Auditory Cortex Mediates Hearing-Guided Prey Capture in Mice

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Abstract

Hoy et al. found that vision was necessary for accurate prey pursuit and capture in mice through observing their behavior under various sensory conditions (2016). Although vision was crucial for successful captures, it was found that mice were able to catch their prey in the dark, demonstrating that hearing can aid in prey capture when vision is obstructed (Hoy et al., 2016).

In this specific research project we are interested in the role that the auditory cortex plays in prey capture. The experimental design isolates the auditory cortex by using a sound proof and dark chamber in which the mice are placed in an arena and presented with crickets. We observed that mice are able to successfully capture prey using auditory cues. In order to further investigate this in a more controlled setting, we set up speakers around the arena, which played pre-recorded cricket sounds. The mice responded to sounds played from these speakers, but the response was not robust. Additionally, using optogenetics to suppress the auditory cortex significantly increased overall capture time. This implies that auditory cortex mediates hearing-guided prey capture in mice, but it does not appear to be necessary for successful prey capture.

Introduction

Witnessing Natural Behavior through Prey Capture

- Other studies look at behavior by teaching mice to push levers and perform other tasks, but those are not natural to the mouse.
- Studying prey capture gives us the opportunity to work with the system and figure out how the brain mediates natural, authentic behaviors.

Mice are Capable of Prey Capture using Auditory Cues (Figure 1)

- Hoy et al. found that mice robustly perform prey capture (2016).
- Comparing capture times in Light, Dark, Ear-Plug Light and Ear-Plug Dark conditions found that hearing can aid in prey capture in the absence of vision (Hoy et al., 2016).

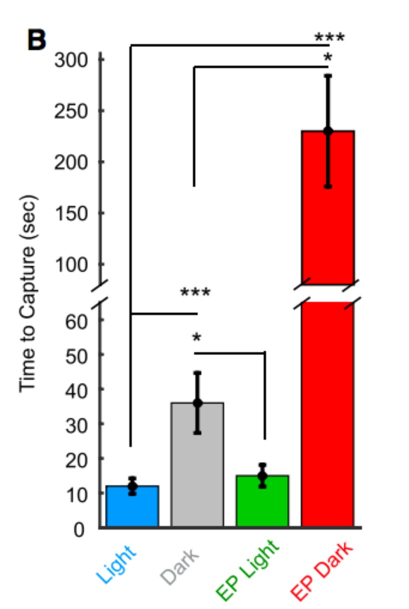

Figure 1. Hoy et al. found a significant increase in time to capture when the mouse had no vision and no hearing, indicating that hearing can aid in prey capture. (2016)

Methods

Experimental Design

- Trials were run in an arena placed inside of a dark, sound-proof booth (Figure 2).
- Mice were allowed to freely roam the arena and given crickets to capture.
- Prey capture behavior was recorded with a night-vision camera.
- Mouse position was tracked using Optimouse in MATLAB, and, more recently, Bonsai.

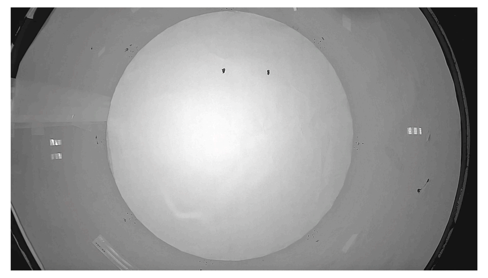

Figure 2. Overhead view of the arena from the night-vision camera.

Optogenetics Shuts Down the Auditory Cortex

- We used transgenic, PV channelrhodopsin (PV-ChR2) mice implanted with bilateral fibers.
- Light sent through the bilateral fibers causes channelrhodopsin to send a positive current to PV inhibitory neurons, causing them to spike.
- These neurons suppress the auditory cortex of the mouse (Figure 3).

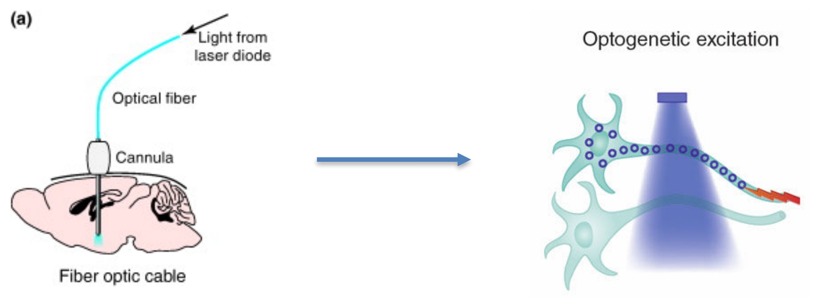

Figure 3. Diagram of optogenetic excitation. Lasers attached to implanted fibers excite PV inhibitory neurons, which in turn shut down the auditory cortex.

Results

Lasers are shown to inhibit prey capture abilities in mice

- The lasers caused the average capture time to increase from 44.9 to 89.7 seconds.
- Using a rank-sum test, the p-value was less than 0.05, indicating that this is a significant change.

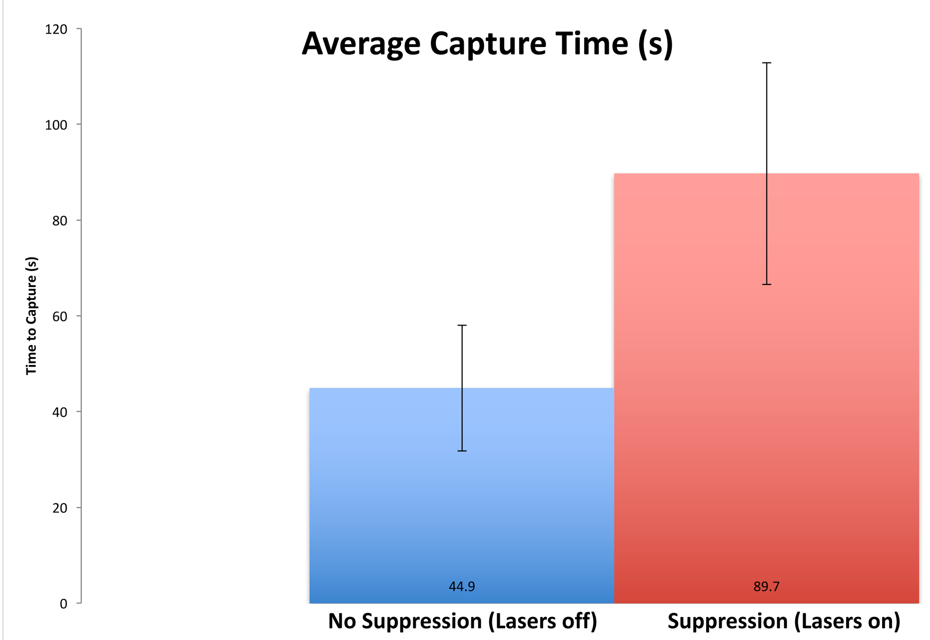

Figure 4. Comparing average capture times of mice without the lasers (hearing) and with the lasers (no hearing).

Response of mice to sounds is not robust

- Speakers around the arena played pre-recorded cricket sounds in order to further isolate the auditory cortex
- The mice soon learned that there was no cricket, and responsiveness to the speakers dropped from 58.3% to 31.25%.

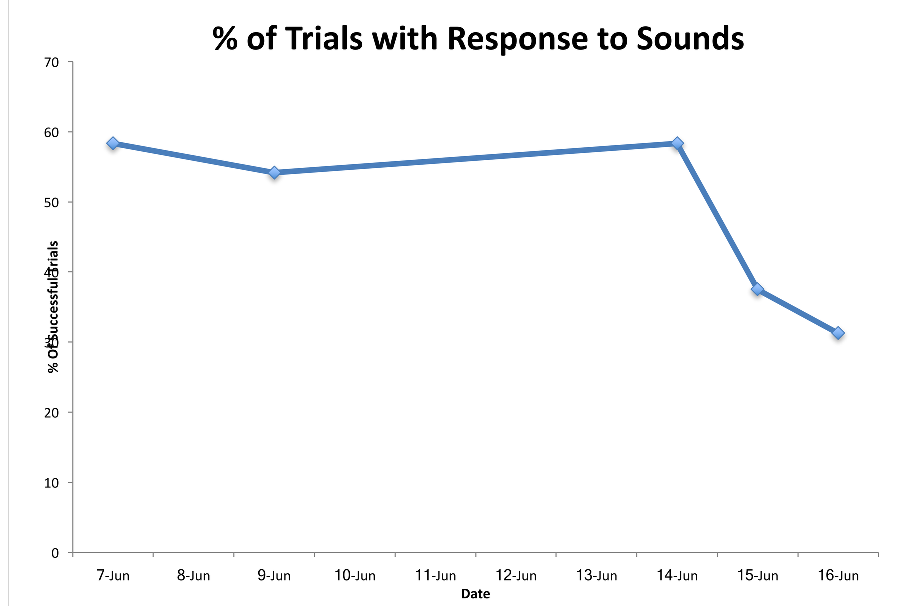

Figure 5. Responsiveness to cricket sounds played through the speakers dropped from 58.3% to 31.25% as a result of habituation

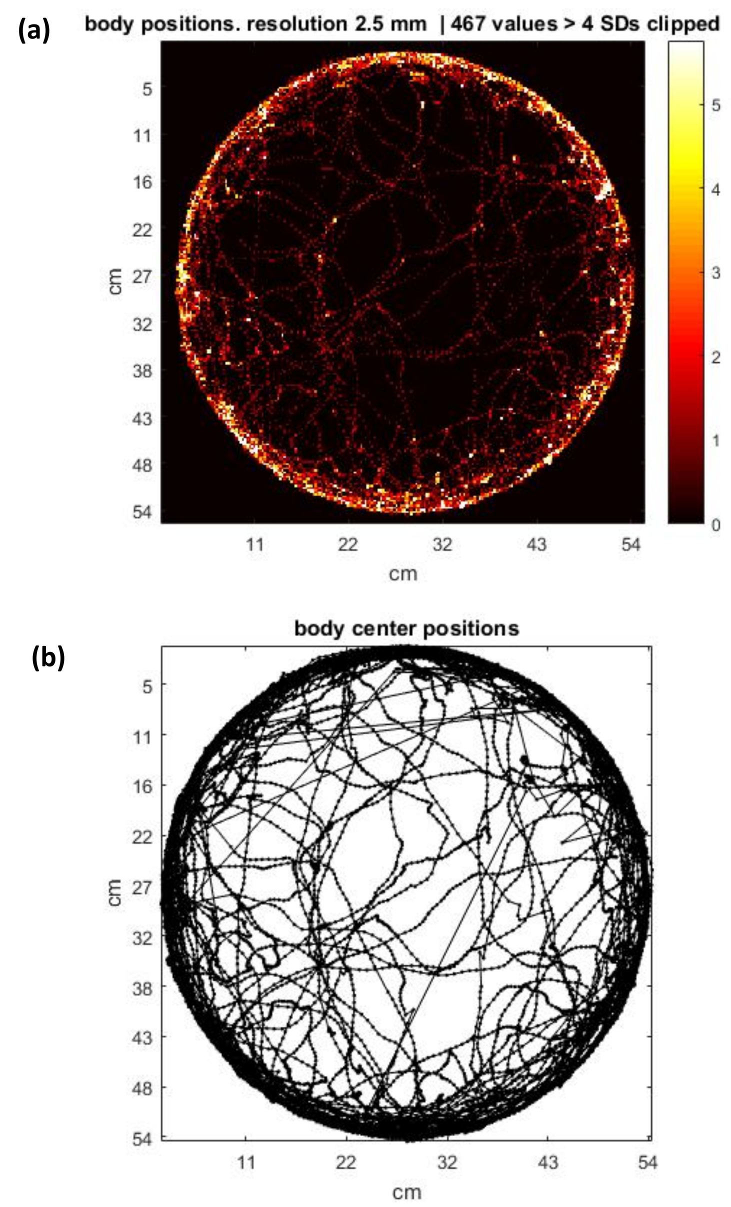

Figure 6. a) Heat map of mouse body positions during a single trial, generated in Optimouse, b) Body center positions of mouse during a single trial, generated in Optimouse.

Both mice and crickets are known to prefer the perimeter in an open-field environment

- The mice appeared to use the arena perimeter to their advantage when hunting (Figure 6).
- Both mice and crickets are known to prefer the perimeter of an open-field environment, which increases the odds of the mouse running into the cricket even when it cannot hear it.
- Once they have located the cricket, we hypothesize that they are able to follow and capture it using their sense of touch or sense of smell.

Capture time trends indicate that mice may be adapting the ways they catch crickets

- While suppressing auditory cortex appeared to slow down their capture times initially, the mice improved over time.
- Capture times with the lasers on, or without their hearing, increased in the beginning, but decreased as time went on (Figure 7).
- The mice most likely are adopting new strategies to catch the crickets.

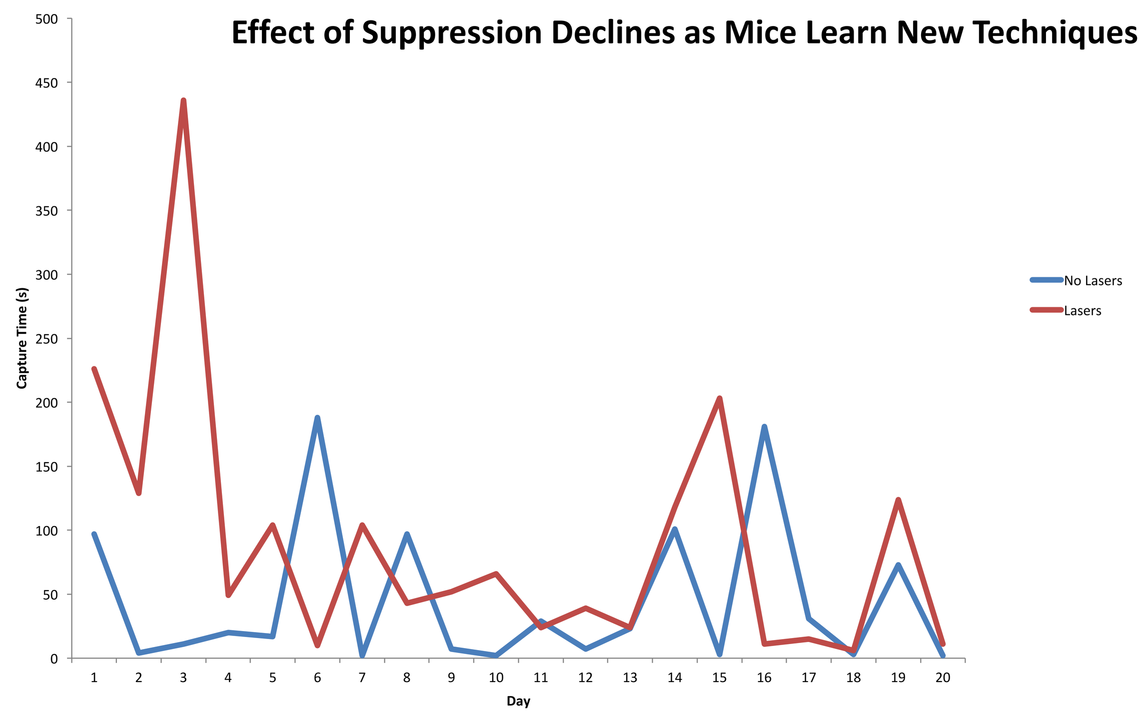

Figure 7. Effectiveness of the lasers appears to decrease overtime. The lasers increased capture times initially, but capture times decreased as the mice learned new strategies

Future Studies

- Repeat trials with new cohorts of mice
- Limit speaker use to prevent early habituation and be able to better assess the response of mice to sounds in the context of prey capture
- Utilize Bonzai, a tracking software written in Python, to gather more quantitative analyses of motion tracking data, such as head angle and the position of the mouse relative to the cricket

Figure 8. With Bonsai, we will be able to track both the mouse and the cricket in real-time, as well as obtain valuable information about the orientation of the mouse.

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