

Evaluation of Brain Attention Levels Using Arduino and Neurosky Mindwave EEG According to Age and Sex

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Abstract. Attention is one of the main cognitive skills that is constantly used in everyday life. However, various factors can be diminished and even blocked by various disorders, diseases or behaviors that affect people's performance. To analyze the brain signals, the Neurosky MindWave EEG device is required, this device determines the levels of attention of people when they perform some activity and Arduino for data capture. This article compares data obtained from reading the level of care of people of different ages and sex using the Neurosky and Arduino Uno devices. The results obtained show that women (sex) and adults (age) have greater stability of attention over time, and that men (sex) and youth (age) get to obtain higher levels of attention.

Keywords: Attention, brain signal, neuronal sensor, microcontroller.

1 Introduction

Attention is the basic cognitive skill in the life of every person regardless of age. Its importance lies in the fact that thanks to these mental processes, both school, and work performance tend to increase. This favors the development of other skills such as imagination and creativity. This capacity generates greater confidence in ourselves and improves our interpersonal relationships.

Currently, problems of concentration in society have been increasing [1], however, this deficit can be overcome with adequate training and motivation. Training our attention capacity helps us to increase and improve our level of concentration and this makes us much more productive people; athletes, for example, exercise these skills and this allows them to improve their athletic performance [2].

Currently, there are numerous projects and researches that make use of these devices. For example, the Neurosky MindWave EEG, a device with neuronal sensors to measure attention levels, has been used to interact with games[3], control a robot with

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the mind[4], improve the concentration of children with autism[5], assess attention levels in children [8], among others. On the other hand, the Arduino device, a plate with a microcontroller that reads sensors and allows digital and interactive devices to be built, has been used in education [6], in improving the quality of life of adults and people with disabilities [7], in the development of a fire alarm system [8], and so on.

This research has as objective integrate two devices, the Arduino and the Neurosky MindWave EEG to measure the level of attention of the person using it. The collected data are stored in a spreadsheet, and in real-time a graph of lines is generated, according to the concentration values, to obtain the patterns according to each profile. This article shows in the second section the related works, in the third section the applied methodology, in the fourth section it shows the development of the project and the statistics obtained from different samples, the results and discussions are presented in the fifth section, and finally the conclusions.

2 Related work

Research works focused on identifying the level of attention have been of interest for many researchers. Several training programs are used to enhance memory capabilities in childrens. In [9], a type of sensors called “neurosky” is applied to analysis brain waves. This device determines the attention levels when people are doing some activity. The results present scores achieved by each person regarding attention and meditation levels through a daily scanner using the WinWave device.

In [10], a device based on Brain Computer Interface (BCI) or also called Mind-Machine Interface (MMI) was developed for instrumenting the meditation and attention level of human brain. The mindwave mobile headset captures electrical signs from the brain and identifies thoughts and emotional states, and also gives information on the brainwave frequency bands. Results of experiments show differences of attention between girls and boys when doing similar activities, but girls have higher meditation level when solving problems.

The Neurosky’s MindWave device is used in [11] for detecting attention levels when studies do multiple readings. Some interesting results show that students presented better attention levels when information is presented in the format of Power Point and digital maps in real classroom activities.

The alpha and beta waves in human brains generally determine the attention level, but it can be affected when moods turn from normal to stress. These variations and their effect on level attention is researched in [12], also taking into account the age and sex. Results demonstrated that with the normal mood a better concentration can be achieved than with a stressed mood, and that girls generally show more attention level than the boys.

In conclusion, the measurement of the brain signs using different kind of devices have as main goal identify the mental level in order to make corrective actions in restoring the level attention. The researchers propose the use of Arduino together with similar devices identified in the research works as a contribution to enhance the researches in this area.

3 Methodology

The development of the proposal consists of 4 stages:

- **Proposal design.** - A design was made about the integration of the different devices, to achieve the objective of obtaining the reading data of the different people.
- **Development of the proposal.** - It consisted of programming the Arduino microcontroller and configuring the Bluetooth HC 05 and the Neurosky MindWave EEG.
- **Tests of the proposal.** - To test the proposal, the level of attention to different persons of age and sex was read.
- **Interpretation of results.** -Through the data obtained, it was possible to rescue patterns according to the profiles of people and establish comparisons with other related research.

4 Project Development

To capture the data we used an Arduino Uno board, a Bluetooth HC-05 to connect Arduino to MindWave, a 2X16 LCD screen, and 3 LEDs (red, yellow and green) that will light up depending on the level of attention. The elements and actions carried out in the project are described below:

4.1 Connection LCD screen 2X16 I2C

This is a device that allows the user's attention level values to be displayed when using the MindWave [11]. The connection of this device to the Arduino board is shown in Table 1.

Table 1. Arduino-LCD Display Connection.

Arduino	LCD Screen
GND	GND
VCC	5V
SDA	A4
SCL	A5

Sometimes, even if all pins are connected correctly, the display does not show values. This is because the potentiometer of the device must be calibrated for its intensity. To solve this problem, turn the potentiometer until the desired result is obtained.

4.2 Connection and configuration of Bluetooth module HC-05

There are several models and versions of the HC-05 module. Its main feature is that it has a push-button that will serve to enter AT Mode and then configure it. [13].

The configuration of the Bluetooth module is described in the following steps:

Step 1: Connection. - The connection of the HC-05 to the Arduino board is shown in Table 2.

Table 2. Arduino-LCD Display Connection

Arduino	HC-5
GND	GND
VCC	5V
RX	RX
TX	TX

There are some models where the connection is RX →TX and TX →RX.

Step 2: Enter AT mode. - After making the connection, you have to load a sketch in Arduino. Before connecting the Arduino board to the computer, the HC-05 pushbutton must be held down while connecting to the PC until the Bluetooth module LED turns on and off intermittently, indicating that it is in AT mode.

Step 3: Configuration. - Once the previous step has been completed, the Arduino serial is opened and the options "38400 baud" and "Both NL & CR" are changed. This will allow you to enter AT commands, which are shown in Fig. 1. These commands allow you to configure the Bluetooth module to connect to the MindWave.

```
AT
AT+NAME=UCSM
AT+UART=57600,0,0
AT+ROLE=1 (Master Mode)
AT+PSWD=0000 (0000 is required to connect to the Mindwave)
AT+CMODE=0 (Device Specific Address)
AT+BIND="XXXX,YY,ZZZZZ" (Mindwave MAC)
AT+IAC=9E8B33
AT+CLASS=0
AT+INQM=1,9,48
```

Fig. 1. AT- Commands

4.3 Integration of all devices

Once the HC-05 and the LCD are connected and configured, 3 LEDs (red, yellow and green) are added, as shown in the final diagram (see Fig. 2).

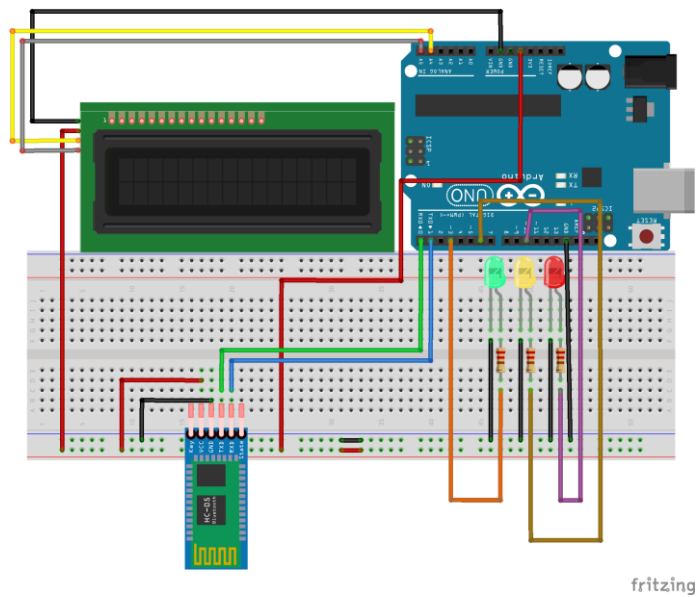


Fig. 2.Final Scheme

4.4 Program Coding

The code sketch included the LiquidCrystal_I2C.h and Wire.h libraries, this to visualize the level of attention of the person through the LCD screen.

The following code allows you to display the user's level of quality and attention on the Arduino serial, as well as to display the level of attention on the LCD screen.

```

Serial.print("PoorQuality: ");
Serial.print(poorQuality, DEC);
Serial.print(" Attention: ");
Serial.print(attention, DEC);
////////////////////////////////////
lcd.setCursor(0, 1);
lcd.print(attention);
lcd.print("          ");
////////////////////////////////////
Serial.print(" Time since last packet: ");
Serial.print(millis() - lastReceivedPacket, DEC);
lastReceivedPacket = millis();
Serial.print("\n");

```

Finally, care ranges were implemented, ranging from 0 to 100, with 0 to 40 considering a low level, 40 to 70 intermediate and 70 to 100 high. Depending on the level of attention, the red, yellow and green LEDs will be illuminated accordingly (see next code).

```

if(attention <40 && attention > 0)

```

```

{
    digitalWrite(GREENLED1, LOW);
    digitalWrite(YELLOWLED1, LOW);
    digitalWrite(REDLED1, HIGH);
}
if(attention <71 && attention > 39)
{
    digitalWrite(GREENLED1, LOW);
    digitalWrite(YELLOWLED1, HIGH);
    digitalWrite(REDLED1, LOW);
}
if(attention <101 && attention > 70)
{
    digitalWrite(GREENLED1, HIGH);
    digitalWrite(YELLOWLED1, LOW);
    digitalWrite(REDLED1, LOW);
}

```

4.5 Compilation of the experiment

The steps to follow to compile the program are the following:

- Make sure that the connections are correctly located.
- Connect the Arduino board to the computer.
- Disconnect the RX from the Arduino board with the HC-05 TX.
- Compile the sketch.
- Open the serial with 57600 bauds.
- Place the MindWave on the head.
- Wait a few seconds and switch on the MindWave
- The Arduino board and the MindWave must be connected automatically (if this is not the case, press upwards for 3 seconds until the headset light and the LED of the Bluetooth module stop flashing).
- Reconnect the Arduino RX with the HC-05 TX.
- Check the variation of the LEDs concerning their level of attention.
- Observe the attention level on the LCD screen.

The complete code can be located at [14].

4.6 Data capture in an Excel file

The data capture was worked based on an excel sheet developed by [15] that consists of the reading of the incoming values by the serial port of the computer. This file makes use of the library created by David M. Hitchner and adapted to work with 64 bits by Hal Evensen[16].

The main modification to the file is in the code linked to the "Open Port" button (see next code) since it was originally made to work with 9600 bauds, but as we remember, our program works at 57600.

```
Private Sub Open_Port_Click()  
    Dim ID_Port As Integer ' Choice of port COM1 to COM4.  
    Dim State As Long 'Returns 0 if there have been no error  
    ID_Port = 3 ' COM3 port is established.  
    ' The port is opened with the following characteristics.  
    ' Retry action is not implemented.  
    State = CommOpen(ID_Port, "COM" & CStr(ID_Port), _  
        "baud=57600 parity=N data=8 stop=1")
```

With the addition of this file in the project, the sketch code shown above must be modified so that only the value of the "attention" variable is displayed by the serial. Afterward, just connect the Arduino to the computer (the previously compiled program is already stored in the Arduino memory). You must select the button "Open Port" and then "Read Port", and you will see how the values of the table and the graph are modified by capturing the level of attention through the Mindwave.

5 Results and Discussion

For this research, a level of care test was done on 46 people, of whom 20 were men and 26 women; and in turn, xz is a common factor to which people are subjected, even in their hours of study, at the end a test of compression of what they had read.

5.1 Comparison of data by sex

According to the data obtained (See Fig. 3a), it is appreciated that men reach higher levels of attention, but over time these go down. On the other hand, although women do not get high levels of attention, it remains more constant. A normal distribution was observed for each group (Kolmogorov-Smirnov test: $p > 0.05$). The average value of men is statistically significantly higher than the women's value (t test, $p < 0.05$) (See Fig. 3b)

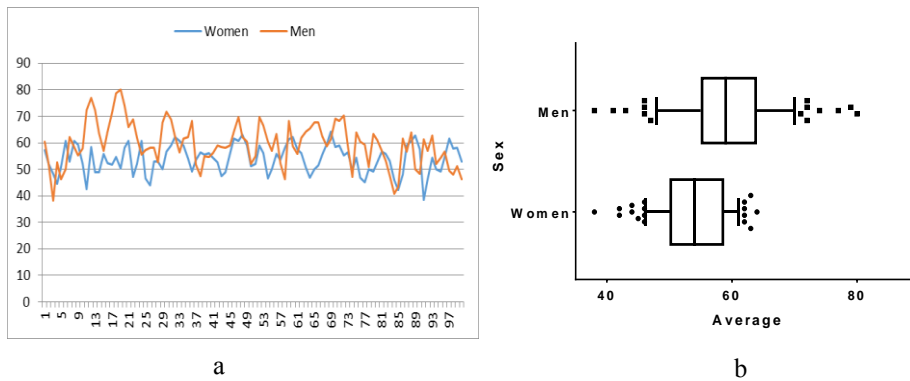


Fig. 3. Results by sex. a. Time series analysis b. Box and whiskers analysis

5.2 Comparison of data by age

The results obtained are shown in (Fig. 4a). It can be seen that although the minors were very enthusiastic about trying the experiment and could reach good levels of attention, the values were very unstable. On the other hand, young people had the possibility of having a higher level of attention, but these values decreased with time, presenting a bit of instability. Finally, the values show that adults were the most stable during the evaluation time. A normal distribution was observed in two groups (minors and young people). Adult data had a non-normal distribution. The analysis showed statistically significant differences between the groups (Kruskal-Wallis test, $p < 0.05$). Young people have a higher average than the minors ($p < 0.05$). Adults have a higher average than the minors ($p < 0.05$). No statistically significant differences were found between adults and young people average ($p > 0.05$) (See Fig. 4b).

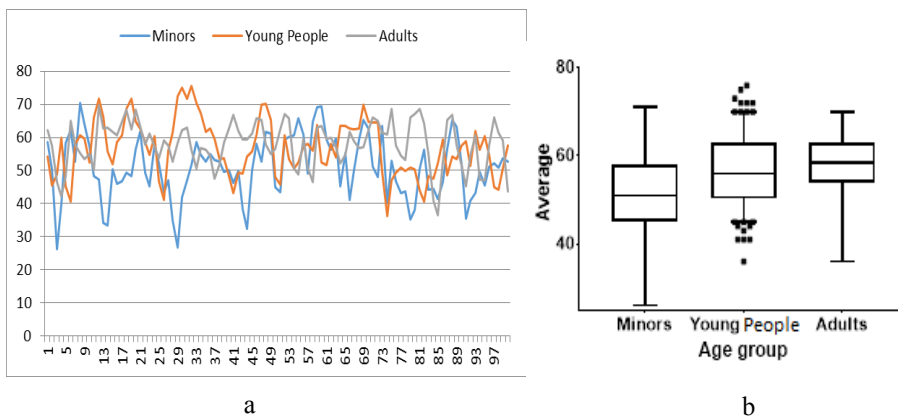


Fig. 4. Results by age. a. Time series analysis. b. Box and whiskers analysis

The results show that students lose attention levels over school hours, being similar to the results in men and young adults people, who low their attention level over time. When students are training to improve their attention, it comes with constant values. The attention of the children when they read a book reaches an average of 51. Finally, in the tests carried out, the existence of small-time ranges was appreciated where people low their level of attention, maybe due to the emotion that can be transmitted when reading a book.

6 Conclusions

The Arduino and Neurosky MindWave EEG allowed us, with a low cost, to carry out an in-depth evaluation of how people's attention changes according to age or sex, this required a spreadsheet that collects the samples sent by Arduino.

The fundamental cognitive ability in the life of the human being is the attention, this one favors the yield and personal development. This cognitive ability varies according to the age or sex of the human being, as expressed in this research.

Males tend to have high levels of attention compared to females, however, this decreases over time. On the other hand, women's attention tends to remain constant.

Based on age, the level of attention in children often varies being unstable, young people have a level of attention, but little by little this decreases. In contrast, adults maintain a constant level of attention

With this research, you have the basis to perform various tests in different situations that know if a human being is attentive, in future research you will have more detail to develop new methodologies of how to improve education according to age and sex.

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