Odor concentration change sensing in mice

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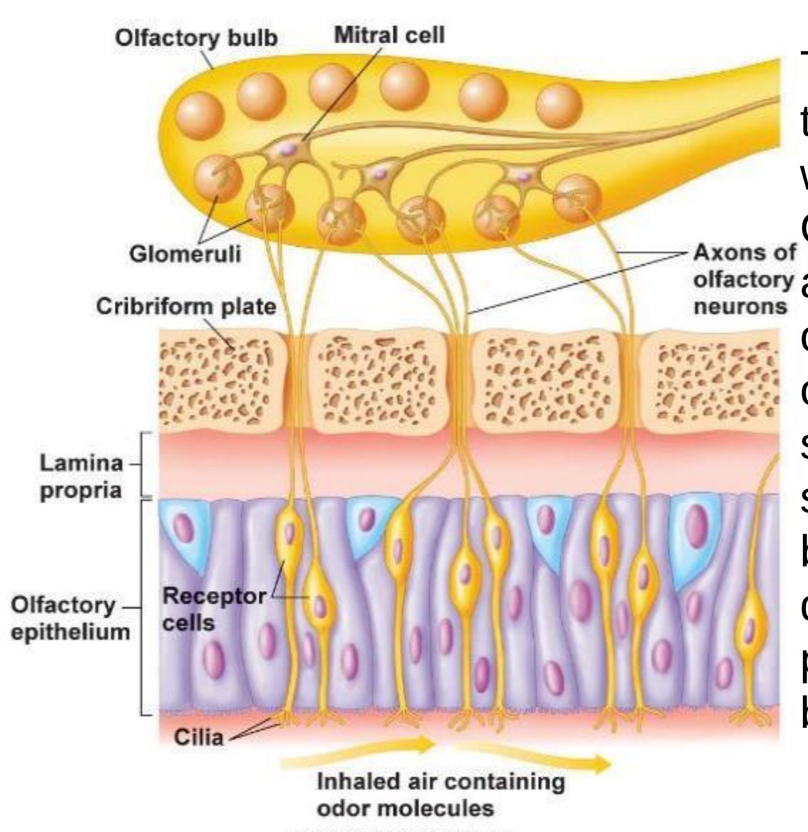
Abstract

Mice rely on their sense of smell for spatial navigation in their environment. Navigation with regards to smell relies on using odor concentrations to home in on an odor source of interest. Olfactory neuron populations exist that are sensitive to changes in odor concentration. However, the olfactory sensory processing that mediate this behavior in mice is not fully understood yet**.** The overall goal is to understand how the brain tracks changes in stimuli. We focus on how the olfactory system processes change in odor concentration.

Our paradigm involves the use of trained head-fixed mice. The use of head-fixed mice allows for precise control over the odor stimuli. Our equipment allows me to present a concentration of odor directly when a mouse inhales. This allows me to manipulate the concentration of odor to which the mice will be exposed between various sniff cycles. Using a behavioral paradigm, I will test how sensitive mice are to detecting a change in odor concentration. This behavioral task will demonstrate how mice track stimulus changes over time and will lay the groundwork for determining how perception relates to neural activity.

Olfactory System



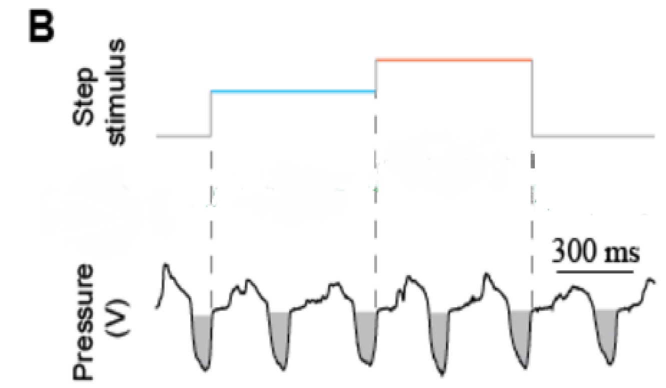
The olfactory system involves the transformation of odorant molecules into what we perceive as our sense of smell. Odorants bind to odorant receptor proteins, activating a signal carried via the axons of olfactory sensory neurons (OSNs) to the olfactory bulb. In the olfactory bulb, OSNs synapse onto Mitral/Tufted cells in structures called glomeruli. The olfactory bulb is where most olfactory processing is done before that information can be projected and read by higher levels of the brain, such as the olfactory cortex.

Purpose

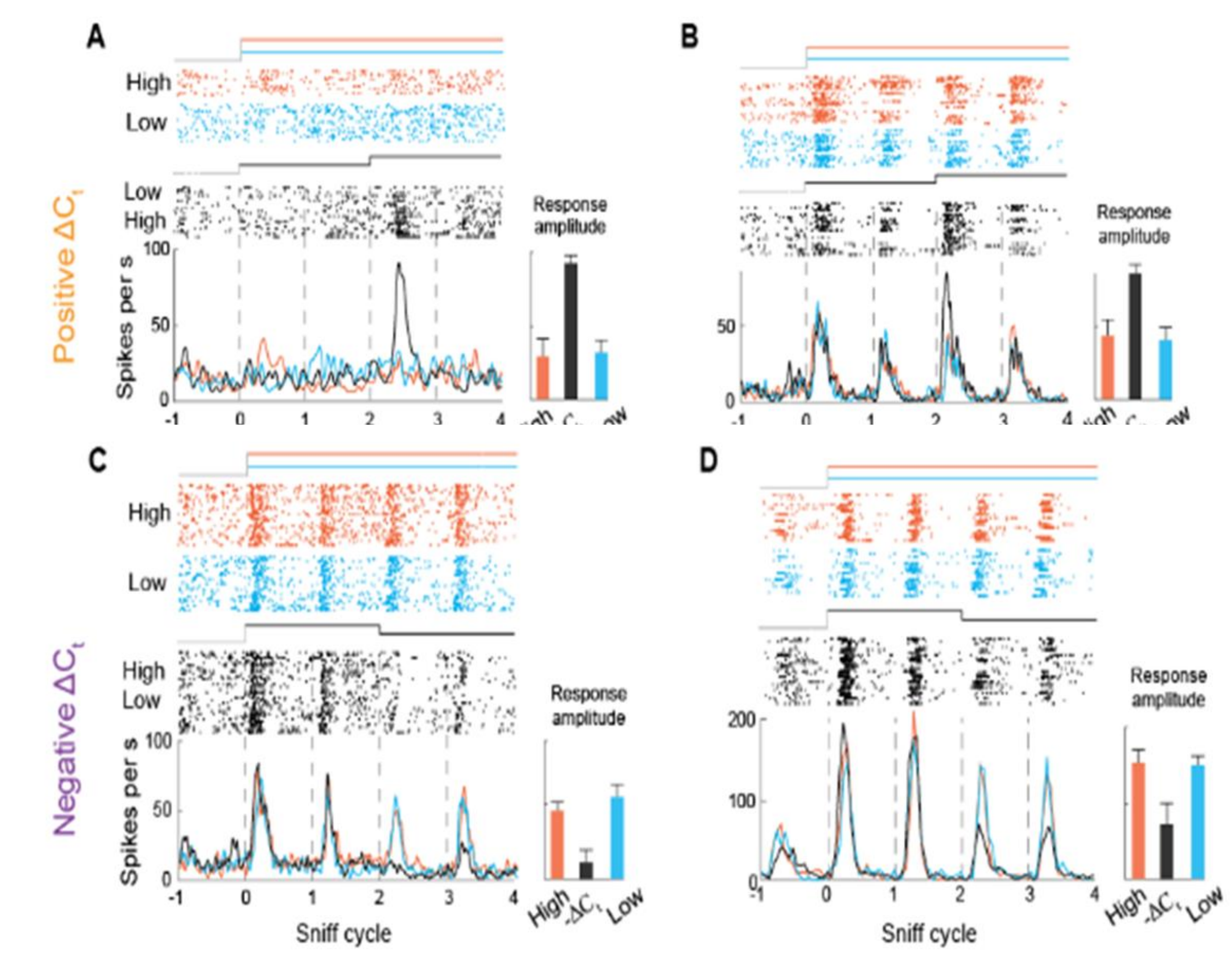
Our brains are constantly tracking dynamic sensory information from our environment. Exactly how the brain computes sensory input over time is not fully understood.

- The mice olfactory system provides a great model to study stimuli changes over time because mice utilize odor concentration changes for olfactory navigation. It is not understood how mice compute sensory information for spatial navigation.
- One of the mechanisms guiding odor localization involves changes in odor concentration (ΔC). The ability to track odor concentration gradients is critical for vertebrates like the mouse for survival. The brain somehow maintains a neural representation of odor across sniffs, but how?
- A behavioral representation of ΔC has not been studied. By investigating ΔC tracking behaviors in mice, we hope to increase our understanding of sensory optimization.

Background Work



This figure shows a representative sniff signal from a mouse, and the odor step paradigm. The black line shows the sniff wave form. Grey areas indicate inhalation. Vertical dashed lines indicate onset of concentration changes. The blue to red transition is an example of the odor step paradigm from low to high concentration.



Previous work in the Smear lab has revealed a population of neurons in the olfactory bulb that respond to dynamic stimulus changes. By recording mitral/tufted cell activity, three different response types were observed. One of the response types was concentration sensitive.

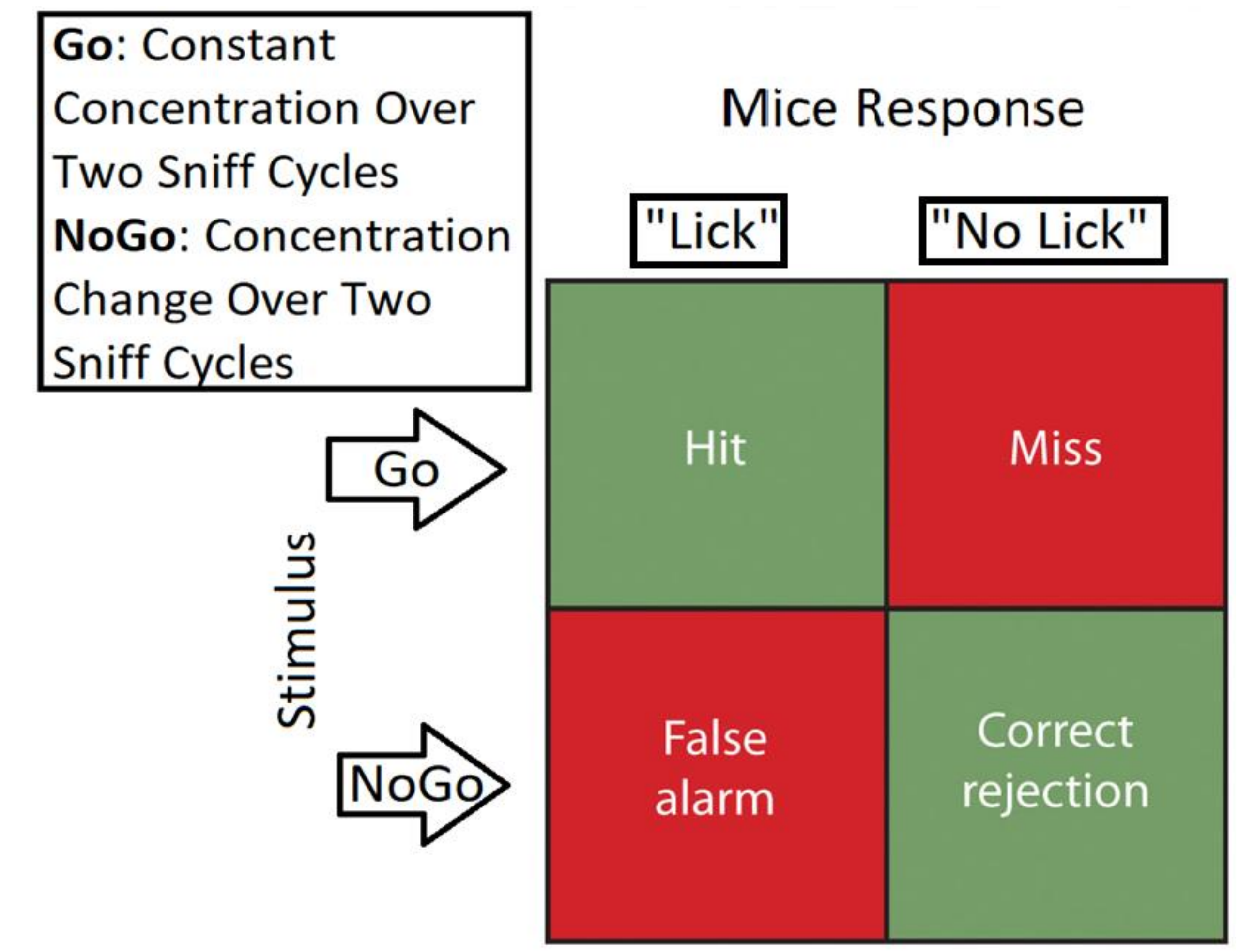
My project focuses on the concentration sensitive population of ΔC neurons. Concentration sensitive activity was dependent on the concentration of odor based on the previous and current sniff. The goal is to relate the neural activity we see in this neuronal population with a behavioral representation in mice. That is, I want to test and observe how sensitive mice are to distinguishing concentration changes.

My Project

My project involves the use of trained head-fixed mice set up in an odor delivering apparatus. Odor detection depends on inhalations and an inhalation and exhalation in a mouse is referred to as a sniff cycle. An immobile head allows for precise control of the odor stimuli during the inhalations of a mouse. The duration of a sniff cycle is extremely rapid, however our equipment is fast enough to track the sniff cycles of a mouse.

This experimental setup has not been replicated elsewhere and allows me to manipulate the concentration of odor that the mice will be exposed to between inhalations. Using a behavioral paradigm, I will test how sensitive mice are to odor concentration changes between sniff cycles. This behavioral task will demonstrate how mice track stimulus changes over time and will lay the groundwork for determining how perception relates to neural activity.

Experiment/Procedure

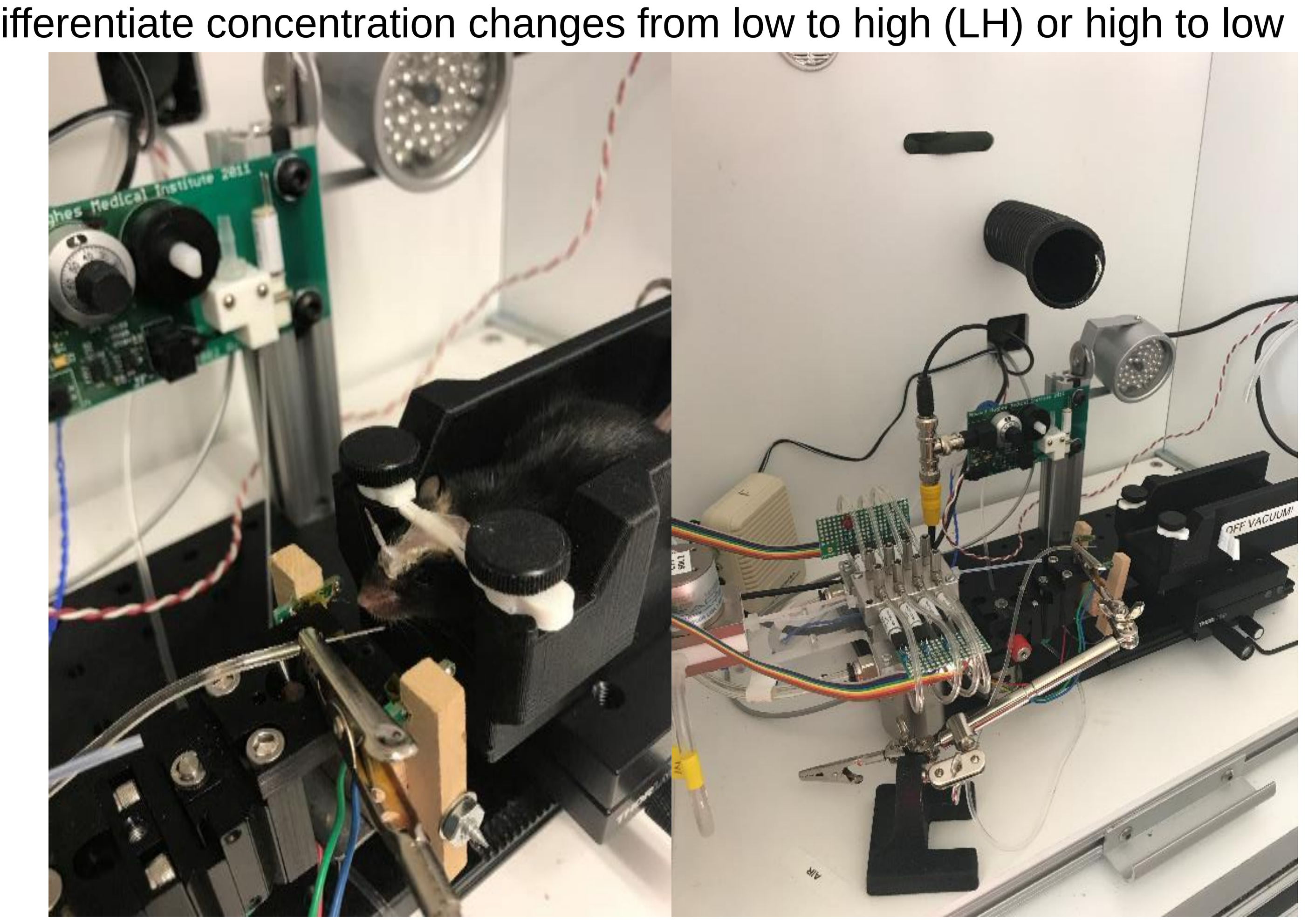


My experiment uses a "Go/NoGo" paradigm. A "Go" trial is defined as a constant concentration over two sniff cycles. A "NG" is a change in concentration over two sniff cycles. My mice are water restricted to incentivize them during the experiment.

On "Go" trials, the mouse can receive water as a reward by licking a metal tube. If they respond incorrectly, then it is a "Miss" and they receive nothing and are given a time-out punishment by delaying the next trial. On "NoGo" trials, if the mouse licks, then it is a false alarm, again followed by a timeout. If the mouse doesn't lick, then it is a correct rejection.

Data is quantified based as proportion correct (***p(c)***), which is the proportion of correct responses divided by the total number of trials. Correct responses are classified as "hits" and "correct rejections."

This paradigm involves two types of tasks. In both odor step paradigm tasks, the mice have to differentiate concentration changes from low to high (LH) or high to low (HL).



Future Directions

The goal of my project was to create a behavioral representation of the previously observed neural activity. In the future it would be ideal to use the trained mice from my experiment and use electrophysiology to observe the neural activity during their behaviors. Also, the odor step paradigm with HL and LH tasks will continued to be used. However, the degree of odor concentration change will shift to continue to test the mice's detection sensitivity.

Acknowledgments

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