Report from 2015 Brainhack Americas (MX)

Open source low-cost device to register dog's heart rate and tail movement

Project URL: https://github.com/nekrum/DogVest

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1 Introduction

In dogs, the perception of an important stimulus can be related to physiological changes such as the heart rate (e.g., in socioemotional situations with humans [1] or dogs [2]) and the movement of their tail (e.g., tail-wagging has a bias that depends on the nature of the stimulus, a bias to the left is related to a withdrawal tendency and a bias to the right is related to an aproach tendency [3]).

Altough heart rate and the tail movement are important gateways to understand dog's cognition, just a few studies report these variables. Perhaps this is related to the difficulty of obtaining records of these variables in natural enviroments (e.g., parks), the elevated cost of a commercial data adquisition hardware (around $5,000 USD [4]) or by inexistence of a tail-movement registering device. For these reasons, the goal of this brainhack project is to design and build a low cost device able to register the heart rate and changes in the tail movement in dogs, both in laboratory and in free movement conditions.

2 Approach

We decided to base our design in arduino hardware for its accessibility and broad use. The materials are detailed in the Table 1.

The arduino UNO were used as the processor unit of the device. It is a flexible device that process the voltage changes in the sensors using analog inputs. It can be programmed to use other sensors or to trigger the sensor readings using a different setup. The EKG-EMG-shield amplifies the changes in the voltage detected by the electrodes and sends them to the arduino. The vibration sensor detects vibrations and transforms them to voltage changes that the arduino collects. We used a 9v rechargeable battery to operate the device but arduino supports different energy supplies and it can be change without affecting the overall operation of the device. The SD Card Reader module ARM MCU connects to the arduino and allows it to write the data acquired to an SD card.

We designed and 3d printed a PLA case to contain the circuit. The case has a slot to add a strap to fix the device on the dogs back. The program for the arduino and the model for the case can be downloaded from the GitHub (scripts directory) repository of the project.

The code generates a csv file that contains the values obtained from samples of the analog inputs, the input voltage (from 0 to 5 volts) is converted to integers that range from 0 to 1023. The sample time and sample rate can be modified from the variables of the code. For the example data, we tested it at 10Hz although according to the manufacturer, an arduino is capable of sampling the analog pins up to 10MHz. We used two types of sensors, a vibration sensor to detect the heart beat and an EMG sensor to detect the tail wagging. The vibration sensor was placed in the chest, close to the heart. The movement in the heart was reflected as a change on the voltage sent from the sensor to the arduino. From these changes, the beats per minute were calculated using ecgbeat function in MATLAB [5]. To estimate the change in the heart beat amplitude, we calculated from the raw signal the standard deviation from the mean. The set of EMG electrodes registered the tail wagging amplitude in changes on the voltage between the electrodes. So, a greater dispersion of the readings from the sensor implies that the dog is waging his tail more.

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Table 1 Materials and cost. The table shows most of the materials used and their approximated cost with a local provider. Other materials were used but their cost is negligible.

Materials	Aproximated cost (in USD)
Arduino UNO rev3	20
EKG-EMG-shield from Olimex with electrodes	48
Vibration sensor from phidgets	11
9v rechargeable battery	7
SD Card Reader module ARM MCU	1.2
Total	87.2

In order to asses if the device could reliably get readings from a dog, we tested it in three phases: baseline, stimulation/no-stimulation and free movement. All phases lasted two minutes and were repeated twice on two dogs. In both, baseline and stimulation/no-stimulation, the dog stayed in sphinx position without movement restrictions but under the command "stay". The stimulation/no-stimulation phase consisted in three interleaved repetitions of two types of conditions, stimulation and no-stimulation, each repetition lasted 20 s. In the stimulation condition the dog owner showed the dog a treat and mention the dog's name. In the free movement condition, the dog walked down a street without any specific command.

3 Results

In the stimulation/no-stimulation phase a Wilcoxon Signed Rank Test revealed statistically significant differences ($p < 0.05$) between the beats per minute, beat amplitude and the tail movement amplitude (Figure 1).

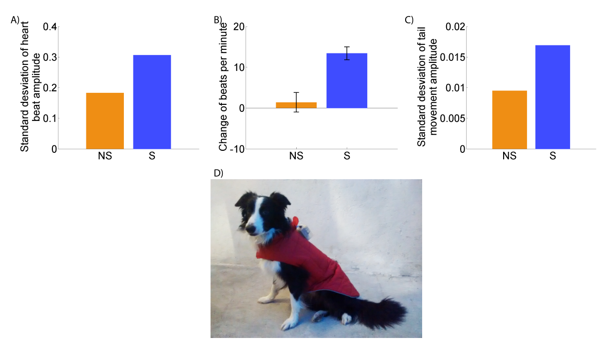

Figure 1 The results shown were obtained from two dogs under two consecutive conditions. Stimulation(S) and No-stimulation(NS). In panels A), B) and C), the colors represent the conditions. The panel A) represents the standard deviation from the mean of the heart beat amplitude. The panel B) represents the change on the beats per minute on both conditions minus a baseline registered directly from each dog. The vertical lines represent the standard error. The panel C) represents the standard deviation from the mean of the tail movement. The panel D) shows one of the registered dogs wearing the device.

By matching the data collected with observations of the movement of the tail, we notice that the data reflects the position of the tail but its resolution depended on the position of the electrode.

The data acquire from the free movement condition was affected by the movement and didn't seem reliable for testing.

4 Conclusions

We were able to build and test a non-invasive low cost device with the capacity to register the heart rate and the tail movement of dogs. We consider that the addition of a movement sensor could provide additional data to reduce the change on the signal due to movement.

Even though the vibration sensor gave us adequate readings on the heart rate in the stimulation and no stimulation conditions, the free movement condition produced to much noise on the sensor, which results in a limiting in the use of the device during movement, it is possible to use different sensors such as an EKG sensor for humans that doesn't rely on movement. In the case of the EMG sensor, both, the vibration sensor and the EMG sensor can be replaced or new sensors can be added.

This device can be integrated in future research on dog's cognition. It can also be used in shelters and homes to easily measure the responses that dogs present to different sets of stimuli; for example, when a dog is left alone in its house and shows stress (i.e. increased heart rate, preferential tail movement to the left) the dog's carer could make changes in the environment to increase the well-being of the dog.

The low cost and the easy access to the materials needed to build the device make it a feasible option to study dog cognition. The results showed that the device could be used to distinguish between two different stimulation conditions.

Availability of Supporting Data

More information about this project can be found at: https://github.com/nekrum/DogVest. Further data and files supporting this project are hosted in the *GigaScience* repository REFXXX.

Competing interests

None

Author's contributions

LVC generated the idea for the project, made the research, help writing the report and acquire the data. EAM and RH designed the device, build it, wrote the code and help writing the report.

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