University of Birmingham

School of Psychology

Assessment Submission Form

The purpose of this coversheet is to ensure you receive targeted feedback that will support your learning. ***Please*** complete all sections and use this template to start your written assignments.

Student ID:	**2261842**
Programme:	Postgraduate
Module title:	**Current Research and Practice**
Assessment type:	
Title of your report:	**Arduino robot for tactile psychophysics**
Word count:	**1739**

I am happy for my assignment to be considered for inclusion as an anonymised exemplar in the Psychology Bank of Assessed Work. ■ Yes ☐ No

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Write a brief comment about something that you have tried to implement in the current piece in response to previous feedback: e.g. "I have been told that I need to include an opening paragraph that identifies the purpose of the piece. I have tried to address this here."

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Arduino robot for tactile psychophysics

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Introduction

The primary purpose of this study is to obtain a basic understanding of phycological methods and Arduino programming to implement an experimental environment. Then, analyse the data to estimate perception judgement on Matlab. We have learned specific techniques to test sensory information like auditory sensation and tactile. Furthermore, the codes should be created enough to launch the open-source software project of this demonstration.

Psychophysics

Psychophysics has been the main focus of research for a long time as it is vital to investigate how perception is accomplished (Stevens, 1960).

The history of psychology started in 1824 by Johann Herbart, recognised as a father of educational psychology (Hoose, 2021). He was not a usual teacher that developed his method and taught it to the students. He highlighted the significance of the relationship between the physical environment and the state of mind. Then, some researchers had gradually solidified the concept of psychology; for example, weber studied the time of action by the weight of objects in 1834. As a whole, this subject is the part of science defining the relationship between physical occasions and psychological experiences—the purpose of this study is to solve these connections, not only the measurements. Some of the keywords in this subject are Quantitative and Objective to define the relationship (Ingleby, 1967). One of the good examples of quantitative is the situation during the class, as the number of photos on screen and brightness. Having this quantitative analysis, humans can explore inter-species or inter-subjects stimulus and perception. The sense of texture is one of the numerous essential research topics in this field, and the experiments carried out here deal with the subject accordingly.

Magnitude Estimation

Magnitude Estimation is one of the essential methods in psychology to create numerical data for the intensity of perception of physical stimuli such as sound and tactile (Huang and Griffin, 2014). Using this method, people can analyse the connection between biological information and perception. If the stimulus intensity will be two times larger than the previous one, the estimation rate should be twice as high (Luca, 2014). In this research, participants were tested by the Absolute Magnitude Estimation(AME) method, a type of Magnitude Estimation without reference information. They had to determine numerical values for roughness without any prior knowledge.

Weber–Fechner Law

A law that describes the different thresholds for sensory information was formalised by Weber in the early history of Psychology, which was in the nineteenth century. He was able to find that the threshold for discriminating a stimulus is balanced to its intensity. The intensity of a feeling is not subjective and can only be measured relatively. In other words, if the ratio of stimuli is the same in different situations, the difference in sensation received is to be equal (Nutter and Esker, 2006). This law is known as below:

$$\Delta I / I \;=\; K$$

Where K is a constant, and I is the expected value of the stimulus.

Gustav Fechner expanded the law by emanating a relationship between a stimulus and the estimated magnitude (Stevens, 1961). According to the discovery, the rate of sensory quantity is inversely proportional to the intensity of the stimulus. Also, it is proportional to the increment of the stimulus. He derived the mathematical relationship from these relationships.

$$P = K \log I$$

Where K is constant, P is the perceived sensory, I is the intensity of stimuli. To conclude, he found that sensory volume is proportional to the logarithm of the stimulus volume. Currently, this law is called Weber–Fechner Law since this finding is based on Weber's law.

Implementation

Arduino software

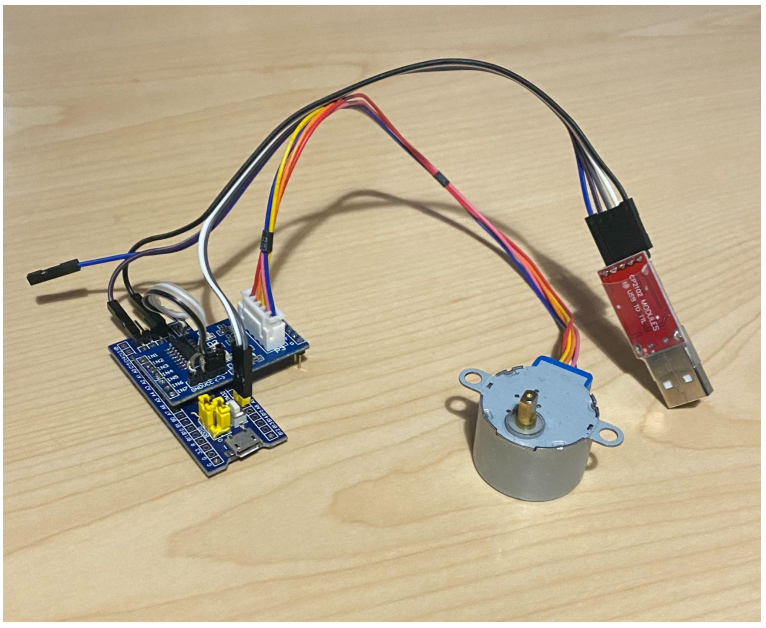
Arduino is an open-source software platform to write and read codes in microcontrollers connecting buttons, sensors, or motors(https://www.arduino.cc/en/Guide/Introduction). We can write codes in C++, which contains three main parts, functions, values, and structure. Thanks to the easiness of getting started experiments, quite a few people have used Arduino in recent years worldwide, not only for simple tasks but also for complicated scientific ones. There are some reasons why it has been chosen. One of the principal reasons is that the simple way of using this platform has allowed both teachers and students low cost. Moreover, developers do not need to prepare specific machines because they run on any operating system.

Establishing the environment

STM32 was used to create the environment for this experiment. This microcomputer delivers the basis for building embedded systems at affordable costs. Coding for this device is done using an Arduino, which may not be as good as the Arduino hardware in terms of detail. Still, it can basically provide the functionality needed for development (Ersin, 2022). This computer was programmed to use a stepper motor in the study, which revolved to set plates for the experiment.

Nonetheless, I had to attach an output device to it as there was only an input function.

For this reason, there were mainly three kinds of apparatus in this device: input board, output board, and stepper motor. The stepper motor has electrodes in each of the four directions. Increasing or decreasing the input value of each enables the reproduction of various movements, not only in the forward direction. The table type in this research is customarily called Lazy Susan, which is able to rotate to cope with the stepper motor's rotation. The table has four holes at 90 degrees intervals into which the boards used in the experiments are inserted.



Picture1 STM32 device with Stepper motor

Programming

With regard to programming, I used Stepper.h function from Arduino, which enables us to use a stepper motor with ease. After setting the values to rotate at 90 degrees, the input ports connected to each direction are matched and initialised. The setup function determines the speed of the rotation.

The table was set to rotate in the loop function. After that, the motor was designed to rotate at regular intervals to trace the finger by setting the number of moving times.

Consequently, the experimental procedure is as follows:

1: Touch the board in front of the participant
2: Record the value of the surface roughness
2: Revolve the device at 90 degrees
3: Back to step 1 until one revolution

Actually, the practice is done before step 1. This practice has nothing to do with programming, so I will not go into detail but will explain it adequately later.

```
#include <Stepper.h>

const int stepsPerRotation = 514;  //set the num to rotate 90 degrees per movement
// initialize the stepper which uses from 1 to 4
Stepper myStepper(stepsPerRotation, 3, 1, 2, 4);


void setup() {
  // set the speed at 30rpm:
  myStepper.setSpeed(30);
}

void loop() {
  // step fixed degree in one direction:
  myStepper.step(stepsPerRotation);
  // make waiting time to touch the board
  delay(1500);

}
```

Methodology

The roughness of the plates is from 1800mm to 4200mm, as shown in the following picture. Each plate has a shallow groove dug in the front made through a 3D printer. There were 6 participants in this experiment. They were instructed to answer how rough the surface was for four different plates using a scale from 1 to 10. In addition, they had to brush the plate just once by finger pad actively. Before the experiment, subjects practised understanding how to do it with a random sample, without any prior information about that sample. After that, the participants would check the roughness of the boards four times in a row with their eyes closed. The boards were placed on the lazy susan table that revolves to make plates located in front of the players. The number of times per board was used varied a little, as it was decided entirely at random which board to use. There was a difference of up to two times. However, as the number of times each board was used was close to the average, it was decided that this did not have any particular influence on the results.

After running all experiments, Matlab was used to analyse the data in order to observe the results at each roughness level from different points of view, such as average, maximum, distribution. Box charts were drawn for each board rather than for each person describing the comparison between the participant's subjective magnitude estimation and the actual roughness of these plates.

Picture2 Six different boards

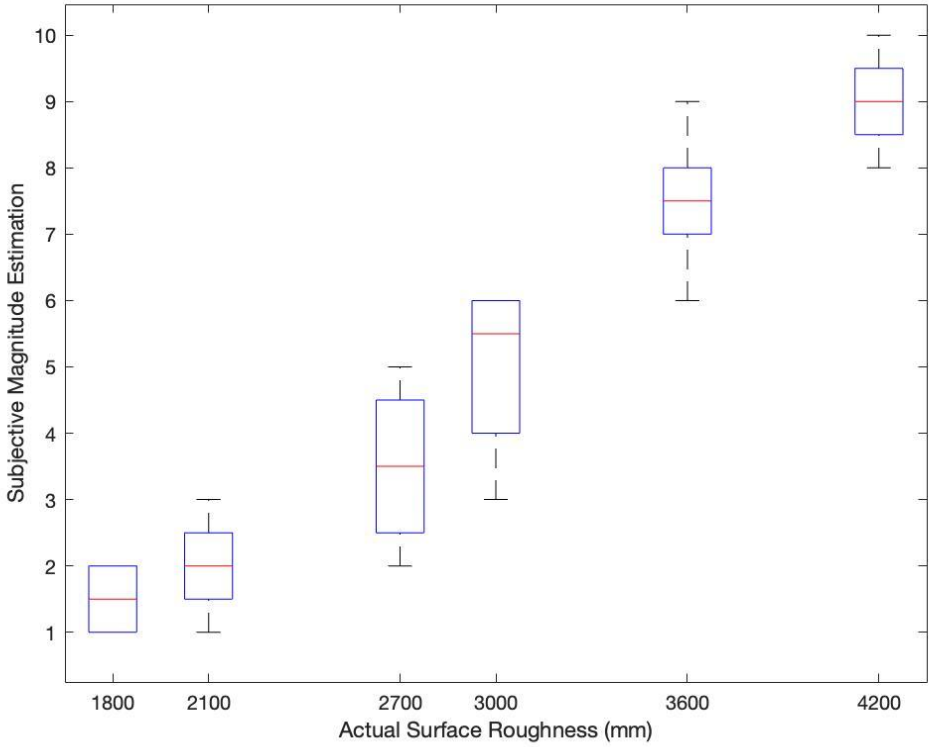


Figure1 Actual Roughness and Magnitude Estimation

Result

According to the results, it is clear that the subject's tactile perception has a strong correlation with the actual roughness. The more actual roughness saw an increase, participants felt more muscular stimuli. Nevertheless, it was challenging to compare the strength of stimuli precisely since the speed of moving by finger differed each step and amongst participants, which is impossible to make players keep the same pace in each experiment. Because of this, the subjective perception did not follow the Weber–Fechner Law. Although there was a correlation, it was not proportional to the logarithm.

Conclusion

Through this experiment, I was able to achieve the first goal. In terms of theory, we have been able to link each theory and understand it systematically. Also, I was able to achieve an ideal design for the assembly and programming of the device and perform the experiment as wanted, including the plotting in Matlab. We did not focus on the results of the experiments, so I was not able to discuss them sufficiently. It will be necessary to pay more attention to details in future work.

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