

Development of a Multi-user System to Identify the Level of Attention in People

Alfredo Garcia¹, Juan Manuel Gonzalez¹, Amparo Palomino²

¹ Benemérita Universidad Autónoma de Puebla,
Facultad de Ciencias de la Computación, Puebla, Mexico

² Benemérita Universidad Autónoma de Puebla,
Facultad de Ciencias de la Electrónica, Puebla, Mexico

alfredo_amigo18@hotmail.com, jumagoca78@gmail.com,
ampalomino@gmail.com

Abstract. The level of attention in people is associated with efficiency in their intellectual activities, in their level of understanding and in the development of their creative ability. The physiological variables with greater relevance in this application are the brain waves due to the cognitive relationship that exists between thinking and brain activity, therefore its implication is direct in this context. There are different techniques and systems described in the literature that are used to measure enumerable physiological variables related to the attention states of people. Some current limitations of these systems is that they only use a physiological variable and these systems are of the single-user type. In this paper an analysis of the state of the art is made with respect to the type of variables, techniques, instruments and types of systems used to measure the level of attention in people.

Keywords. Level attention, physiological variables, bio-feedback, brain waves, corporal posture.

1 Introduction

There are several disorders that affect the level of attention of people both in their childhood and adult-hood.

One of the most recognized disorders is the attention deficit / hyperactivity disorder (ADHD) and is usually diagnosed for first time in the childhood; the symptoms persist in the adolescence and in the adulthood.

The ADHD is characterized by lack of attention, impulsivity and hyperactivity. Recently the ADHD has been estimated that affects 3.5% of school-age children around the world and is one of the most common psychiatric disorders among young people. Children with these problems are often unpopular and lack reciprocal friendships, but are not always aware of their own unpopularity. Although these

symptoms tend to decrease with age, at least 50% of children with ADHD still have symptoms that decrease in the adulthood.

Despite the vast literature that supporting the efficacy of stimulant medication in the treatment of the attention deficit / hyperactivity disorder (ADHD), several limitations of pharmacological treatments underscore the clear need for effective alternative psychosocial treatments.

To know the degree of affectation that ADHD produces in people, is necessary to have tools that can provide a feedback of the level of attention when the user is executing a specific task.

Currently there is a variety of commercial devices that quantitatively provide the level of concentration, meditation, relaxation and user attention, but generally are type mono-user, using a single physiological variable to obtain the final diagnosis. The performance of these devices is limited because they have restrictions by the manufacturer regarding the software and the hardware implemented.

Recent works describe various techniques to measure the level of attention in people (Digital image processing [1], Modification of the frequency range of binaural sounds [2], Wavelet Transform [3], Use of commercial tiaras [4], Classification of brain waves in emotions [5], Classification of text [10], among others, using different physiological variables such as: Facial gesturing [1, 7, 8], Brain waves [2, 3, 4, 5, 6, 9, 36, 37], Body gesturing [8], body posture [8], cardiac pulses [8], respiratory rate [8, 24], way of write a text [10], sight trajectory [25], movement of the head [32], spit [8, 31], sweat [8, 31], temperature [8, 31, 40], glucose in blood [31, 39] and gesticulation in the hands [41].

However, there is still a lack of a system that involves more than one physiological variable, which generates more hardness in the system and consequently provides a diagnosis with greater reliability of the level of attention in the user.

In the literature has been verified that the vast majority of reported works are type mono-user, which generates a restriction only to be applied in an isolated context and not in a real social environment such as a classroom.

In this research work is proposed a model to develop a system to measure the level of attention in people, using at least 2 physiological variables, implementing a multi-user system and generating a feedback in the form of a closed loop to carry out some action that helps to restore the user's level of attention.

2 State of the Art Analysis

The variety of techniques applied in the field of research to quantify the level of attention of people leads toward a descriptive analysis that is presented in this work.

2.1 Acquisition Techniques of Physiological Variables Related to the Attention Status of People

Starting from the review in the literature of the variables used to relate the level of

attention in people, has been found that the brain waves are the physiological variables with greater relevancy due to the cognitive relationship that exists between think-ing and brain activity. Therefore its implication is direct.

The graph of the Figure 1 shows the relevance that each one of the physiological variables has on the level of attention of the people. This analysis is ob-tained from the state of the art of the related works.

Depending on the physiological variable used, the device is chosen to perform the data acquisition. Within the most devices used in the literature are: the electroencephalogram, WEB cam, motion sensors, gyroscopes, electrodes, mouse, electrocardiogram, electrochemical sensors, keyboard, transducers, cam-eras and optical sensors.

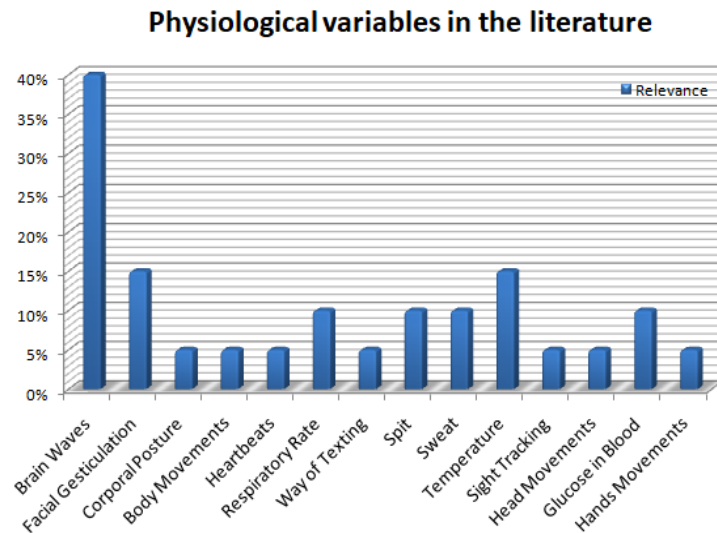


Fig. 1. Relevance of the physiological variables related to the level of attention in the literature.

The Figure 2 shows the relationship between the devices used to obtain the data and the physiological variable sensed.

The techniques applied to obtain the data of the physiological variables also play a fundamental role since the effectiveness of the final diagnosis depends on them. The tables 1 and 2 describe a comparison of various data acquisition techniques and their components as a physiological variable, device and software employees, sampling time, effectiveness and relationship with levels of attention.

2.2 Feedback Techniques Applied on the Attention Status of People

Once the level of attention of the user is known, is necessary to exert some action that gives feedback to the user to stimulate his concentration in the activity or task that he is carrying out.

In the literature has been found that studies related to the classroom showed that

environmental factors, such as cognitive assistance technology (CAT), can help people with cognitive disabilities [27].

An example is the battery of the attention training system. This electronically generated response cost system is placed on a student's desk and handled with a remote control that is given to the teacher. It is designed to send comments in order to increase the levels of attention related to tasks. This system was more effective compared to a pre-existing classroom management program that used chip reinforcement [27]. Another example is the watchminder, a vibrating wristwatch. This self-monitoring device aims to increase the task behavior of elementary school children. The results of this study proved effective for two of each three participants.

The graph of the Figure 3 shows the most used feedback systems to stimulate the attention status of people in general. In this comparative analysis is observed that visual learning environments are the most common tool in the area of cognitive sciences.

SIGNALS ACQUISITION

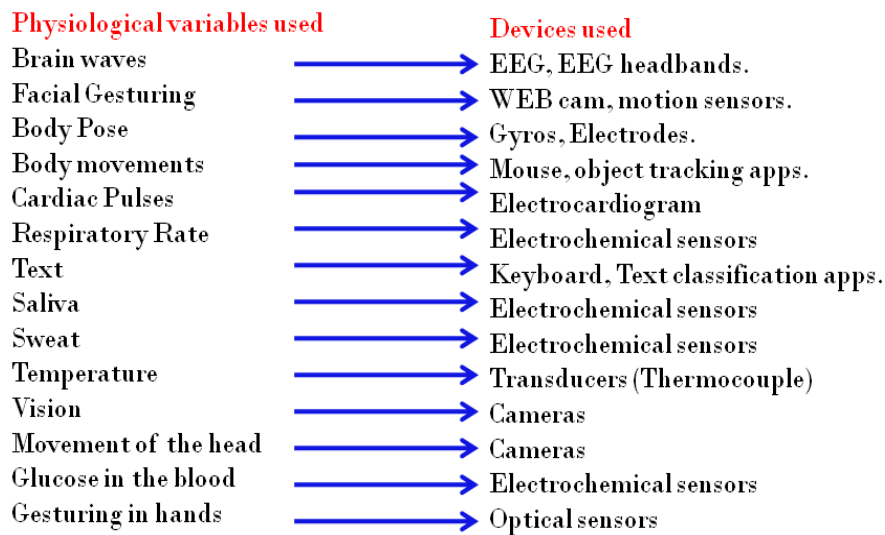


Fig. 2. Devices used to obtain the data of the physiological variable sensed.

3 Construction of the Model for Identifying the Level of Attention in People

In the literature has been found that biofeedback training systems induce a specific mental or physical state in a user through a closed cycle of bio-feedback. These systems gather the physiological state of a person through the detection of hardware, integrate this state into a computer-based interactive system and present the comments so that the user can work to adjust their status [19, 20, 26].

Table 1. Comparison of physiological variables, techniques and relation with the levels of attention.

Reference Number	Physiological variable used	Technique applied	Relationship and impact with the levels of attention
1	Facial Gesticulation	Digital image processing	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
2	Binaural waves (auditory waves)	Modification of the frequency range of the incident waves	Binaural waves cause a positive impact on mental states such as active concentration and creative visualization.
3	Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Wavelet Transform	Use of the Mindwave headband for reading brain signals, which are classified in levels of attention
4	Brain waves produced by facial gestures	Suites of EmotivEpic: *Affective , *Expressiv, *Cognitiv	Use of the EmotivEpic headband for the reading of brain signals, which are classified in levels of attention.
5	Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Classification of brain waves in emotions through their frequency variations	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager
6	Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Bayesian classification and Hill Climbing search algorithm	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
7	Brain waves (Alfa, Beta, Delta, Theta y Gamma)	Digital image processing Affective computing	Automatic feedback can improve levels of adolescent care.
8	Facial gesturing Body movements	Digital image processing Mouse movement	Application of tasks that require cognitive processes such as attention, memory and reasoning.
9	Brain waves Heart waves	Characterization of signal changes Classification of brain and heart waves in emotions through their frequency variations	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.
10	Text	E-learning (Identification of emotions through the way of writing a text)	The automated recognition of emotions can be directly correlated with the levels of attention of a teenager.

Table 2. Comparison of devices, Software, Sampling time and effectiveness in relation with the levels of attention.

Reference Number	Device used	Software	Sampling time	Effectiveness
1	Web Cam Logitech C170 USB 2.0	Open CV Cmake	1 frame / 64.93 milliseconds	Average detection rate: 84%
2	Headset headband	Visual Studio C++	Not specified	Efficiency of binaural sounds: 80%
3	Bluetooth RFCOMM6 Headband Mindwave	Matlab	Sampling frequency: 512Hz	Not specified
4	Headband Emotive EpoC	Labview 2010	Not specified	60% writing efficiency using the BCI (Brain Computer Interface)
5	Arduino Uno Casco de electrodos	JAVA C#	Not specified	Not specified
6	Headband Emotive EpoC	WEKA Wizard	2048 Hz 56 data / image	Stays correctly classified: 53.7879%
7	WEB CAM of PC used for experiment (variable)	JAVA WEB PHP	Not specified	Accuracy in the recommendation system: 5,757%
8	WEB CAM of PC used for experiment (variable)	Face Tracking SDK Kinect for Windows.	Not specified	Not specified
9	Electroencephalogram Electrocardiogram Prototyping data acquisition card	Prototyping software	Not specified	Not specified
10	PC used for measurement (variable)	Word NET Word NET Affect	Not specified	Not specified

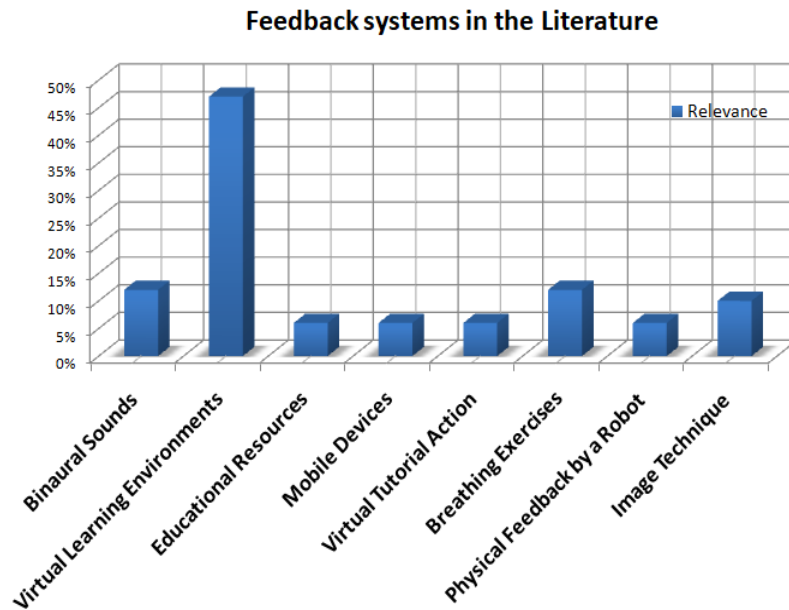


Fig. 3. Relevance of the feedback systems related to the level of attention in the literature.

3.1 Type of Model

For this reason the closed-loop control technique (shown in Figure 4) has been proposed in this work, where the input variables will be the signals of the physiological variables, the output signal will be the feedback that is sent to the user in an automated way, The system floor will be the user whose function is to self-regulate their attention and concentration depending on the feedback received by the system.

3.2 Selected Physiological Variable

According to the relevance of the physiological variables mentioned in the literature, brain waves have been chosen as the main parameter to measure the level of attention of a person.

Body posture has been proposed as a second phy-siological variable, in [8] is placed on its relationship with the state of attention as psycho-educational support in virtual learning environments, this case presenting a development challenge that has not been solved in this context.

3.3 Validation Instruments

These measurement techniques should be available in the language of the participants and should measure the main aspects of cognitive rehabilitation. For example, to

evaluate the improvements of attention in longitudinal studies, the following scales and questionnaires could be used: Integrated Visual and Auditory Continuous Performance Test (VAT), Test of Variable Attention (TOVA), among others [20].

3.4 Data Acquisition

According to the physiological variables selected and supported by the reviewed literature, the information collection instruments will be adapted commercial sensors that obtain the measurement of the selected physiological variables, the reading of these signals will be obtained by the system implemented and sent wirelessly to a computer where the processing, classification and feedback of the automated system will be carried out.

4 Limitations and Experimental Advances

This section describes the research work and experimental work carried out so far. The work planned in the future is also mentioned.

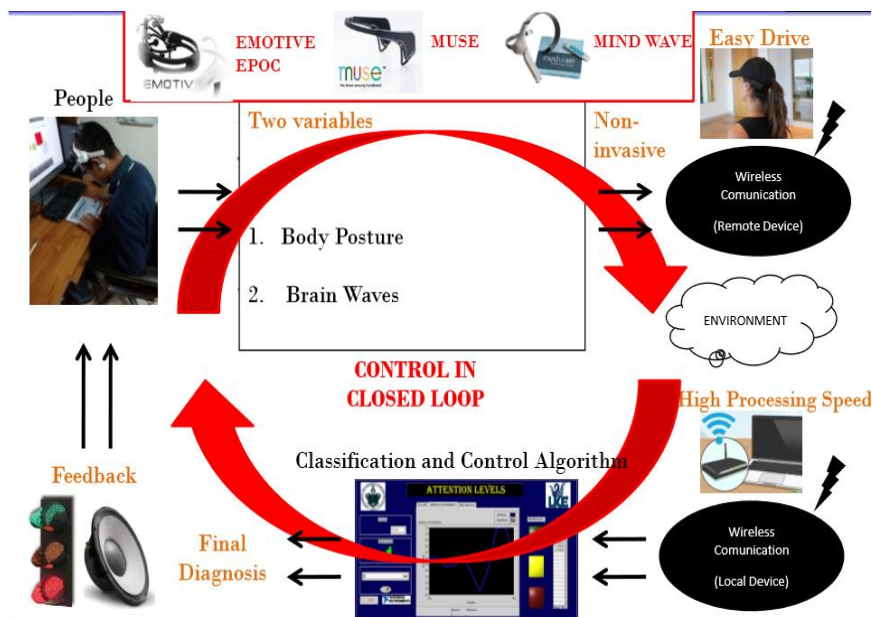


Fig. 4. Model of the closed-loop control technique applied to the attention system.

4.1 Limitations

In the implementation of the works [2, 5, 7, 8, 11, 12, 14, 15, 19, 21, 23, 24, 25, 27, 28, 29, 30] re-viewed so far, systems have been developed of mono-user type, which represents a development challenge towards multi-user systems in this context.

Another limitation that has been found in the literature is the use of a single physiological variable in most of the works [2, 5, 7, 8, 11, 12, 14, 15, 19, 21, 23, 24] presented, which also represents a challenge on the robustness of the systems in this context.

4.2 Experimental advances

In the first instance, experimental tests were carried out using the MindWave commercial device of the Neurosky company, to detect the level of attention in first semester students of the computer degree of the BUAP. A sample of 22 students whose ages are between 17 and 22 years old was used.

To obtain the data of the brain signals, a mono-user system was implemented, using the LABVIEW software. Figure 5 illustrates the graphical interface where you can observe the behavior of the brain signals, a traffic light as feedback, a vector where are saved the sampled data and the variation of the user's level of attention.

The test was carried out in two modalities: with tablet and desktop computer. The practical development is shown in figure 6.

With the data obtained an analysis is made and is shown in the graph of Figure 7, which reflects higher concentration reached by users when handling a tablet than by manipulating the mouse of a desktop computer, which indicates that the device mouse influences as a distractor agent when executing a specific task.

A second experiment was carried out in the laboratory of the Computation faculty of the BUAP, where 12 undergraduate students were integrated into 3 teams. The activity to be carried out consisted of developing ideas for a science project in an organized way, where each team member participated actively in its elaboration.

While the activity was being carried out, 5 students were randomly monitored, where their attention level was obtained for 10 minutes, the feedback was observed in another independent room through a physical traffic light and a laptop where they received the data sensed with the MindWave diadem, which described the student's level of attention in each sampling.



Fig. 5. Graphical interface implemented in LABVIEW.



Fig. 6. Graphical interface implemented in LABVIEW.

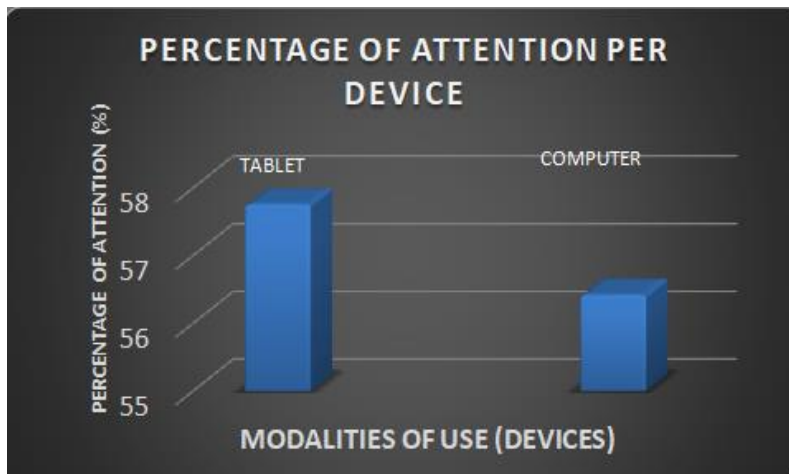


Fig. 7. Percentage of attention per device.

Table 3. Level of attention in the monitored students.

Student	Attention Level (%)
Ruben	57.39
Fernando	45.36
Marcos	60.98
Melani	52.77
Noé	48.35
Global Average	52.97

The samples were taken every 500 milliseconds with an instantaneous feedback to the person who monitored the activity in an isolated room. The average of the samples of each monitored student is shown in the Table 3 and in the Figure 8.

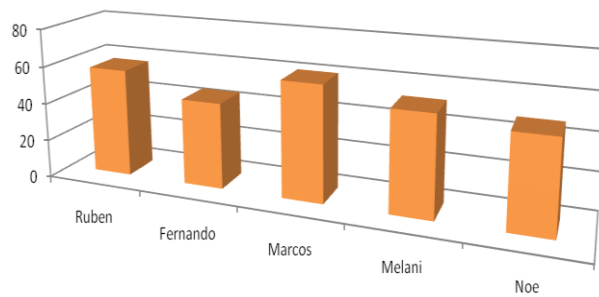


Fig. 8. Graph of the level of attention in the monitored students.

As a continuation of the work, the use of other commercial devices was validated in order to compare their performance.

For this motive 3 attention monitors were implemented using the three commercial headbands with the highest number of mentions in the literature: Muse, Emotiv Epoc and Neurosky. At first, the software of each manufacturer is explored and subsequently a system of transmission and reception of information is implemented to obtain the data read by the sensors, sending them to an own interface to be processed freely.

The software developed by the manufacturer Inte-raxon, provides direct access to the data read by the Muse brain sensor, this feature allows to perform a better interaction with the device and is used to develop a mono-user data acquisition interface, shown in figure 9, which has a panel to visualize the level of attention of the user, 1 virtual traffic lights and 1 table where the numerical data of the user's attention level is displayed in an approximate time to the real time.

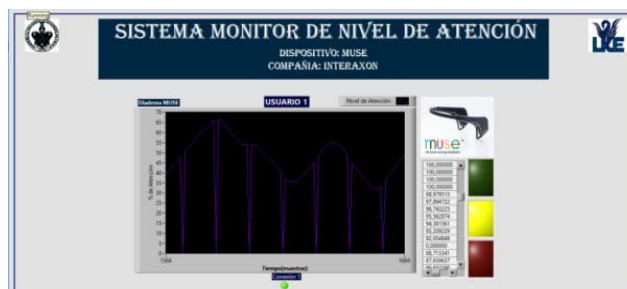


Fig. 9. Muse attention monitor implemented in Labview.

The software developed by the manufacturer Emotiv Systems, provides direct access to the data read by the brain sensor Emotive Epoc, this feature allows a better

interaction with the device and is used to de-velop a single-user data acquisition interface, which It is shown in Figure 10, which has 1 panel to display the user's attention level, 1 virtual traffic lights and 1 table where the numerical data of the user's attention level is displayed in an approximate time to the real time.

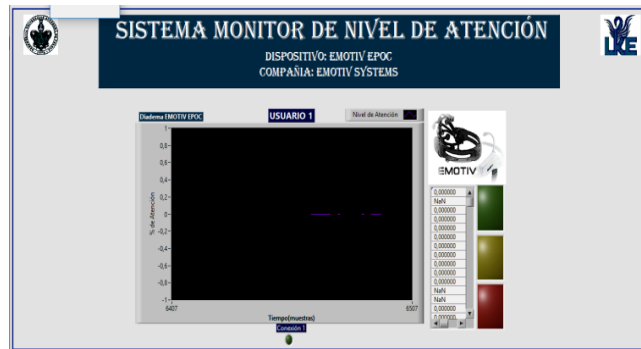


Fig. 10. Emotiv EPOC attention monitor implemented in Labview.

The software developed by the manufacturer Neu-roSky, provides direct access to the data read by the brain sensor MindWave, this feature allows to per-form a better interaction with the device and is used to develop a multi-user data acquisition interface, which is shown in figure 11, which has 2 panels to visualize the level of attention of each user, 2 virtual traffic lights and 2 tables where the numerical data of the level of attention of each user is displayed in a time approximated to the real time.

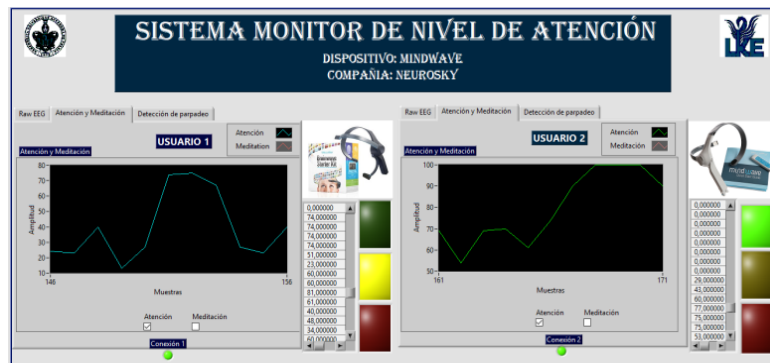


Fig. 11. MindWave attention monitor implemented in Labview.

5 Conclusions

The implementation of single-user systems and the use of a single physiological variable are 2 of the main limitations that have been found in the literature in the context of the systems used to measure the attention of people.

Based on these limitations, the first implementation of a single-user type system was performed, using brain waves as the only physiological variable.

In the second experiment is shown that the level of attention in students when working as a team is on average 53%, only 3% above the expected half, this is due that diverse factors influence a collaborative context, where there is noise, diversity of opinions and other distractors that divert the attention more easily than in a controlled environment where concentration is stimulated individually.

As a continuation of the work, a data acquisition system is made for 3 different headbands, where a multi-user system with the Mindwave device of the Neurosky company was efficiently implemented.

As a future direction of this research work, has been proposed to correlate a second physiological variable with the attention states and increase the number of users in the system.

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