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Hardware Article

An open-source lickometer and microstructure analysis program

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ABSTRACT

Described herein is a design for a user-constructed electronic lickometer, intended to allow users to conduct relatively simple behavioral experiments with rodents while avoiding several common stumbling blocks. Primarily, this system does not require the purchase of specialized scientific equipment or software. Additionally, it is possible for users to construct and operate this lickometer without the prerequisite of advanced knowledge of electronics or programming. Overall, the goal of this apparatus is to provide a simple and affordable alternative for users seeking to study ingestion behaviors in rodents, while still allowing the user to obtain high-resolution data and conduct sophisticated microstructural analysis of the behavior in question. All of this is achieved using low-cost and commonly available materials for the construction of the apparatus itself, and open-source software to collect and analyze data. The only substantial prerequisites for this design are a PC with a 3.5 mm microphone input and a comfortable understanding of power tools. Finally, a validation of the operation of the describe apparatus is included.

Specifications Table

Hardware Name	Soundcard LickometeR
Subject Area	Neuroscience
Hardware Type	Animal Behavior Analysis
Open Source License	GNU General Public License
Cost of Hardware	$24–216

1. Hardware in context

Those seeking to conduct behavioral experiments with mice face fairly substantial challenges. While they are the preferred animal model for many different areas of research, based in large part on the genetic tools available, their diminutive stature presents certain difficulties to effective measurement.

This is well-evidenced in ingestive research; one common method for assessing drinking behavior is to simply measure the amount of fluid a subject consumes. This method of measurement, however, faces several conflicting threats to

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resolution when applied to mice; since mice drink very little, one must choose between tracking very long periods of behavior (thus sacrificing any degree of temporal resolution), or attempting to measure very small changes in volume (a process highly susceptible to measurement error) [1,2].

A long-standing solution to this dilemma exists in the form of lickometers; devices designed to record the physical act of licking a spout. Lickometers allow users to record individual licks over a variable period of time, tidily solving any issues of resolution. However, while lickometers allow much more sophisticated measurement of animal drinking behavior, they also set the bar for entry much higher. Commercially available lickometers, while serving as uniquely powerful tools for recording animal behavior, are prohibitively expensive, and many of them must be custom made. For decades many industrious scientists have managed to circumvent that particular dilemma by constructing their own lickometers, but these alternative designs often come with their own challenges; the designs that are simple to construct and operate often rely on some other bit of prohibitively expensive hardware or software [3], while the designs that are relatively affordable also require an advanced understanding of circuit design and programming to construct and operate [2,4,5].

Our design attempts to address both of those problems by replacing the most sophisticated components of lickometer designs with a resource that most common users will have readily available; a PC soundcard (the component of computers that processes audio information). Since most lickometer designs rely on the subject to close the recording circuit when it licks a drinking spout, it's a relatively simple matter to route that circuit through a standard 3.5 mm microphone jack, and obtain a high-resolution, high-fidelity recording of the licking behavior by treating the electronic signal as an audio file. This raw data can then be exported in a variety of forms, allowing users to conduct sophisticated microstructure analysis fairly easily with open-source statistical software.

2. Hardware description

The Soundcard LickometeR is fairly simple, with a few critical elements:

- A durable, waterproof, non-conductive chamber to contain the animal.
- Drinking bottles with conductive spouts.
- A non-conductive device to hold the drinking bottles in the chamber.
- A conductive surface that the animal must stand on as it drinks.
- A computer with a sound card and 3.5 mm microphone input.
- Wiring to connect the sound card to the drinking bottles and the grounding surface.

Beyond these critical elements, system components are flexible. Our chamber is built from acrylic sheets, with two sliding doors, opaque walls and floor, and a transparent ceiling (Fig. 1). Acrylic is durable and easily washed. The sliding doors allow for the system to be somewhat modular: different doors can be cut with a mill or table saw to change the number or position of drinking spouts fairly easily. The featureless opacity of the walls reduces extraneous distractions, and the transparent ceiling allows visual monitoring or recording.

The bottle holder is similarly flexible; ours was milled (Central Machinery 44991; Larkin Pence and Martin A. Raymond) from a delrin block, but any plastic capable of holding set screws could replace the delrin. In many situations, it may be advantageous to 3D print the bottle holder (chuck) rather than milling it. There is no reason why the bottle holder must only hold two bottles; that number is somewhat variable (space permitting), so long as the bottles are uniformly positioned.

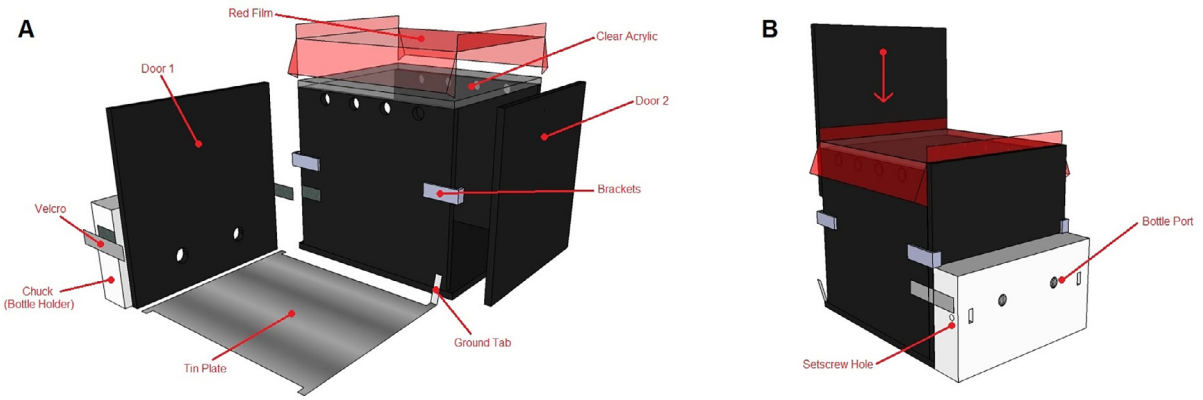

Fig. 1. Digital illustration of the behavioral chamber. 3D render of the completed behavioral chamber, acrylic. A: Exploded view; the chamber, filter film, two doors, tin floor, and bottle chuck. B: The assembled chamber (rotated 180°), with chuck affixed by Velcro. Doors slide down through brackets. Tin plate inside the chamber.