The Janelia Smart Cage: A system for automated training of head-restrained mice in their home cage

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Motivation

Head-fixed behavioral experiments in non-human primates, and more recently rodents, have been the 'gold standard' in the exploration of the dynamics of the mammalian brain. The combination of precise stimulus control, monitoring of motor output and neurophysiology over large numbers of trials is the foundation on which many conceptually rich and quantitative studies of the neural basis of sensation, cognition and movement have been built. However, head-fixation and behavioral shaping requires the presence of an expert trainer. This process is time-consuming and difficult to document. Differences in training procedues across trainers and labs can lead animals to develop different strategies to solve the same task.

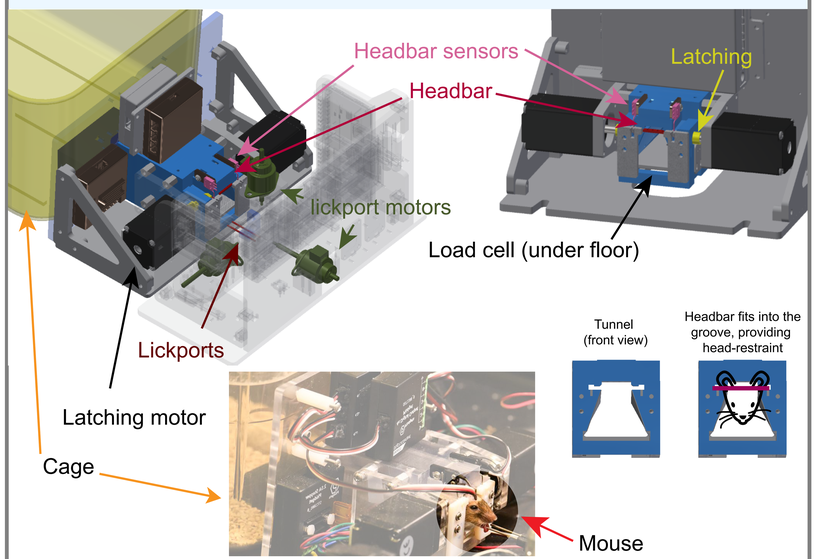
Experiments

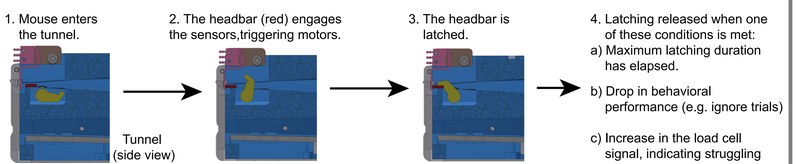
- We developed the Janelia Smart Cage for voluntary head-fixation and automated behavioral training.
- Mice were trained in an auditory delayed-response task with directional licking (Guo, Li et al Neuron 2014; Inagaki et al JNS 2018).
- We successfully trained mice using two training conditions:
  Head-restrained: In this more gentle paradigm the headbar of the mouse was progressively more restrained as the mouse approaches the reward port.
  Head-fixed: The headbar in addition is latched by a pair of motors.
- We tested mice after permanent lesions in anterior lateral motor cortex.

Result

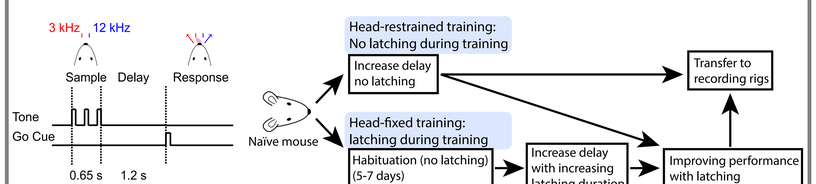
- The Janelia Smart Cage is based on commodity hardware and 3D printed parts. The device can be easily replicated and modified. Total cost per cage is approximately $1,000 (excluding BPod and computers).
- Head-restrained or head-fixed mice learn the auditory delayed-response task, similar to manual training by experts trainers.
- Head-fixation improved rate of learning and performance.
- Lesioning anterior lateral motor cortex (ALM) in well-trained mice dropped behavior to near chance level. Behavioral performance did not recover for mice with bilateral lesions, but did recover for unilateral lesions.

1. Janelia Smart Cage



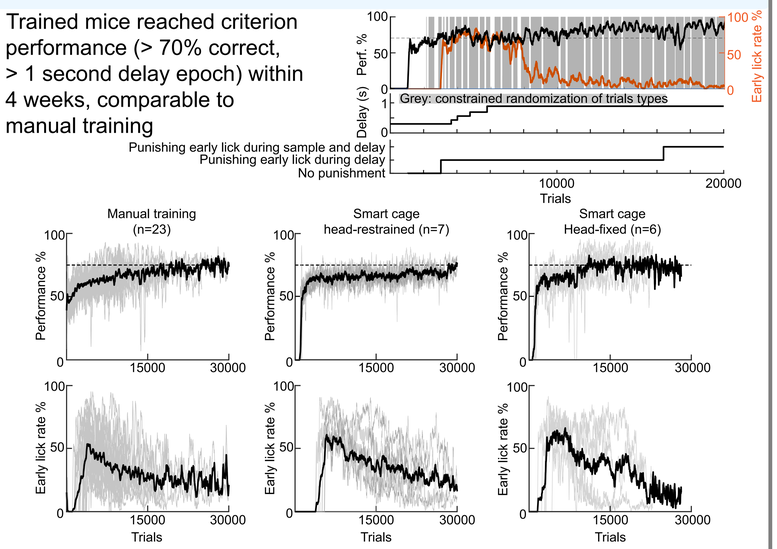


2. Behavioral training



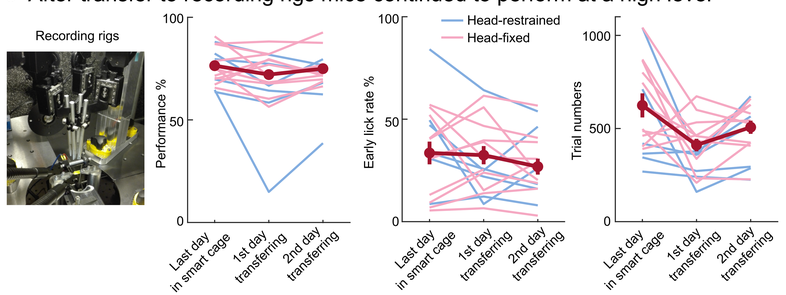
3. Automated behavioral training

- Trained mice reached criterion performance (> 70% correct, > 1 second delay epoch) within 4 weeks, comparable to manual training



4. Transferring to different recording rigs

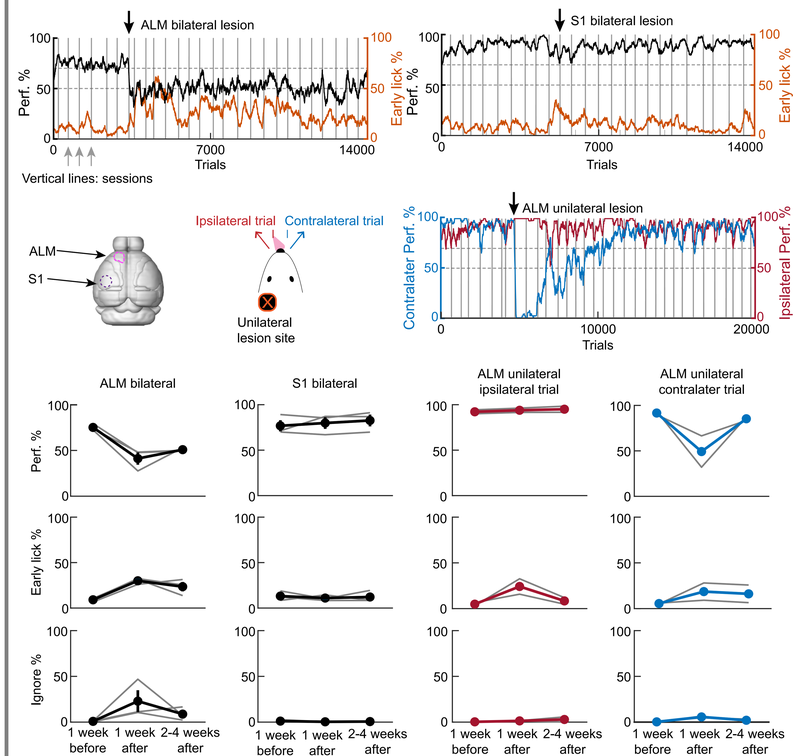
- After transfer to recording rigs mice continued to perform at a high level



Interested in the Janelia Smart Cage for your experiments? Design files and instructions will be available early in 2020. Please email to tienn@janelia.hhmi.org

5. ALM and S1 lesion in trained mice

- Lesioning ALM bilaterally dropped performance to chance level. Performance did not recover.
- Lesioning ALM unilaterally also dopped performance, but performance recovered over several weeks.
- Control lesions in S1 had no effect.



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