Use of Intelligent Agent Through Low-Cost Brain–Computer Interface to Analyze Attention and Meditation Levels by Gender

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Abstract The realization of activities in daily life can generate cognitive processes such as paying attention and having meditation to what is done, and with the use of these abilities, it is sought to obtain better results or to carry out the desired activity of the best possible way. Although people have the same capacities, there are activities where there may be differences between men and women or vice versa, for this reason, it is important to consider through gender, what are the attention level and the level of meditation presented during the performance of a specific activity. With this information, clustering of the elements is applied to visualize different levels and how it behaves in each gender, as well as in general.

Keywords EEG (Electroencephalogram) · Mindflex · Attention · Meditation · Intelligent agent · Brain–computer interfaces

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1 Introduction

People perform activities that generate different cognitive processes, understanding that there are influences that affect these processes such as physiological factors where the most important are sight and hearing [1]; through neuropsychology it has been revealed that music activates certain brain areas related to the attention that is one of these cognitive processes [2].

This paper explains the design and development of an experiment to collect information about attention and meditation in different people, in order to analyze the data obtained from the test subjects and start to visualize characteristics of the population, to get to this point, it was determined for this article to focus on the gender information of the person and having the data, it is sought to group it into two groups that represent a high level and the other a low level, both levels for the two characteristics to be evaluated.

2 Background

This section describes the definitions of terms that are important for the study. It also explains the tools that have been developed.

2.1 Intelligent Agent

If a computational system can perform in an automatic way to reach goals and this system is located in an environment, this is considerate as agent. The condition to be intelligent agent is that it can perceive information about an environment and send a corresponding action [3] and for this reason the mindflex diadem is considered an intelligent agent because it perceives information of the electrical pulses generated in the neuronal communication in the brain and as it passes through the different algorithms it processes the information and as a result a score is obtained for the attention and the meditation. These data are part of the actions you can perform.

2.2 Music

The music used as music therapy is a modern approach in the implementation of different types of therapy, not based on an idealistic concept about the healing ability of music, but rather on research and scientific techniques. The goal of music therapy is to alter the patient's behavior, aiming at correcting habits and attitudes that cause health risks in a global way [4]. In an application example, María del Mar [2] used a

methodological process to guarantee the stimulation of attention in the classroom for students, focusing on hearing, movement, and improvisation based on film music. Assuming an increase in learning and using Disney's musicals allowed the acquisition of meaningful and functional learning of the students.

2.3 Attention

Attention is defined as the cognitive capacity that allows selecting the desired or required information modality at a given moment [5]. It has been previously observed that attention can be stimulated with the appropriate musical educational strategies. For example, if a person has attention problems during childhood, then the lack of attention may persist in adolescence and reflects the difficulty of following instructions to perform specific tasks, or in problems of acquiring concepts [6]. "The selective nature of attention and its importance for guiding goal-directed behavior has been one of the most extensively studied areas of Western psychology and neuroscience" [7].

2.4 Meditation

Meditation is something complex to define, for example, the following explanation was found: "Meditation is a state of no-mind. Meditation is a state of pure consciousness with no content. Ordinarily, your consciousness is too full of rubbish, just like a mirror covered with dust. The mind is a constant traffic: thoughts are moving, desires are moving, memories are moving, ambitions are moving—it is a constant traffic! Day in, day out. Even when you are asleep the mind is functioning, it is dreaming. It is still thinking; it is still in worries and anxieties. It is preparing for the next day; an underground preparation is going on. This is the state of no meditation. Just the opposite is meditation. When there is no traffic and thinking has ceased, no thoughts move, no desire stirs, you are utterly silent—that silence is meditation" [8]. To clarify the idea, you can review the information found in the topic of cognitive science and define it as "a family of complex emotional and attentional regulatory training regimes developed for various ends, including the cultivation of well-being and emotional balance" [7].

2.5 Measurements for Electrical Signals of the Human Brain

Different frequency changes are distinguishable in the spectrum of measured electric signals of the human brain. The detection of brain signals and their transmission to the signal processing unit is implemented with the use of the EEG signal measuring

sensors that are placed on the head and the signal processing and transmitting electrical units [9]. There are tools that help us obtain this information and it is described in the following paragraphs.

Open EEG offers hardware, data, and freeware schemes to build the EEG system. Open EEG uses the ForceTrainer and MindFlex toys to obtain the same data in a more economical way, although it is not officially a development platform, so some modifications have to be made and the hardware is to obtain data in other contexts.

Most processes occur in the brain band, which contains the EEG hardware. The microcontroller in the brain band sends data from the EEG chip and sends the updates to a base station. In this investigation, a modification was made to the Mindflex device, which is detailed with the specifications of Knuth [10].

2.6 Measurements for Attention and Meditation

The MindFlex headband has a signal processing unit, also developed by the ThinkGear technology of NeuroSky, which can determine the value of attention and meditation [9]. eSense is an algorithm developed by the company NeuroSky, with the purpose of measuring levels of attention and meditation of people; for the different measurements of eSense, the scales of values are between 1 and 100. Taking this scale, from 1 to 20, it indicates a strongly low level; between 20 and 40 indicates a reduced measurement; from 40 to 60 at any time is considered neutral; a value between 60 and 80 is considered slightly elevated, and can be interpreted as higher than normal. Finally, values of 80–100 are considered high, meaning that they are strong indicative of the weight levels of that measurement.

When a sensor measures 0, it is indicating that ThinkGear is not making measurements, and this, most of the time, may be due to noise. The value of attention eSense indicates the intensity of the level of focus or mental attention of the user, such as that which occurs during intense concentration and directed (but stable) mental activity. Its value varies from 0 to 100. Distractions, wandering thoughts, lack concentration, or anxiety can decrease the levels of the attention meter [11]. The value of meditation eSense indicates the level of a user's mental "calmness" or "relaxation". Its value ranges from 0 to 100. Distractions, wandering thoughts, anxiety, agitation, and sensory stimuli may lower the meditation meter levels.

3 Related Work

In the following paragraphs, some papers related to the investigation are explained. It is important to know what information was obtained to carry out this work.

3.1 Assistive Context-Aware Toolkit

Assistive Context-Aware Toolkit (ACAT) developed by Intel labs is a free platform to allow people with neuronal diseases or disabilities to have full access to computer skills and applications using interfaces tailored to their condition [12]. One of the most recognized uses of this application was the one given by scientist Steven Hawking, who used this technology in combination with a series of sensors connected to different parts of his body, so that the scientist could express verbally his ideas, using a database of all the publications made by the scientist, pretending with this that the system learned about the drafting methodology of Hawking.

3.2 The Design and Preliminary Implementation of Low-Cost Brain–Computer Interface for Enable Moving of Rolling Robot

The paper explained the design of transmitting a command to a robot based on brainwave data, collected via Mindflex. They used three brainwave states to command the wheeled robot to move forward, turn left, and turn right. They worked with the alpha and beta brainwave which are processed using backpropagation neural network [13].

3.3 Evaluation of the Neurosky MindFlex EEG Headset Brain Waves Data

The paper explained the development of a system to do different activities such as measuring, data collecting, data processing, and visualizing software to investigate how brainwave signals alternate in time and how they depend on the changes of brain activity. The program helps in the development of individual processing algorithms. On the other hand, the EEG headset can be interfaced to other devices owing to this application and the control of these devices can also be solved [9].

3.4 Psychophysiological Evaluation of a Simple EEG Device

The paper described the evaluation of a simple EEG device, the Mindflex, by means of psychophysiological measurements. The Mindflex EEG controlling signal is speculated to be a complex function of EEG attention signal and electrode impedance. Such control results in what seems to be a stochastic ball lifting when the user plays

with the game included. It should, however, be noted that the physiological EEG signal is indeed needed for a voluntary foam-ball lifting. In the opposite case, the foam ball would not move in a controlled manner [14].

4 Methodology

The brain wave data were obtained while the test subjects listened to a playlist and solved a "letter soup" at the same time. A modified Mindflex coronet was used [11] that returns 11 signals in a range of 420 s, obtaining an array of 11×420. The processes to obtain this information will be explained.

The data from the NeuroSky must be performed, so library used in Arduino will do this job since the library will take the information and turns into friendly format values separated by commas [10]. Data is received by serial port into Matlab and it is recorded by 7 min (420 s) for each person. The program contains information about a user so that it would be easy to identify the data during the next process.

From the set of data obtained for all users, the signal belonging to the concentration was separated and K-means grouping method is used due to its simplicity and versatility [15]. They were grouped using two centroids, in which one of them represents low attention and the second centroid represents high attention. Thanks to this study, it can see what gender predominates in each centroid [16].

Motor imagination is a process that consists of a cognitive process where a person plans a movement without executing it [17]. It is important in the way in how headband is on the user. That is based in the International System 10 20, electrodes place headband electrodes were placed in Fp1, A1 and A2 points [18].

5 Experiments y Results

The purpose of the creation of the experiment is to obtain the information extracted from the "MindWave" device to analyze the characteristics related to the attention and meditation levels, which will be labeled to make the identification of the gender to which the test subject belongs and then perform a grouping to generate groups with different levels. In its implementation, a series of parameters were applied where the subjects were found in the same conditions at the time of the test.

It was decided that the user performed an action with the intention of focusing their attention and meditation on a specific situation while the EEG data were taken, then the action to be performed was to solve a "letter soup", where the user has to find a series of words that are not visible to the naked eye, since they are placed in a grid that is filled with several letters and the way to find them is to see the union of letters to form a word.

Another point that was considered is the use of music, as mentioned above, music is an element that can influence the development of an activity by the user; therefore,

music was used that is designed to influence the attention, and for this, we decided to implement the experiment with a playlist that exists in an online music reproduction platform; for this case, we chose to use the Spotify software and as a consequence reproduce the list called "Perfect Concentration".

A final point that was integrated into the test was the time to measure the characteristics in each person; for this case, it was decided to use 7 min to perform the activity and thus be able to play the first three complete songs of the playlist and also play about seconds of the fourth song to be able to meet the specific minutes to work on the activity. The development considered that the time was necessary since the letter soup has a certain number of words to look for in a certain time with the objective that the person was focused on carrying out the activity and thus have a considered time to be looking for the terms.

5.1 Data Obtained

For the correct performance of this research, 62 subjects of different gender (31 male and 31 female) were tested regardless of age, race, social group, level of studies, etc. Tables 1 and 2 show the data obtained by men and women.

5.2 Color Results

A topic to highlight is that for the realization of the tests, they were given to choose a color down desired by the test subjects, to mark the localized words, of which, most of the women preferred the green color in some of its tonalities, followed by the color blue, while men greatly preferred the color blue, followed at par, by the color green and black (Table 3).

5.3 Attention Results

The analysis is intended to identify the difference in attention levels for men versus women. From each test subject, 420 measurements were taken with the EEG, obtaining with this a data set of 26040 rows by 11 columns of which 61.37% showed an average concentration of 30.7037 and the remaining 38.62% of the total population showed an average concentration of 67.63; on a scale of 1–100 for the concentration levels provided by the eSense algorithm (Table 4).

Table 1 Obtained data by men

Person	Gender	Color	Words	Average attention	Average meditation
1	Male	Blue	14	7	1
2	Male	Blue	9	59.15	61.32
3	Male	Blue	7	40.66	68.94
4	Male	Blue	11	63.92	24.73
5	Male	Blue	8	44.56	72.51
6	Male	Blue	14	27	70
7	Male	Blue	15	55.66	59.74
8	Male	Blue	10	53.27	86.61
9	Male	Blue	6	61	43
10	Male	Blue	11	31.27	49.79
11	Male	Blue	9	43	44
12	Male	Green	10	47	43
13	Male	Green	12	48.29	50.87
14	Male	Green	13	45.06	46.95
15	Male	Green	13	12.13	79.47
16	Male	Green	13	40	50
17	Male	Green	12	47.7	59.78
18	Male	Black	7	59.08	65.15
19	Male	Black	10	47.29	38.08
20	Male	Black	6	59.71	81.89
21	Male	Black	14	52.65	74.2
22	Male	Black	12	73	70
23	Male	Black	9	25.04	47.34
24	Male	Red	8	47.37	46.33
25	Male	Red	13	24.6	15.6
26	Male	Red	13	41.86	87.74
27	Male	Red	7	25.15	93.14
28	Male	Purple	11	22.41	51.41
29	Male	Purple	19	40	40
30	Male	Brown	16	35.74	64.92
31	Male	Orange	16	39.3	60.23

Table 2 Obtained data by women

Person	Gender	Color	Words	Average attention	Average meditation
32	Female	Blue	13	47	63.53
33	Female	Blue	10	36.8	47.05
34	Female	Blue	19	36.31	81.51
35	Female	Blue	12	42.56	75.46
36	Female	Blue	7	45.5	79.24
37	Female	Blue	20	53.46	65.69
38	Female	Blue	16	41.3	48.74
39	Female	Blue	6	65.99	51.1
40	Female	Black	9	43.64	43.09
41	Female	Green	9	90	73
42	Female	Green	8	11.63	58.47
43	Female	Green	15	94.57	22.95
44	Female	Green	11	40.99	54.24
45	Female	Green	15	41	56
46	Female	Green	8	30	44
47	Female	Green	13	75.01	43.02
48	Female	Green	12	40.31	66.23
49	Female	Green	17	41.4	54.6
50	Female	Purple	11	70	16
51	Female	Purple	15	29	64
52	Female	Purple	8	35.03	54.2
53	Female	Purple	9	56.29	55.37
54	Female	Purple	18	89.47	29.82
55	Female	Purple	13	41.04	50.1
56	Female	Red	20	16	93.8
57	Female	Red	10	52.78	46.08
58	Female	Red	13	36.58	63.67
59	Female	Red	8	21	64.15
60	Female	Red	9	75	56
61	Female	Orange	13	50.85	73.4
62	Female	Yellow	17	16	54

Table 3 Average data obtained by color

Average data obtained by color				
Gender	Color	Words	Average attention	Average meditation
Male	Blue	10.36	44.23	52.88
Male	Green	12.17	40.03	55.01
Male	Black	9.67	52.8	62.78
Male	Red	10.25	34.75	60.7
Female	Blue	12.88	46.115	64.04
Female	Green	11.38	52.94	52.24
Female	Purple	12.33	53.47	44.92
Female	Red	12	40.272	64.74

Table 4 Attention outcomes

Attention obtained data		
Gender	Counted data	Average attention
Male	8095	30.70
Male	4925	67.63
Female	7887	30.70
Female	5133	67.73

Table 5 Meditation outcomes

Meditation obtained data		
Gender	Counted data	Average meditation
Male	6785	71.66
Male	6235	35.79
Female	8121	71.66
Female	4899	35.79

5.4 Meditation Results

Likewise, it is concluded that from this set of data, regarding the levels of meditation; of 100% of the data taken, 42.76% of the general population has an average of meditation levels of 35.7859 while the remaining 57.24% has an average of meditation levels of 71.6621 on a scale of 1–100 (Table 5).

6 Conclusion

The men found a total of 304 words, while the women found 343 words, that is, 39 words more than the men, under the same circumstances all. The largest number of words located in a test, women have 20 words located, while the highest value of men is 19 words.

Based on the high levels of attention, 48.96% are men while 51.04% are women. On the other hand, in the highest values of meditation, 45.52% corresponds to men and the remaining 54.48% to women, and these results may leave us uncovered that women obtain levels of care with higher values than men, performing some activity in specific and under the same time-space conditions; however, it is important to understand that the difference is minimal to determine that it is something general.

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