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Design and construction of a low-cost nose poke system for rodents

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A B S T R A C T

Operant behavioral tasks for animals have long been used to probe the function of multiple brain regions (i.e., understanding the role of dopamine in electrical brain stimulation reward [1], or determining the rewarding properties of feeding oriented brain pathways [2]). The recent development of tools and techniques has opened the door to refine the answer to these same questions with a much higher degree of specificity and accuracy, both in biological and spatial-temporal terms [3,4]. A variety of systems designed to test operant behavior are now commercially available, but have prohibitive costs. Here, we provide a low-cost alternative to a nose poke system for mice. Adapting a freely available sketch for ARDUINO boards, in combination with an in-house built PVC box and inexpensive electronic material we constructed a four-port nose poke system that detects and counts port entries. To verify the applicability and validity of our system we tested the behavior of DAT-CRE transgenic mice injected with an adeno-associated virus to express ChannelRhodopsin 2 in the Ventral tegmental area (VTA) and used the BNC output to drive a blue laser coupled to a fiber implanted above the VTA. Over 6 days, mice perform as it has been reported previously [5] exhibiting a remarkable preference for the port that triggers optogenetic stimulation of VTA dopamine neurons.

- We provide a low cost alternative to commercially available nose poke system.
- Our custom made apparatus is open source and TTL compatible.
- We validate our system with optogenetic self-stimulation of dopamine neurons.

A R T I C L E I N F O

Method name: Arduino based nose poke system for rodents

Keywords: Operant behavior, Rodent, Reward, Nose poke, Optogenetics, Lowcost

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Method

Operant behavioral tasks designed for rodents are often used to probe the involvement and function of different brain regions linked to a variety of physiological and pathological brain states. The systems used to perform these experiments are often very expensive and beyond the reach of small labs or low budget projects.

Here we recapitulate the steps taken to construct a custom-made nose poke system designed for mice, taking advantage of open source technology and inexpensive materials.

Arduino boards are becoming increasingly popular due to their versatility and low cost. They have dedicated software and hardware that allow them to be programmed and therefore be applied to suit any need.

Starting from a freely available sketch (Supl. Ref. 1) containing source code designed to make a laser tripwire, we applied the same principle to detect the nose entries to a port and built a nose poke system around it.

The circuit is composed of a light dependent resistor (LDR) that gets exposed to a light source, in our case a red LED, a second LED (here green) that turns on every time the light beam onto the LDR is interrupted and an output BNC connector that drives the laser (GMP S.A. MBL-F-473-500 mW) for optogenetic stimulation.

For a list of all the necessary electronic components to build the Arduino based four-port nose poke system see Table 1.

Our system includes four different ports that have separate circuits connected in parallel. The ARDUINO UNO board processes all of the inputs and outputs.

As schematized in Fig. 1, the red LEDs (LED1) used as light sources for the LDRs are each connected in series with a 100 Ω resistor (R1) and all connected to the 5 V port of the Arduino board and the ground port, creating a very simple circuit to provide power to the LED1. The light sensing circuits are composed of an LDR connected between the 3.3 V port of the Arduino board and the ANALOG-IN ports A1 to A4. A voltage divider is created connecting a 10 kΩ resistor (R3) between the LDRs and ground (Fig. 1).

The green LED (LED2) circuits are formed connecting a 120 Ω resistor (R2) between DIGITAL ports D8 to D11 and the LED2s, which then are connected to ground (Fig. 1).

Finally the DIGITAL port D13 is connected to the live contact of the BNC connector and the shielding to ground (Fig. 1).

We designed the frame that would hold all the electronic components to fit a rectangular PVC box normally used for open field experiments with mice (Fig. 2E and F). We developed our design using SketchUp, a freely available and intuitive 3D modeling software (see Supl. Fig. 1). The frame is composed of two semi-closed compartments one designed to hold the mice while they perform the tasks and the other designed to hold all electronic components and connections (Fig. 2A and B). The front compartment has only a platform and a wall with four 15 mm diameter holes (nose poke ports)

Table 1
Inventory. List of all the electronic materials needed to build a four-port nose poke system designed for mice.

Item	Quantity	Item Number	Company	Schematic Name
Arduino Uno	1	642818	Distrelec	Arduino Uno
100 Ω Resistor	4	722324	Distrelec	R1
120 Ω Resistor	4	728023	Distrelec	R2
10 kΩ Resistor	4	728104	Distrelec	R3
Red LED	4	632048	Distrelec	LED1
Green LED	4	632043	Distrelec	LED2
LDR	4	631603	Distrelec	LDR
BNC Connector	1	103032	Distrelec	BNC
Breadboard	1	920250	Distrelec	N/A
Jumper Cables	50–100	1705	Pololu	N/A