal-oriented navigation** behavior and **ability to reverse** innate directional biases
- **VTE behavior** also displayed in anti-bias training by exploring both branches before the completion of a single trial
- Common failure modes: animals ran through dead ends or were unable to walk backwards out of dead end branches
- Future Directions:
  - Emulate this behavior in non-dead-end environments
  - Modify walls to increase dead-end salience