Rapid-learning whisker detection task

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# Hardware

## Data acquisition

Data acquisition is performed with two NI PCIe-6343 together with two BNC-2110 blocks controlled with Matlab DAQ toolbox.

Data acquisition hardware list for one behavior setup:

* Acquisition card: NI PCIe-6343 (2 units)
* BNC block: NI BNC-2110 (2 units)
* Shielded cables: SHC68-68-EPM (2 units)
* Computers: Dell Precision Tower 3620 Core i7-6700 16GB DDR4 512GB SSD

## Auditory stimulation

Auditory stimulation hardware list for one behavior setup:

* Headphone: SONY MDR- EX110AP (1 unit)
* Audio mixer: ANLEON MX200 (1 unit)
* Connectors:
  + Jack cable: SpeaKa Professional 3.5 mm jack connection cable SuperSoft 1.5 m (1 unit)  
    <https://www.digitec.ch/en/s1/product/speaka-professional-35-mm-jack-connection-cable-supersoft-15-m-150-m-35mm-jack-aux-audio-cable-21601961>
  + Jack extension cable: SpeaKa Professional 3.5 mm Klinke Verlängerung SuperSoft 5 m (1 unit)  
    <https://www.digitec.ch/en/s1/product/speaka-professional-35-mm-klinke-verlaengerung-supersoft-5-m-5-m-entry-level-35mm-jack-aux-audio-cab-14529249>
  + 2x male RCA to 3.5mm female jack: Lindy Audio adapter cable with 2x RCA to 3.5mm jack plug (1 unit)  
    <https://www.digitec.ch/en/s1/product/lindy-audio-adapter-cable-with-2x-rca-to-35mm-jack-plug-025-m-entry-level-35mm-jack-aux-cinch-audio--6082722>
  + 2x male RCA to female RCA (1 unit): SpeaKa Professional Cinch adapter cinch socket cinch plug, cinch plug  
    <https://www.digitec.ch/en/s1/product/speaka-professional-cinch-adapter-cinch-socket-cinch-plug-cinch-plug-audio-splitter-audio-adapters-21602280>

## Whisker stimulation

Whisker stimulation hardware list for one behavior setup:

* Coil: Monacor LSIP-390 Air Core Coil
* Coil amplifier: Electro-voice Q1212, 1800 W/CH Class‑H power amplifier.
* Teslameter (for calibration of stimulus strength; several units are handy as calibration is required at the start of each whisker session):
  + Teslameter FM 302, Projekt Electronik
  + Probe AS-LTM, Projekt Electronik
* Metal particle: reference length, diameter and weight.
* Dental cement to embed the coil for soundproofing: find reference

## Reward delivery

Reward delivery hardware list for one behavior setup:

* Reward valve: ASCO SCH284B002.24/DC.
* Piezo sensor:
* Piezo amplifier: Dynavox TC-750
* Silicon tubing 1 mm inner diameter, Alba-therm:  
  <https://www.alba-therm.ch/en/Silikonschlauch_10x05_25m.a408.2.html>
* Lick spout tubing: hard tubing.
* Water tank: find ref of syringe.

# Software

Behavior control GUI written in MATLAB is available here:  
<https://github.com/LSENS-BMI-EPFL/behavior_control>

# Training procedure

## Calibration of sensory stimuli and reward size

Magnetic impulse strength decreases rapidly with axial distance and different mice may be positioned at varying heights from the coil due to implantation differences. As a result, the strength of the whisker stimulus must be calibrated before each whisker session. This is a crucial step as differences in the order of the millimeter affect the saliency of the whisker deflection. To do so, place the mouse on the setup and bring the teslameter probe at particle location. Play a few whisker stimuli (e.g., 3 is sufficient) to verify that the measured magnetic strength is at 40 mT. If not, either adjust the height of the mouse from the platform or, alternatively, adjust the stimulus strength in the GUI. Make sure to center the coil at particle location.

Use a sonometer to calibrate the amplitude of the white noise at 75 dB and the 10 kHz tone at 85 dB. The sonometer must be place colinearly to the speaker and 2 mm away from the speaker at the same distance than the ears.

Calibrate reward size to 5 µL per drop. Perform this calibration by collecting 500 rewards in a small vial and measuring weight difference. Adjust opening valve time in the GUI accordingly.

## Water restriction

Start water restriction (WR) 1 or 2 days before free-licking. During every WR days when mice are untrained, give water to mice according to mouse weight:

|  |  |
| --- | --- |
| **Mouse weight range (g)** | **Water per day (mL)** |
| 15-20g | 0.9mL |
| 20-25g | 1.0mL |
| 25-30g | 1.1mL |
| >30g | 1.2mL |

During behavioral training, complement mice to these volumes after each session. To complement water, place the mouse in an empty cage and feel a 0.5 mL syringe with the right amount of water. The mouse will easily learn to take water from the syringe. Use usual water from the animal facility for training and complementation.

## Free-licking session

Perform 1 to 2 free-licking (FL) sessions before the start of the auditory pretraining. Position licking spout close to mouse mouth so that mouse locates the spout’s presence

Start a behavior session on the GUI to start free-licking with the following parameters:

Auditory stimulus trials only

Tone duration = 0ms (i.e. no stimulus)

Reduce quiet window, trial duration and ITI parameters relative to default parameters, so that there are more trials given to the mouse i.e. more chances for the mouse to have rewards during licking

Manually give a few reward droplets at beginning to indicate presence and location of lick spout, and availability of water.

## Auditory detection pre-training

**Parameters:**

Quiet window: 3 to 5 sec, sampled uniformly.  
Response window: 1 sec.  
Artefact window: 50 ms.  
Inter-stimulus-interval: 6 to 10 sec, sampled uniformly. Time in between two stimuli, including no-stimulus trials.  
Trial duration: 7 sec (time from trial start for which lick traces will be saved).

Tone frequency: 10 kHz.  
Tone amplitude: 85 dB.  
Tone duration: 10 ms.  
White noise amplitude: 75 dB.  
Trial proportions for auditory sessions: 50% no stimulus trials – 50% auditory trials.

Whisker stimulus amplitude: 40 mT.  
Whisker stimulus waveform: 3 ms biphasic cosine pulse.  
Trial proportions for whisker sessions: 35% whisker trials – 50% no stimulus trials – 15% auditory trials.

**Shaping of auditory learning:**

Set the white noise at 20% of its maximal 75 dB volume (use an audio player). Progressively increase to 100% as performance gets better. Inter-stimulus-trial can be shortened to increase the frequency of stimulus presentation. Lick spout starts close to the mouth and is progressively lateralized and lowered to a final position of approximately 2 mm contralateral, 2 mm anterior and 5 mm ventral to mouth opening. When the lick spout is in position give one or two water drops to the mouse to indicate spout location and water availability. Two days without shaping and one day with hit rate ≥80% and false alarm rate ≤20% are required before entering the whisker day.

**Session steps:**

1. Make sure the contralateral whiskers are trimmed, except C2.
2. Weigh the mouse before the session.
3. Place and head-fix the mouse in cardboard tube.
4. Restrain mouse paws by taping a piece of cardboard/plastic to the side of the tube.
5. Place the earphones 2 mm from the mouse’s ears.
6. Set lick spout. Place the tip of the spout on the contralateral side.
7. Place the particle on a C2 whisker by rubbing hair wax on a glove. Place the particle at a distance of 2 mm from the base.
8. Make sure to center the coil below the particle.
9. Play white noise.
10. Launch the behavioral control GUI from MATLAB.
11. Check task parameters.
12. Start the session on the GUI.
13. Make sure that the particle stays on. If not pause the session with the GUI, put it back on and resume.
14. When the mouse reaches satiation (stops licking at the auditory stimuli) stop the session.
15. Take note of the total amount of reward indicated on the GUI display in order to complement.
16. Weigh the mouse after the session.
17. Place the mouse back in its home cage. Wait 5 min of recovery so it is willing to take water. Complement to the amount of water indicated above.