HardwareX (2018) e00031

Contents lists available at ScienceDirect

HardwareX

journal homepage: www.elsevier.com/locate/ohx

Hardware Article

An inexpensive modified weight-bearing device assembled in-house for high throughput unbiased behavioral pain assessment in mice

Brendan Drackley, Matt Holtz, Jay Yang *

Department of Anesthesiology, University of Wisconsin School of Medicine and Public Health Madison, WI, USA

ARTICLE INFO

Article history:
Received 24 January 2018
Received in revised form 10 May 2018
Accepted 13 May 2018

Keywords:
Pain assessment
Weight bearing
Arduino shield
Mus musculus

ABSTRACT

Assessment of pain in rodents is essential for analgesic development and investigations of fundamental neurobiology of pain. We have previously reported on a modified weight bearing apparatus we call VASIC (voluntarily accessed static incapacitance chamber) enabling unbiased and high throughput assessment of pain in rats. The present report provides a detailed description of the construction of the apparatus with all necessary computer assisted design files for the printed circuit board and the plastic components, and the required software for controlling the data capture and data analysis hosted in an online source file repository to allow assembly of the device in-house at a cost affordable to most academic laboratories. We extend the application of the apparatus to assess weight bearing in mice to enable the use of genetic mice models to study pain.

Specifications table

Hardware name	VASIC – Voluntary Access Static Incapacitance Chamber
Subject area	Medical Neuroscience
Hardware type	Measuring physical properties and in-lab sensors
Open Source License	GNU General Public License (GPL)
Cost of Hardware	~$725
Source File Repository	https://osf.io/w7mvj/ (Public Repository) https://osf.io/ytf8c/ (Archived Registration)

1. Hardware in context

Chronic pathological pain remains an unsolved medical problem and the development of new analgesics is an active endeavor in both academic laboratories and the pharmaceutical industry [1,2]. A major bottleneck in pain research continues to be the assessment of pain in animal models. In rodent pain models, the traditional method of pain assessment largely depends on quantifying the behavioral response of the animals following applied painful stimuli, such as thermal stimulation or mechanical probing [3]. This traditional quantitation of reflexive responses has been criticized as an inaccurate

* Corresponding author.
E-mail address: jyang75@wisc.edu (J. Yang).

https://doi.org/10.1016/j.ohx.2018.e00031
2468-0672/

reflection of pain in humans where no external stimulation is required for the subjects to experience pain [4,5]. Furthermore, it is impossible to truly blind the observer during rodent behavioral pain assessment experiments since animals in pain can be readily identified by visual observations of awkward gait or less weight placed on the afflicted limb, which increases the likelihood of operator bias confounding the experimental data. More recently, methods that significantly reduce the likelihood of operator bias by assessing spontaneous pain in rodents without application of painful external stimuli, such as through a conditional place preference paradigm, assessment of facial expression, and quantitation of gait, have been introduced (reviewed [6–8]). Validation of these newer assessment of pain by the scientific community is ongoing, but a wide-spread use of these methods is somewhat limited by the requirement for expensive specialized equipment.

We recently introduced a modification of the traditional weight bearing test we call VASIC (Voluntary Access Static Incapacitance Chamber) as a simple, operator-independent, and high throughput method for assessing pain in rats [9]. In contrast to the traditional weight bearing test, our modification combined a brief water deprivation to encourage rats to seek water in the test chamber where weighing platforms were placed underneath the water spout, thereby eliminating the need to restrain the rats to forcibly place them on the weighing platforms. Rats voluntarily entered the weighing chamber, triggering mass data acquisition by a host computer and producing hundreds of mass measurement data points during a 30 min recording session. The operator plays no role in data gathering except for placing the rodents in the test chamber, essentially eliminating the possibility of an operator bias. Weight bias or shifting of the mass distribution to the uninjured side resulting from a standard nerve injury and an inflammatory pain models were accurately captured by this method. The simplicity of the device enables multiple VASIC devices to be controlled by a single laboratory computer, greatly increasing the throughput of behavioral assessment of pain in rodents and reducing the bottleneck inherent to pain research.

In the present paper, we introduce modifications to the device that extend the applicability of the VASIC device for assessing weight bias in mice. Furthermore, details for constructing the device in-house at a very low cost well within the reach of most academic laboratories are provided. All the necessary computer-aided design (CAD) files for reproducing the hardware and both executable binary and the source code for the software necessary for controlling the microcontroller, data acquisition, and data analysis are provided.

2. Hardware and software description

2.1. Electronic circuit design and printed circuit board (PCB)

The electronic circuit consists of 3 functional domains: 1. Load cell control, 2. Infrared (IR) sensor control, and 3. Arduino microcontroller interface. A voltage-drop across the load cell, configured as a resistor of a Wheatstone bridge, is sensed by the AD8426 instrumentation amplifier, which amplifies the signal according to the selected gain resistors, and passes it through a second order Bessel low-pass filter for 1 kHz before sending it to the Arduino (version Uno R3) analog pins A0 and A1. The AD8426 instrumentation amplifier also provides a DC voltage offset to the signal which can be adjusted by potentiometers REF1 and REF2 to take advantage of the full dynamic range (5V) of the built-in 10-bit analog to digital converter. The IR sensor utilizes a trans-impedance amplifier circuit to convert small current changes from the photodiode into larger voltage changes that may be read by the Arduino. The value for R4 may be increased to provide greater signal amplification at a slight loss of signal resolution. The voltage signal from the IR sensor is read by the Arduino analog pin A2.

The circuit schematic (∗.sch file extension) and the printed circuit board (PCB) layout (∗.brd file extension) were designed in EAGLE (v7.6.0, Autodesk Inc, San Rafael, CA). The final PCB layout can be found in Arduino_Shield.zip in the VASIC Hardware CAD folder of the Source File Repository. A free EAGLE software download can be found at https://www.autodesk.com/compare/eagle-vs-eagle-premium. The files are also saved as KiCAD (http://kicad-pcb.org/), a popular open source PCB design software, compatible files. The ∗.brd output file from the EAGLE software was sent online to the OSH Park PCB manufacturer (https://oshpark.com/), which offers high quality, lead-free boards (emersion gold finish), manufactured in the USA. A complete list of all electronics parts and vendors can be found in Hardware Parts List.xlsx in the VASIC Hardware CAD folder. The components are soldered onto the PCB via a hot-air reflow station in the laboratory.

2.2. Plastic and metal hardware

Additional CAD files (SolidWorks, Dassault Systems, Waltham, MA) of all other components (outside enclosure, inside chamber, bottom plate, metal enclosure) are provided in Vasic_(1004LC)_SOLIDWORKS.zip in the VASIC Hardware CAD folder. We submit these CAD files to a local plastics manufacturer (Routed 4 U LLC, Sun Prairie, WI, www.laser-4-u.com) for production, except for the metal enclosure which is purchased premade (SC-12101, Bud Industries Inc, Willoughby, OH) with holes cut and markings engraved on the surface by the same local plastics manufacturer. Supplemental Data 1 shows images during the hardware assembly of VASIC with the parts cross referenced to the parts list Excel file.

2.3. Software

There are 3 pieces of software required for operating VASIC: 1. Arduino script uploaded to the microcontroller for controlling local data averaging of analog signals from the load cells reflecting the mass measurements (Supplemental Data