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A RESEARCH VISION

Omnidirectional robot for the diagnosis of the attention deficit

Robot omnidireccional para el diagnóstico del déficit de atención

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) occurs in 16% of the Colombian student population [1] and estimates that between 30-70% of these children continue to show symptoms in adulthood [2]. Thus, a tool is proposed for the professional to support his diagnosis according to the criteria offered by the Diagnostic and Statistical Manual of Mental Disorders (DMS) [3]. An omnidirectional platform is implemented, striking for its design, for children, adolescents and that becomes a concentration challenge for adults.

With an Electroencephalography (EEG) [4] helmet a brain wave reading is made; with the help of a Computer Brain Interface (BCI) you can have the reading of facial gestures, having said reading is implemented to control the omnidirectional platform, with the same BCI you also have the reading of concentration, stress, excitation, etc. of individuals; Thus, the professional in the area can support his diagnosis according to several factors, such as: EEG interpretation, emotional data (concentration, stress, excitement ...), and the observation of the individual. The evaluation of the patient makes the health professional, generating some challenges to overcome the platform and interpreting the different data according to their professional criteria.

Keywords: BCI, Diagnostic Tool, EEG, Emotions, Mobile Robot.

Resumen

El TDAH se presenta en un 16% de la población estudiantil colombiana [1], además, estima que entre el 30-70% de estos niños sigue presentando síntomas en edad adulta [2]. Así, se plantea una herramienta para que el profesional, apoye su diagnóstico según los criterios ofrecidos por el “DMS” [3]. Se implementa una plataforma omnidireccional, llamativa por su diseño, para niños, adolescentes y que llega a ser un desafío de concentración para adultos.

Con un casco de EEG [4] se hace una lectura de las ondas cerebrales; con ayuda de una BCI se puede tener la lectura de los gestos faciales, al tener dicha lectura se implementa al control

de la plataforma omnidireccional, con la misma BCI también se tiene la lectura de la concentración, estrés, excitación…etc. de los individuos; así el profesional en el área puede apoyar su diagnóstico según varios factores, como: la interpretación EEG, datos emocionales (concentración, estrés, excitación…), y la observación del individuo. La evaluación del paciente la hace el profesional de la salud, generando algunos retos a superar con la plataforma e interpretando los diferentes datos según su criterio profesional.

Palabras clave: BCI, Herramienta diagnóstica, EEG, Emociones, Robot móvil.

1. Introduction

According to DMS-V, ADHD (attention deficit) is a "persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development" [3] and hyperactivity disorder in an excess of activity that is maintained 24 hours a day [5]. The diagnosis of attention deficit nowadays is given by means of different aspects, such as consulting the individual's behavior to parents and teachers if he is a minor, and there are also different tests, among them the CTP II (Conners Continuous Performance Test), which is applied from the age of 6 and is a "game" in which letters with discontinuous times appear on a computer screen, and every time a letter appears it has to be clicked, except for the letter X [6]. Another test, is the FACES test, this consists of several drawings similar to faces, with eyes, mouths, eyebrows, made with elementary lines, and the final objective is to find the identical faces, this test is applied for older than 6 of and under 18 [7]; to give another example the test of Cancellation of Figures, is applied for children from 4 to 13 years old and deals with two sub-tests; In the first one, the child has to point out the diamonds distributed randomly among 140 geometric figures, and the second one, similar to the first one, tries to find the number 592 among 140 trios of numbers. With this test, the visual permanence of the patient can be evaluated, and it is necessary to take into account the successes, omissions, errors and execution time.

This document presents the development of a tool for the detection of the 9 aspects given in the book DMS-V (Diagnostic and Statistical Manual of Mental Disorders) [3], which covers most of the considerations to be taken into account when diagnosing ADHD (attention deficit), such as:

- He does not follow instructions, and does not finish tasks, or chores.
- Avoids, dislikes, or shows little interest in starting tasks that involve sustained mental effort.
- Seems not to listen when spoken to directly.
- Poor attention to detail or mistakes due to inattention.
- Has difficulty organizing activities or tasks.
- Is easily distracted by external stimuli.
- Difficulty in maintaining attention.
- Loses necessary things.
- Forgets everyday things. [3]

And for hyperactivity it gives the following behaviors:

- He plays with his feet or hands or may even squirm at his post.
- Pulls himself out of his seat at inopportune times.
- Runs, climbs, and so on at times when behavior is not expected (or he became restless).
- Is unable to play or engage in recreational activities quietly.
- Is frequently "busy" and always has a lot of energy.
- Talks excessively.
- Responds unexpectedly to unfinished questions
- You find it difficult to wait in shifts or lines.
- Interrupts or interferes with others [3].

In Colombia, this disorder is widespread in 16% of the student population[1], and although these are approximate figures, they tend to vary greatly due to different diagnostic methods and criteria [8], accompanied by the fact that the state does not keep frequent records, they are taken as approximate figures and only taking into account minors who are part of schools, as shown in the research of Cornejo Ochoa (2005) and Bara Jiménez (2003), the schools that carried out their research were in Medellín and Cali, respectively. Also, there are antecedents of erroneous diagnoses, in which it is possible to be confused with other pathologies, like:

Obsessive-Compulsive Disorder (OCD): in which the subject is often focused on their compulsions and obsessions instead of paying attention to instructions or what happens in front of him.

Post-Traumatic Stress Disorder (PTSD): Children may exhibit behaviors that closely resemble those of ADHD, such as great difficulty concentrating, excessive alarm reaction, and hypervigilance, making the child appear absent and startled.

Learning difficulties: a child who is not focused on his book reading, does not necessarily have to present ADHD, is that it may be for other reasons such as dyslexia, which can be traumatic, the frustration and shame of not being able to do what their peers can do.

Cellular waves are read by means of an electroencephalogram, which is a graphic record of the brain's electrical activity, which is obtained by means of electrodes placed on the surface of the scalp and obtains a nomenclature according to Table 1.

Table 1. Nomenclature of the electrodes according to their position [9].

Brain area	Left Hemisphere	Medium Line	Right Hemisphere
Polar Front	FP1		FP2
Front	F3	Fz	F2
Temporal front	F7 C3	Cz	F8
Medium Temporary and Parietal	T3 P3	Pz	T4 P4
Temporary posterior and Occipital	T5 O1	-	T6 O2

These are distributed throughout the head according to different standards; the normal analysis that makes the EEG waves are classified according to their frequency; these are divided into four bands:

- Delta
- Theta
- Alfa
- Beta

Determined by the corresponding frequencies and amplitudes so the characteristics of each band are described:

Band Delta

- Frequency 0.1 to 4 Hz.
- Amplitude: variable, greater than 50uV.
- Distribution: typical of childhood, children under three months; and is in Phase III of physiological sleep, its appearance in adults is considered abnormal.

Band Theta

- Frequency 4 to 7 Hz.

- Amplitude: Greater than 40uV, if it is less than 15uV it can be considered abnormal, although if it is accompanied by a well-established Alpha rhythm it can be considered normal.
- Distribution: Front-central.
- It is typical of children between 3 months and 5 years. It is also present in phase I and II of physiological sleep and during hyperventilation and fatigue.

Band Alfa

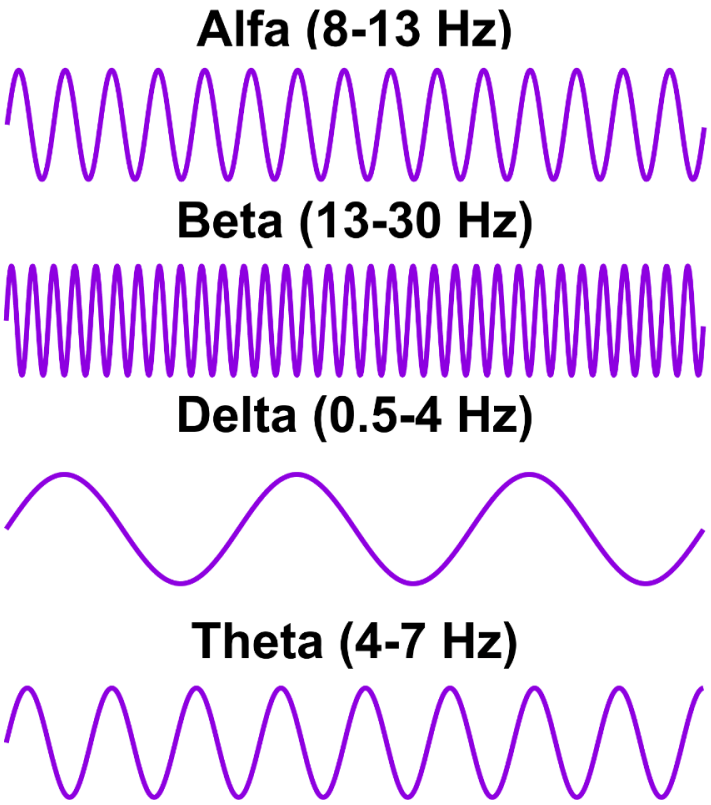
- Frequency 8 to 12 Hz.
- Amplitude: Variable, greater than 15uV, can vary according to age, the older the patient, the lower the voltage, it can also change according to the distance between electrodes or changes in bone density.
- Distribution: Occipital.
- Regulation: Rhythmic.
- Symmetrical: An asymmetry greater than 50% is considered abnormal.
- Reactivity: It is blocked with the palpebral opening and concentration. [10].

Band Beta

- Frequency: Greater than 12 Hz.
- Amplitude: More than 15uV and less than 50 microvolts.
- Distribution: Front and upper front.
- Symmetrical: An asymmetry may indicate anomalies.
- Reactivity: It is frequently opaque due to artifice of muscular origin superimposed on these same areas [11].

In Figure 1 we can see the representation of the bands of the electroencephalogram.

Figure 1. Representation of bands of the electroencephalogram.



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The BCI (Brain Computer Interface) interfaces:

Which were at first quite expensive; over time different instruments of this type have been developed such as Mattel's MindFlex, NeuroSky's MindSet, InteraXon's Muse and the Emotiv EPOC and Insight [12], delving into the device used by the Emotiv EPOC; this device is wirelessly low cost compared to others, has a short preparation time; Before use a special solution is placed on the sponges of the COPD helmet electrodes and it is not necessary to clean the scalp [13], with the interface provided by Emotiv (Emotiv Control Panel) makes the processing of EEG, detecting facial expressions (Figure 2), emotions (Figure 3), and cognitive commands (Figure 4).

Figure 2. Expressiv Suite Emotiv Control Panel.

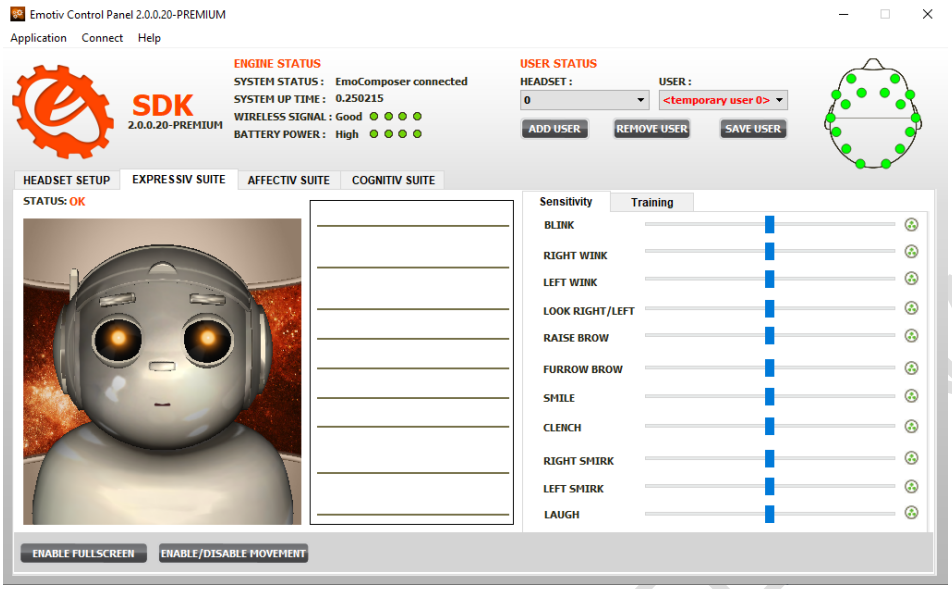

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Figure 3. Affectiv Suit Emotiv Control Panel.

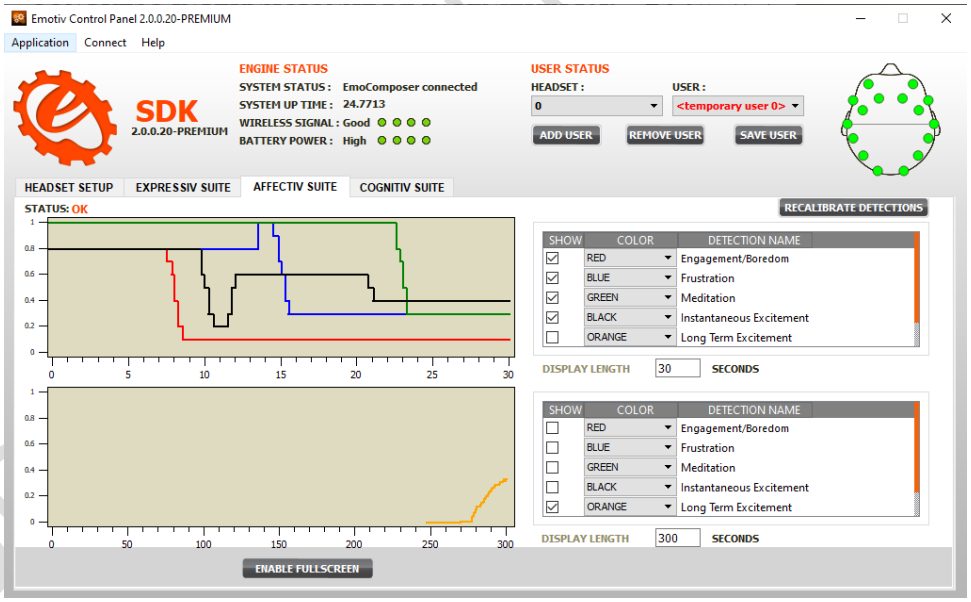

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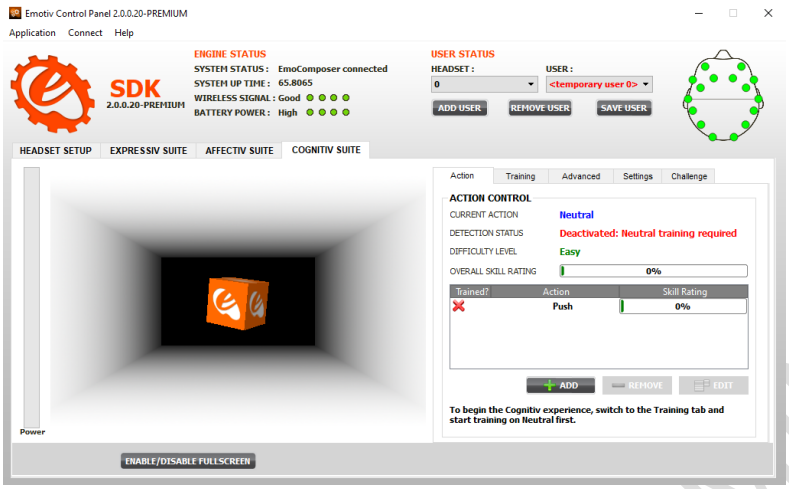
Figure 4. Cognitiv Suit Emotiv Control Panel.



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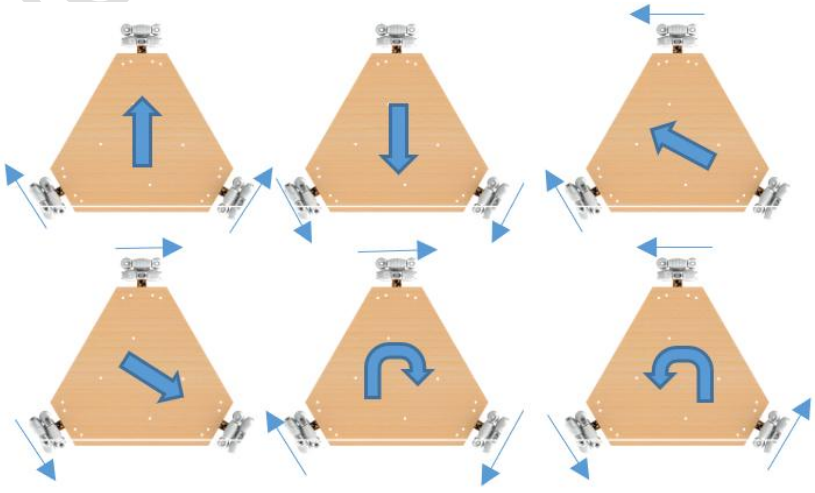
Omnidirectional mobile platforms using Swedish wheels can only execute their movement by installing two axes: one vertical and one horizontal with respect to the surface. While the movement on the axle and is due to the position of the rollers on the perimeter of the wheel, to use a three-wheeled dolly it is necessary that the rollers are located at 90° from the turning axis of the wheel; this type of dolly has greater freedom compared to those using conventional wheels (Figure 5).

Figure 5. Representation of movements of the Swedish three-wheeled omnidirectional platform.



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The problems in diagnosing the different symptoms of attention deficit can be characterized by carrying out rigorous tests with the accompaniment of professionals; these tests must have an increasingly higher level of elaboration. For this reason, an omnidirectional mobile platform was used, which attracts children and adolescents and is a challenge for adults, taking into account that these symptoms can occur even at the age of majority; That is why an adaptive tool is presented, along with studies that show how facial expressions can be linked to ADHD, allowing to create a different control for the omnidirectional platform, and thus providing a perfect excuse to use an EEG helmet, with which to provide a more truthful diagnosis of the pathology mentioned.

2. Methodology

It begins by reading the channels of the helmet according to the 10-20 standard, the processing is done by Emotiv SDK, the most used tools on this occasion were: the expressive suit which reads all facial gestures and the emotional suit that provides very relevant data such as concentration, stress and momentary excitement, these interpretations that makes the SDK, can communicate through sockets with java, which establishes communication via UDP with the mobile platform, which in turn has a board with Wi-Fi connectivity, which only receives the speed and direction of each engine.

The control of the platform was wanted to be done in the simplest way possible, in order to have a more rigorous approach in the implementation, just as they present a diagram that illustrates this idea in Figure 6.

Figure 6. Omnidirectional dolly control representation.

Sources: own.

After having the control of the mobile platform, we looked for the best way to implement it in the diagnosis of the attention deficit (Figure 7), so different tests were done, such as:

I.

- Number different characters.
- Put 5 at random on the floor
- Give the patient the instruction to follow in ascending order the numbers of each character starting from the minor and giving the instruction to remember the details of each character.
- At the end of the test ask 11 questions of each character.

II.

- Number different characters.
- Put 5 at random on the floor
- Give the patient the instruction to follow in ascending order the numbers of each character starting from the minor and giving the instruction to remember the details of each character.
- At the end of the test ask 4 questions for each character.

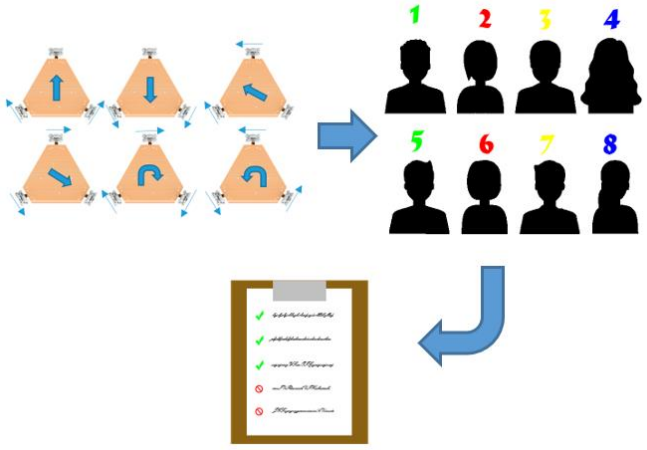
III.

- Number different characters.
- Put 3 at random on the floor, with a space of 50cm between them determined by the floor tiles where the first tests were being done.
- Instruct the patient to follow in ascending order the numbers of each character starting from the smallest and giving the instruction to remember the details of each character.
- At the end of the test ask 4 questions for each character.

IV. In the end the following test was chosen the most viable was:

- Number different characters.
- Put 3 randomly on the floor waxed in separate circles.
- Give the instruction to the patient to follow in ascending order the numbers of each character starting from in minor, when arriving at the circles where the character was, put a task, for example, to rotate 3 times or to make some type of zigzag, and giving the instruction to remember the details of each character.
- At the end of the test ask 2 questions for each character.

Figure 7. Representation of how the diagnosis was made.



Sources: own.

At the end of each test a survey was made and a note was taken of the behavior of each patient, if he forgot instructions, or if he changed his mood, in turn the behavior of the emotions were compared with those provided by the EmotivControlPanel, most tests were made on young people who did not have the attention deficit disorder, to contrast them with a patient suffering from this disorder.

3. Results

In the Table 2 we can see the results were taken with the methodology number 5 and in the Figures 8, 9, 10, 11, 12 and 13 we can see the graphics.

Table 2. Results of successful questions by patients.

Respondents	Answers	Notes
1	6/6	N/A
2	5/6	You forgot the instruction to follow the numbers in order
3	4/6	N/A
4	5/6	Frustration
5	2/6	He looked angry and frustrated

Sources: own.

Figure 8. Graph of the percentage of questions correctly answered by the first patient.

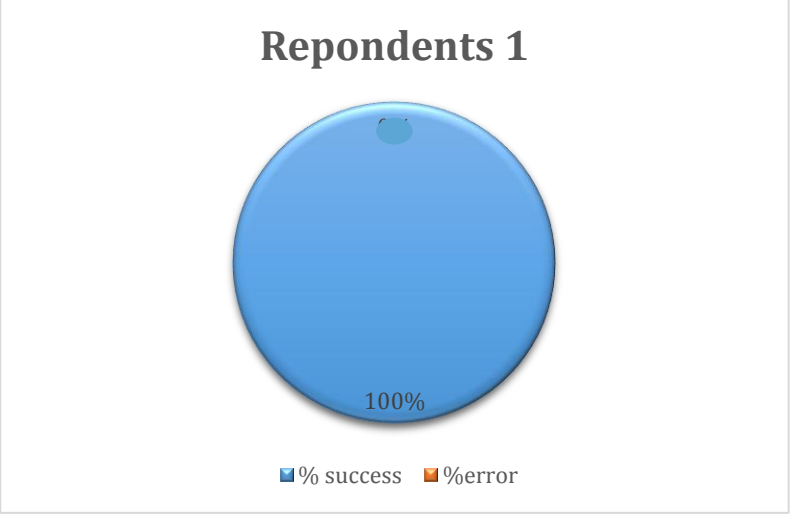


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Figure 9. Graph of the percentage of questions correctly answered by the second patient.

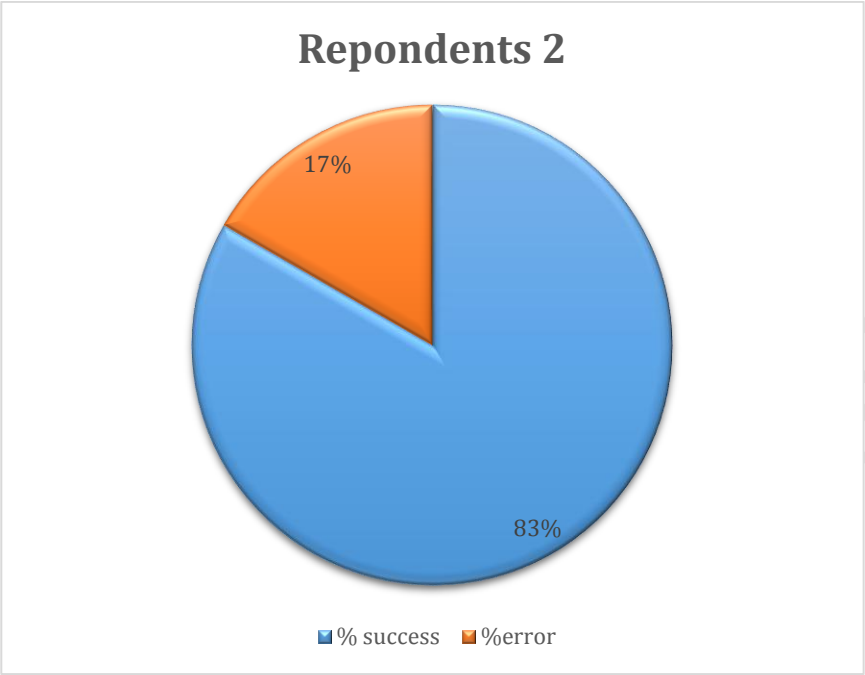

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Figure 10. Graph of the percentage of questions correctly answered by the third patient.

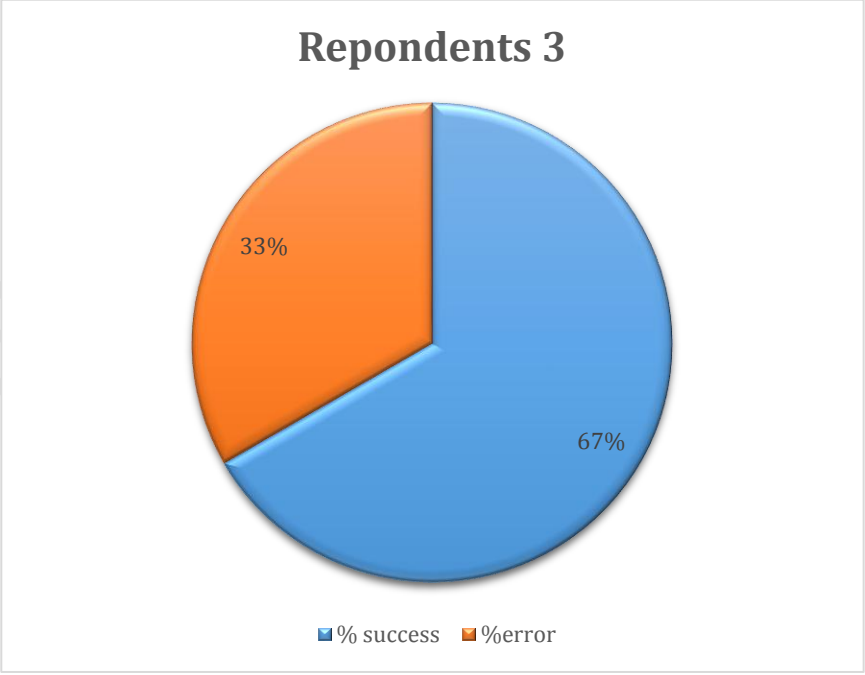

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Figure 11. Graph of the percentage of questions correctly answered by the fourth patient.

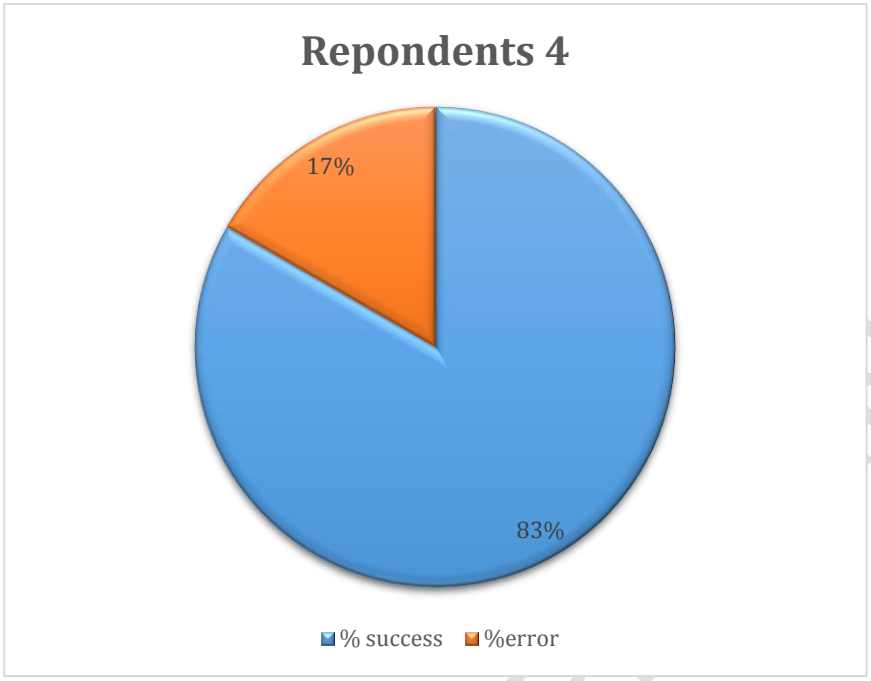

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Figure 12. Graph of the percentage of questions correctly answered by the fifth patient.

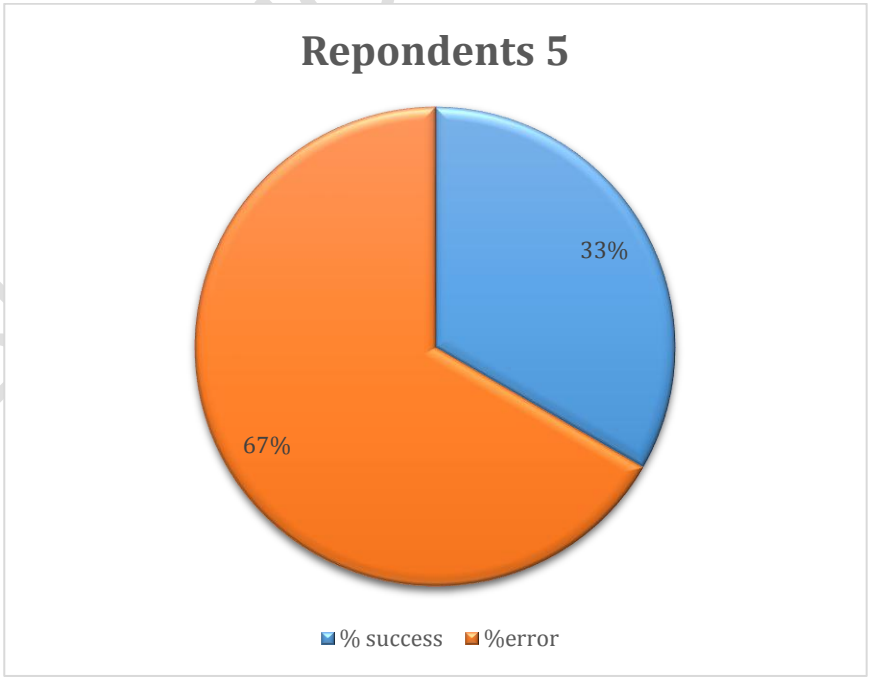

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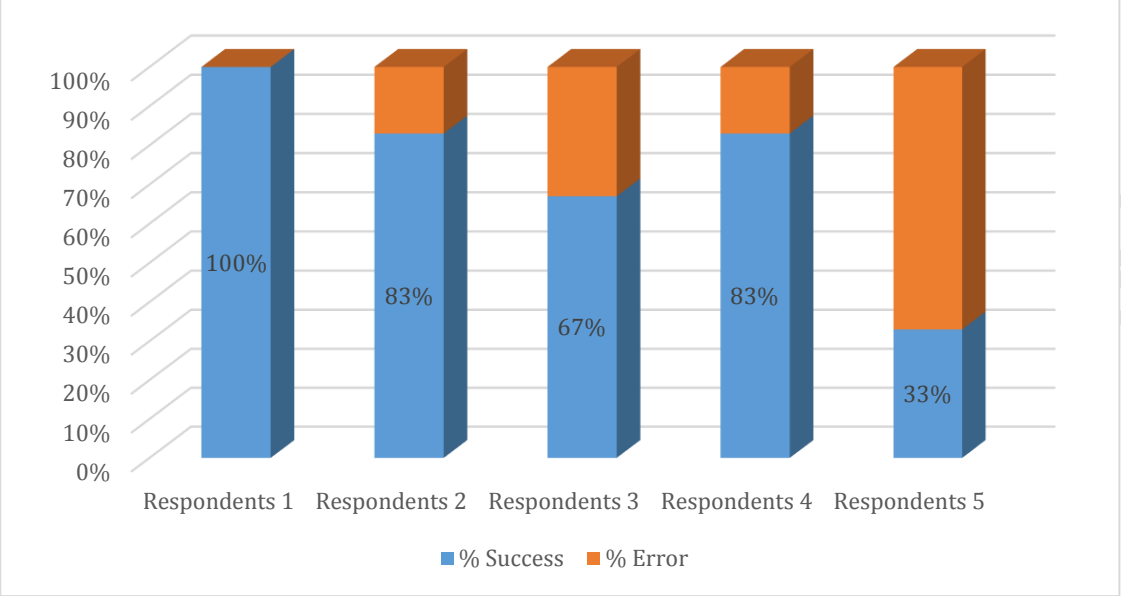
Figure 13. Bar chart of the percentage of questions correctly answered by all participants.



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At first the results were inconclusive because of the types of methodology being used for the experiment, although some of the subjects were able to pass most of the test, some who did not suffer from the disorder were not able to pass the test by more than 5%, so it was decided to omit these results, and to make tests by rotating the individuals who suffered from the attention deficit and changing, for example, characters, or tests to be passed, so that the experiment would not be repetitive, At the same time, the control of the platform was more tedious than what was thought at the beginning of the investigation, since it sometimes gave false positives, or simply did not read the expression on the face, so overcoming some of the tests was complicated by causing loss of concentration or losing focus on the details of the subjects who did not suffer from the deficit, so that the final results given by the tool could vary from those given by the professional in the field, since he took note of each fault that could give the mobile platform. The changes in the methodology were gradually made until a conclusive method was reached where the results of success, with the diagnosis of the professional, were similar.

It is observed that the fifth respondent or patient, was the one who had the best performance, and just this was the one who suffered from the already diagnosed attention deficit, although studies and tests are missing, there are very important facts to continue developing this tool.

4. Conclusions

- One of the most important factors to take into account is the age of the patient being tested. It is difficult to deal with minors who suffer from attention deficit and hyperactivity, as they are usually very irritable, and the preparation of the subject can become tedious as it is a helmet with wet electrodes.
- Some failures in the reading of facial gestures could distract people who do not suffer from the deficit, giving inconclusive results.
- Using an omnidirectional platform calls the attention of the youngest patients, and they were enthusiastic when they started the test. This and the accompaniment of the parents at every moment, helps the minors to be more relaxed and that neither he, nor the equipment used is damaged.
- The accompaniment of a professional in this type of deficit is important, since the communication with the patients and the treatment with them is a very important factor before, during and after the test.
- In the moments prior to the test, retention and follow-up of instructions are measured.
- In the moments after the test, stress levels are measured, and the diagnostic test of attention to detail is done.

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