Odor-Guided Navigation Strategies in Mice

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Abstract

Our sensory systems allow us to navigate dynamic environments. For example, the olfactory system plays a key role in foraging behavior, such as the localization of an odor source. We will study sensory navigation in the sensitive olfactory system of the mouse. The primary navigation strategies observed in mice include bilateral nostril comparisons at a single sniff (stereo olfaction), and bilateral comparisons across multiple sniffs (serial sampling). While these sampling strategies have been observed, the overall sampling behaviors used by mice to locate an odor source is largely unknown. Our lab has developed a behavioral assay for studying freely moving odor-guided navigation in mice. In this system, mice receive a reward for correctly navigating towards an odor released from one of two odor ports. The aim of this study is to define the navigation strategies used by mice to locate an odor, and determine if this sampling strategy generalizes across multiple odorant identities. We hypothesize that a mouse's sniff rate and body movements will slow when introduced to a novel odorant, and that there will be increased serial sampling. Identifying and analyzing these sampling behaviors will create the foundation needed to discover the physiological mechanisms underlying these behaviors. In future studies, we will record from the olfactory bulb to access the neural representation during odor-guided navigation.

Methods

Behavioral Assay-

A. A fluorescent strip of red paint was painted from the mouse's nose to head for nose and head tracking. A thermistor is implanted to measure sniff rate (seen in Figure 1).

Figure 1

B. An overhead camera records the mouse's behavior while the open-source program Bonsai isolates head and nose position. The thermistor wire is attached to an overhead commutator and the mouse's head-fixed pins.

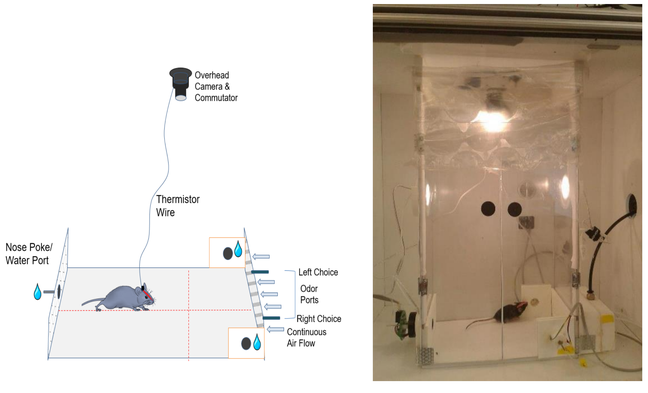
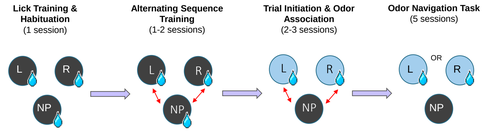


Figure 2

Training Sequence-



Odor Visualization

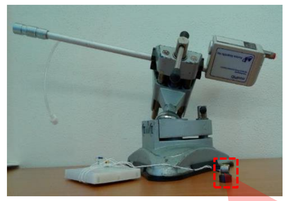
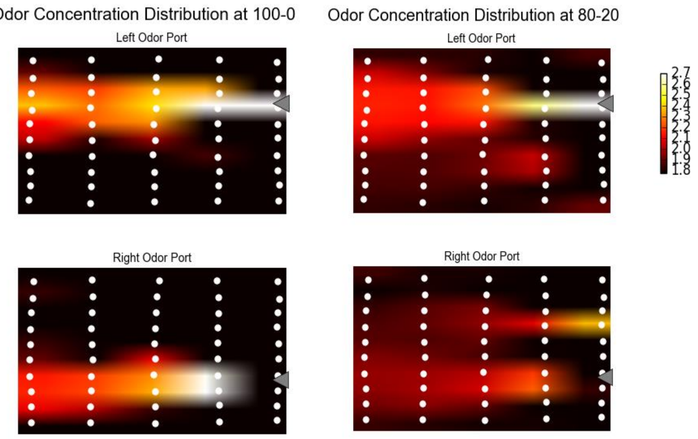
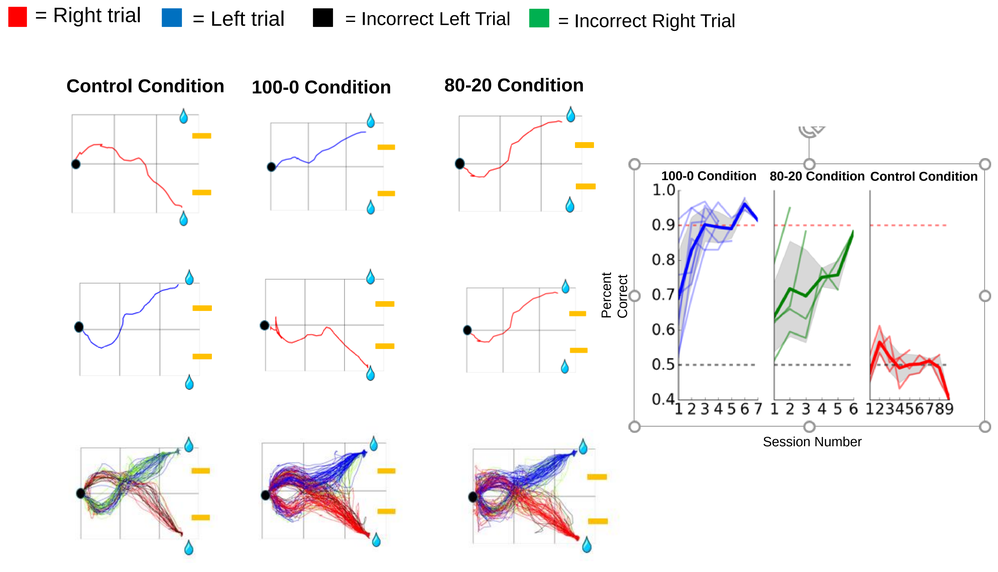


Figure 3: PID (Photoionization detector) and Breathalyzer (in red rectangle) pictured

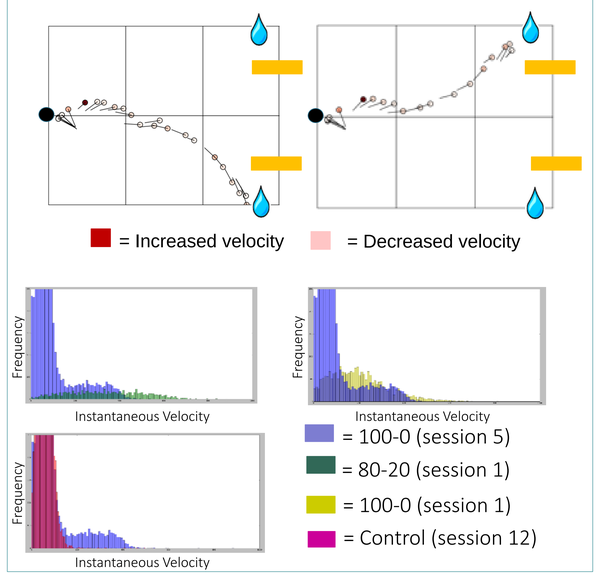


A. A breathalyzer (seen in red rectangle) was utilized to visualize the plumes of odor in the behavioral assay during a single trial. The PID was used to calibrate the percentage of odor being released from each odor port.

Nose Trajectories and Task Performance



Sampling Behaviors



Conclusions & Future Directions

Conclusions-

- Mice rely on active sensation to navigate to correct odor port.
- Head casting is a stereotyped active sampling behavior.
- Mice learn 100-0 task after approximately 5 sessions.

Future Directions-

- Recording from the olfactory bulb via calcium imaging
- Test Ehud Ahissar & Eldad Assa's (2016) theory of active sensation as closed-loop versus open-loop perception

Acknowledgements

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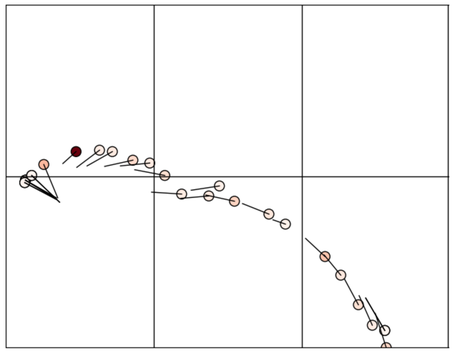
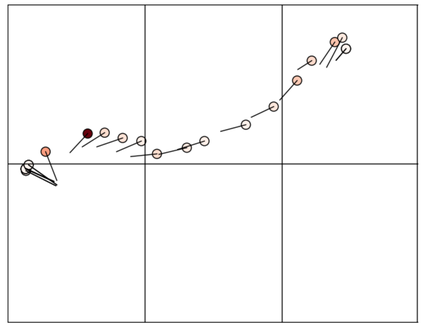
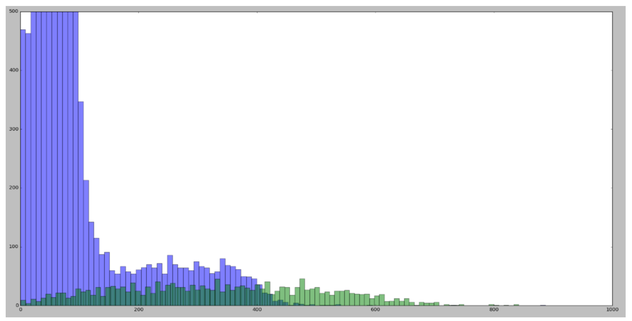
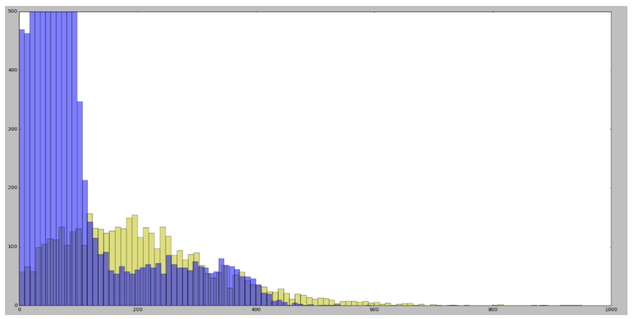
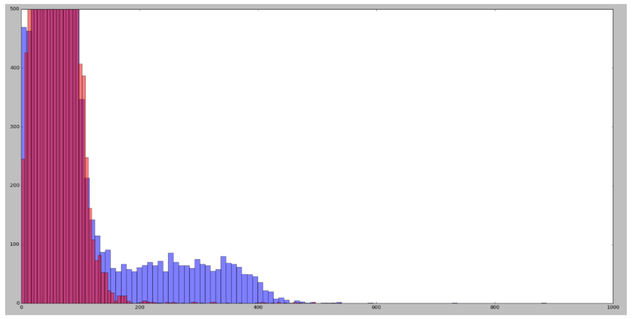
National Institutes of Health









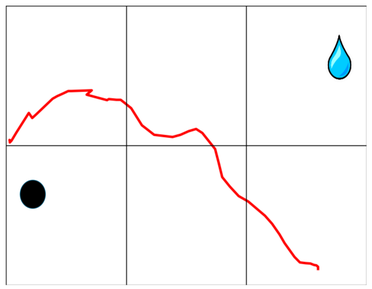


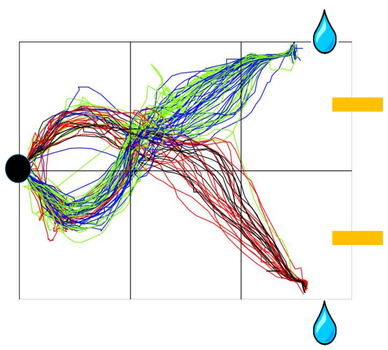
= 100-0 (session 5)

= 80-20 (session 1)

100-0 (session 1)

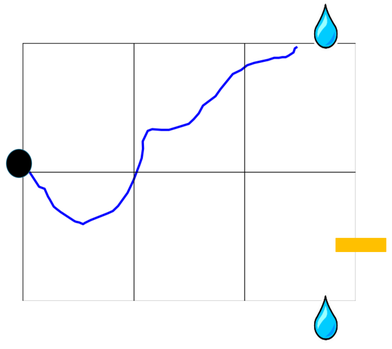
= Control (session 12)

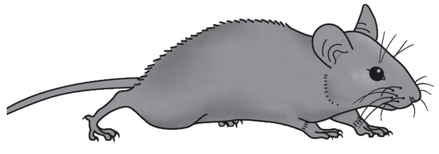




= Right trial = Left trial

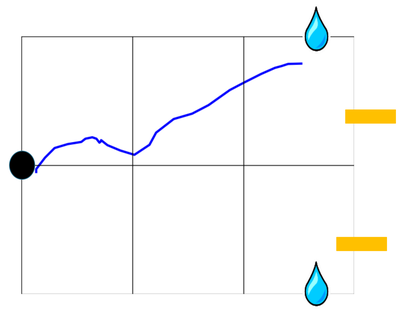
Nose Poke/
Water Port

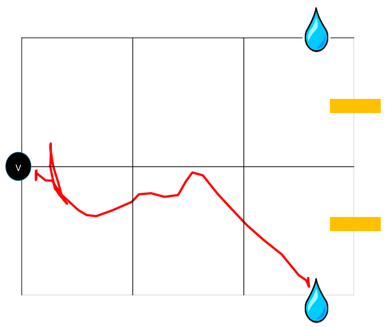


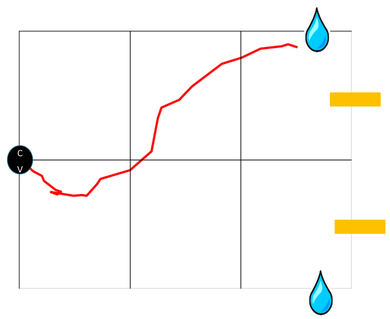


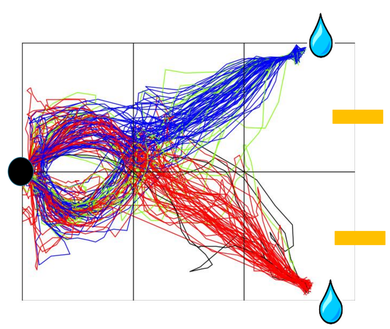
Odor
Ports

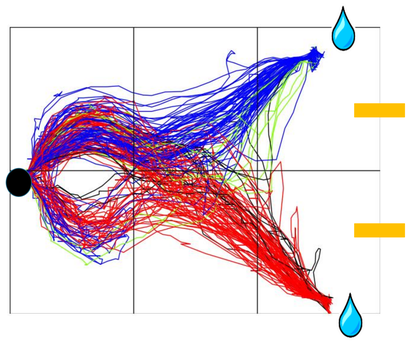
Continuous
Air Flow

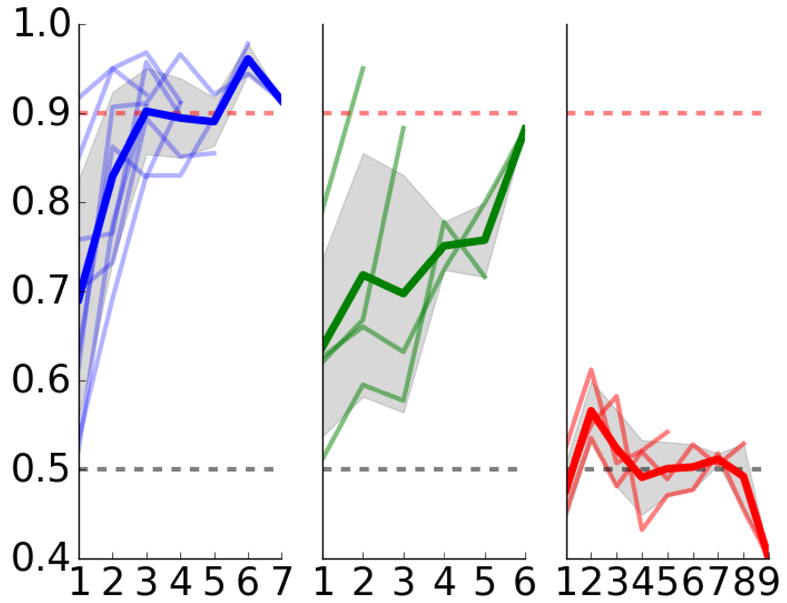











1.0
0.9
0.8
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0.5
0.4
1 2 3 4 5 6 7
1 2 3 4 5 6
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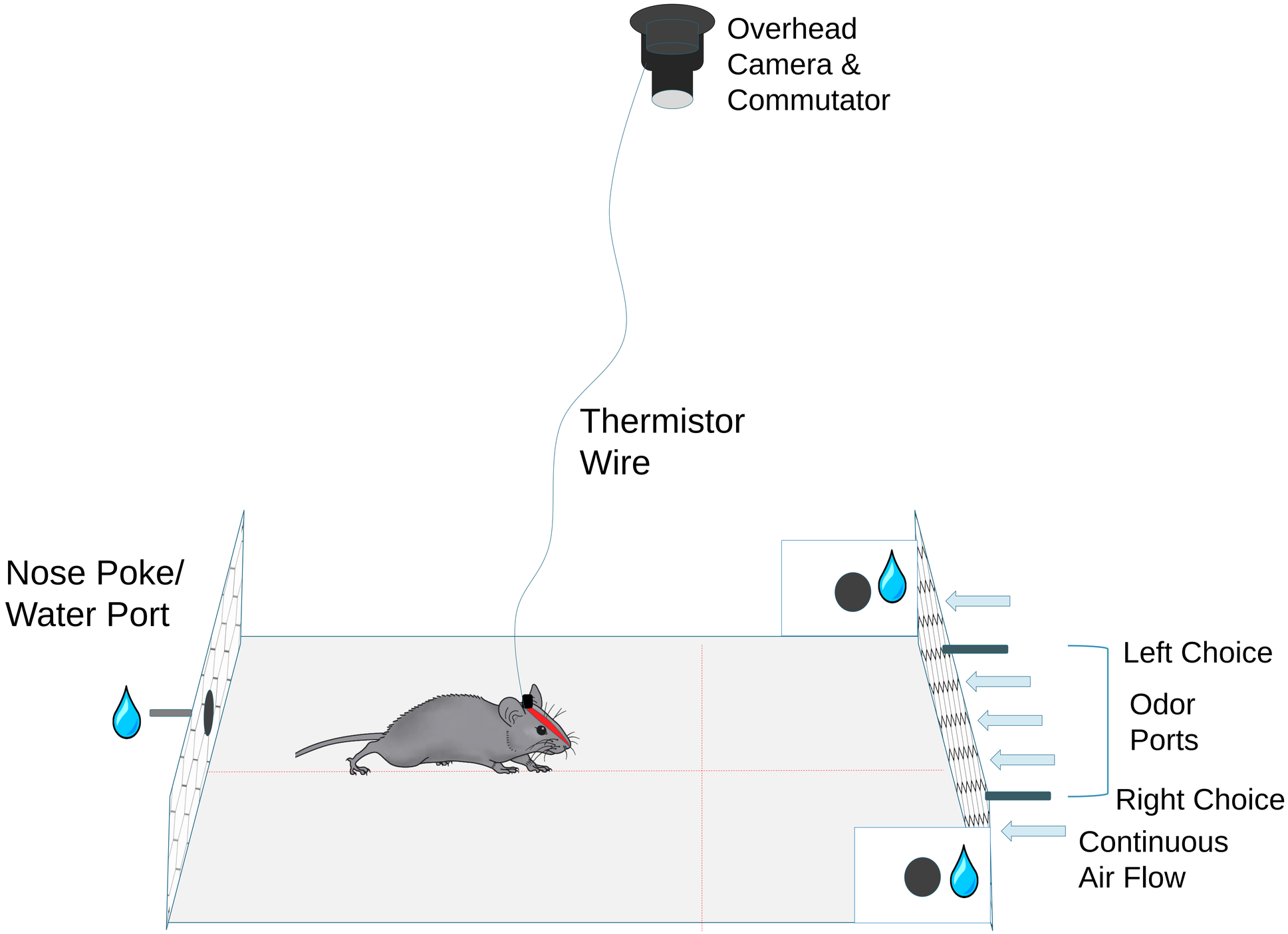
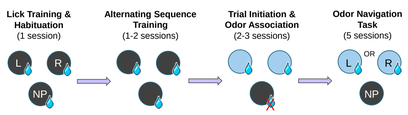

Overhead
Camera &
Commutator
Thermistor
Wire
Nose Poke/
Water Port
Left Choice
Odor
Ports
Right Choice
Continuous
Air Flow


Lick Training & Habituation
(1 session)
L
R
NP
Alternating Sequence Training
(1-2 sessions)
Trial Initiation & Odor Association
(2-3 sessions)
Odor Navigation Task
(5 sessions)
L
OR
R
NP