Biofeedback based on a microcontroller and sensors for anxiety management

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Abstract— This project is based on the construction of a biofeedback capable of displaying and storing measurements of various physiological indicators, such as heart rate, muscle tension and skin sweating, which are directly related to an anxious response of the organism when facing a certain stimulus. Electronic components have been used to measure these body responses, and software has been developed to interpret them. A cost analysis has also been carried out to decide the feasibility in the event that this prototype should go through a production phase and the opinions and proposals for improvement raised by four health professionals have been analyzed, who assisted a semi-structured interview designed to measure their satisfaction and the usefulness they think the final product might have. This report shows the process that has been followed to develop this biofeedback.

Index Terms— Biofeedback, microcontrollers, sensors, Arduino UNO, SEN-11574, AT-04-001, GSR Sensor, embedded.

1 Introduction

THE main motivation that has led to this work is the curiosity and desire to generate an embedded System from scratch by the Student.

The term biofeedback is defined as a process in which the patient learns to control his or her body's responses at will through the constant receipt of information about his or her physiological response.

A biofeedback device is the electronic mechanism by which measurements of the physiological response can be obtained. In fact, its origin is in the early seventies, but this project aims to make a built-in system that is adapt to the usefulness and comfort of both the therapist and the patient, facilitating the understanding and agility of the data shown.

In the medium term, outside the completion date of the final degree project (TFG), the aim is to develop a web page with the aim of creating an environment in which the therapists who use the product can both provide new stimuli to the community as obtained from the common library. In this library it is hoped that the stimuli can be ordered, filtered and reported on the effectiveness and the number of uses of each one.

2 Objectives

The objectives that are pursued with this project are raised at two levels: the objectives of the project and the objectives of the final product.

2.1 Objectives of the Project

1. Have a microcontroller that communicates with the computer and with three sensors: one that measures the heart rate, another that takes care of muscle tension and one that measures skin sweating.
2. Implement a therapist-friendly user interface that includes the following features:
   a. Have three graphs that show in real time the measurements of the sensor that corresponds to each one.
   b. That the value of the readings is displayed and that the minimum, maximum, mean and standard deviation are calculated, also in real time.
   c. Have the reproduction of the stimulus that the patient sees in miniature format. This is especially useful if the stimulus is a vídeo, so that the therapist has an idea of what the patient is seeing.
   d. Have a notebook where various data are recorded, such as the start of the session, the moment the stimulus starts or pauses, among others, as well as possible comments that the therapist wants to write down throughout the session.
3. Make an interface oriented to the patient, in which the stimulus is shown in full screen and the measurements in real time.
4. Program the calculations of the maximum and minimum values, the means and the standard deviations relevant to each sensor throughout each session and save them in a database (DB), which must be portable and must be integrated into the program itself, so that the end user does not have to configure anything to save the data correctly.
5. Test the prototype with people and ask them to participate in a semi-structured interview that measures user satisfaction and the usefulness of the product.
6. Make two versions of the graphical part of the application for users to say what they like the most.

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7. Put the microcontroller and wiring inside a three-dimensional box.
8. Carry out a study on the costs involved in mass production of this project.

2.2 Objectives of the Final Product

1. Make measures of the patient's biological functions available when faced with stimuli. The expected consequence is that these data allow the patient to make subtle relaxation learnings for self-modification of signs and symptoms that correlate with physiological data.
2. Allow the therapist to have data on the evolution of their subjects, thus being able to establish individualized therapeutic approaches.

3 State of the Art

3.1 As for the Hardware

For the preparation of this work, certain principles have been respected, such as simplicity and efficiency. This has also been taken into account when choosing each component.

3.1.1 Arduino UNO REV 3

As for the microcontroller, the Arduino UNO R3 has been chosen because this project is focused on developing a prototype of an idea that wants to know if it is useful for the psychology sector or some other field of science and / or the investigation. It is intended to prioritize a good data collection and take advantage of the availability of the Arduino libraries, which facilitate part of the work when programming the firmware. This programming has been done with the Arduino integrated development environment (IDE), which is open source.

Regarding the selection of the sensors, it has been valued that they have user manuals to facilitate intelligibility, as well as compatibility with Arduino.

3.1.2 SEN-11574

It is the sensor responsible for measuring the heart rate.

3.1.3 AT-04-001

This sensor measures muscle tension.

3.1.4 GSR Sensor

It is the sensor that measures the sweating of the skin, that is, it measures its galvanic resistance.

3.1.5 Serial Communication

Serial communication is a digital data communication protocol in which information is transmitted sequentially (bit by bit). To carry it out, a USB cable is used that connects to the microcontroller and to the computer.

This type of communication has been chosen because this project is designed to be used on a computer, either fixed or portable and, therefore, the 5V provided by the USB connection can be used to power the microcontroller and avoid using external batteries.

3.2 As for the Software

3.2.1.NET Framework

Visual Studio Community 2019 has been used to implement the software because it is an extensible and free integrated development environment (IDE) for individuals, which allows creating modern applications for various operating systems, such as Windows, Android and iOS.

The .NET framework has been used because it is a free and open source development platform that is compatible with Windows, which is the most widely used operating system on PCs and this facilitates integration and is easily understood by most users. This does not mean that it cannot be developed for other operating systems.

The programming language used is C# because it is a language that integrates very well with the Windows operating system. While it is true that Visual Basic is an alternative to .NET framework, C# has been chosen because the way it is programmed is very similar to C or C++, which are the languages that have been studied the most throughout the degree.

3.2.2 Windows Forms Library

The Windows Forms library has been used to implement the program's interface because it is open source and free. Although there are other libràries more modern than Windows Forms such as WPF and UWP, Windows Forms has been chosen because a project of Microcontrollers and Peripherals subject was programmed using it, and its proper functioning was validated. In addition, both WPF and UWP are designed to make user interfaces more complex than what is needed for this prototype.

3.2.3 Llibreria LiveCharts

The therapist view of the software contains graphs that show the sensor readings in real time. The LiveCharts library has been used to make them because it is a very flexible, free and open source tool. In addition, they offer tutorials and project examples that help to understand how it works.

3.2.4 SQLite

SQLite has been used to implement the program's DB because it is portable and this allows the data to be automatically saved on the end user's computer, without him having to perform any additional steps.

4 Methodology

To implement this TFG, the student and the tutor meet every fifteen calendar days to supervise what work has been done so far and establish the objectives for the next meeting.

For the management of this project and the tasks that are derived, the Kanban methodology is used through a web page called Trello [4].

In addition, the code is versioned to the student's GitHub account [5] so that, every time a significant change is made to the program code, it is updated to its repository.

Sketches of user interfaces are made using a web application called InVision [6].

5 DEVELOPMENT

5.1 As for the Hardware

5.1.1 Pine Allocation

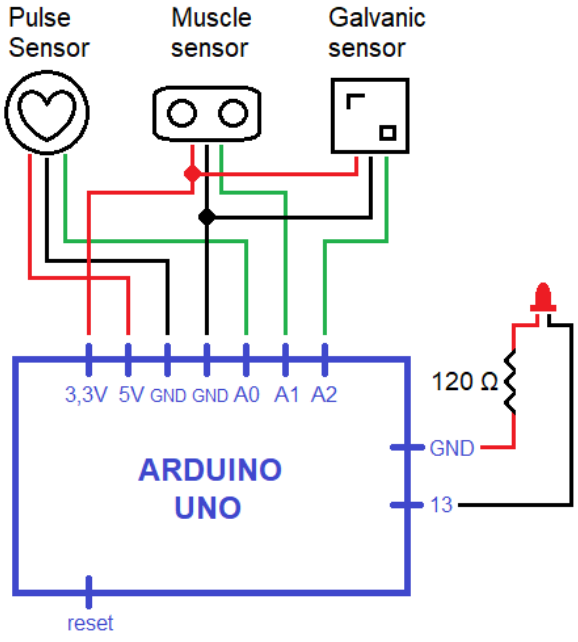

Illustration 1 - Pin allocation schematic

Pin control register	Annotation
Reading: (ADC0) PC0, pin 23 (AD0)	A0 Pulse Sensor
Reading: (ADC1) PC1, pin 24 (AD1)	A1 Muscle Sensor
Reading: (ADC2) PC2, pin 25 (AD2)	A2 Galvanic Skin Sensor

Illustration 2 - Pin control register

5.1.2 Programming

Two different firmwares have been programmed: the first of them is called *Arduino Code - Project* and is responsible for receiving the measurement of heart rate, muscle tension and skin sweating, as well as offering the possibility of check that the connection between the PC and the Arduino is established correctly.

The other firmware is called *Arduino Code - Data in CSV format* and has been used to convert the sensor data into CSV format in order to analyze it later to assess the proper functioning of the sensors.

5.1.2.1 Arduino Code - Project

This algorithm is made up of four tasks, which are the following:

- The first one is in charge of receiving the orders from the computer. It is used when controlling the LED, which lights up whenever it is verified that the connection between the Arduino and the PC is correct.
- The second task is responsible for sending the measurements made by the pulsation sensor. It sends a packet in JSON format that contains the microcontroller identifier, the sensor identifier, and the value it has measured each time a heartbeat is detected. It has been chosen to send it in JSON format because it is an open standard that has a structured and easy to understand format.
- The third task sends the measurements of the muscle sensor every 500 ms in packets that follow the same format and that have the same structure as that of the pulsation sensor.
- The fourth task sends the value of the galvanic response every 500 ms in a package structured in the same way and that follows the same format as the rest of the sensors. However, the galvanic sensor requires a noise filter to be applied to avoid outliers, which consists of taking the average of the last 50 samples.

5.1.2.2 Arduino Code - Data in CSV format

In this case, the procedure consists of three tasks:

- Every time a heartbeat is detected, task 1 sends the device identifier, the sensor identifier and the value detected by the sensor in CSV format over the serial port. CSV files are used to handle a large amount of data in table format.
- Task 2 sends the information referring to the muscle sensor every 500 ms, which follows the same structure and format as the previous task.
- Task 3 sends the information from the galvanic sensor every 500 ms following the same structure and format as the two previous tasks. In this case, the same filter mentioned in the *Arduino Code - Project* section is also applied.

5.1.3 Three-dimensional box

A three-dimensional wooden box has been used to protect and transport the electronic components, while allowing a friendlier use in terms of connection to the computer and the use of the sensors, since it allows to use and store them without having to disconnect them.

Illustration 3 - Wooden box that stores electronic components.

5.2 As for the Software

Two interfaces have been programmed: the therapist's view and the patient's view.

5.2.1 Therapist Window

The therapist window is the most complex one and consists of the sections explained below:

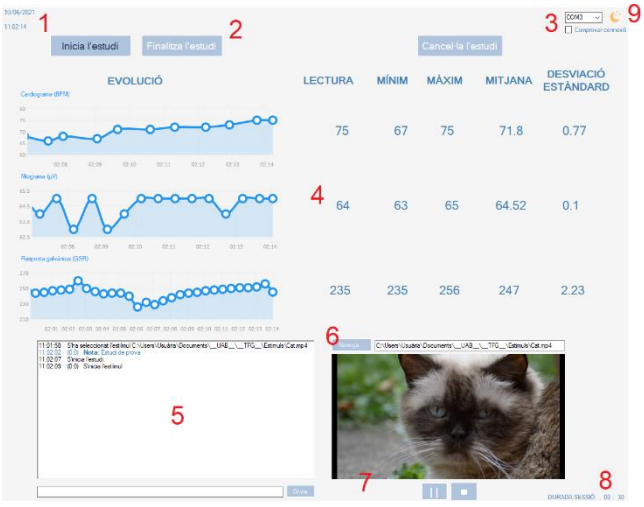

Illustration 5 - Therapist window in light mode

1. In the upper left-hand part there is the current day and time.
2. More to the right there are buttons that allow the user to control the pause, the resumption and the restart of the patient study. That is, if it is started, the measurements of the sensor are displayed and, when it is stopped, the maximum, minimum, means and standard deviations of each sensor that are displayed at the moment of pressing the *End Study* button.

   Initially, among the three buttons, only the *Start Study* button can be pressed. If this is done, the maximum and minimum values, the mean and the standard deviation begin to be observed and the *Cancel Study* and *End Study* buttons become available. The stimulus can only be reproduced if the study has been started. Otherwise, a message appears that tells it, as shown below:

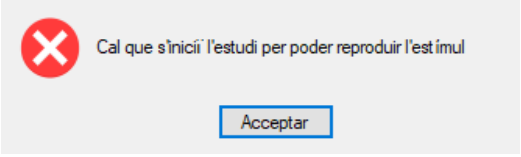

Illustration 6 – Error message #1

   The *Cancel Study* button stops showing the statistical summary values, allows the user to start the study again and makes the button used to end it as unavailable.

   The *Finish Study* button does the following tasks:
   - It deactivates the availability of the *Cancel Study* button and activates the *Start Study* button.
   - Stop showing the statistical summary.
   - It opens a new form that warns that several data have been saved, such as the date of the session, its duration and the statistical summary (they are saved in the portable DB). In addition, it asks if the therapist wants to collaborate in the improvement of the tool by allowing the data mentioned above to be sent, as well as the stimulus that has been reproduced, to a web page that is discussed in the Design of a web page section.

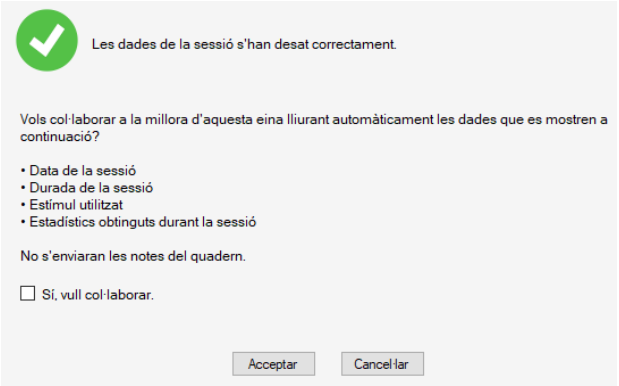

Illustration 4 - "Finish Study" button form

3. The port to which the Arduino is connected is shown and there is a check box that is used to check if the connection has been established correctly. If so, the LED that is connected to the breadboard lights up.
4. Zone 4 is a table divided into two sections: on the left there are the graphs of each sensor and on the right there is a summary of the basic statistics of the data that has been measured.

   When the application is started, initially no value is shown to the statistical summary, but only the real-time readings are seen in the graphs and in the *READING* column.
5. At the bottom left there is a notebook that automatically records all the actions that are carried out during the session, as well as the notes that the therapist points out manually, which are displayed in a different color to easily distinguish them from the rest of the records. Each record shows the time in which it was executed and also the minute of the stimulus, if it is being played.
6. The *Browse...* button opens the file manager to select the stimulus to play, either in video or audio format.
7. In the psychologist's window there is an area reserved to show the stimulus in reproduction. It has some control buttons to start, to pause, to restart and to stop it.
8. Shows how long the user has been logged in.
9. Lastly, this window has a light and a dark mode. The therapist can choose the one that suits him best by pressing the button in the shape of the Moon, in case it is in light mode, or the button that represents the Sun, in case it is in dark mode.

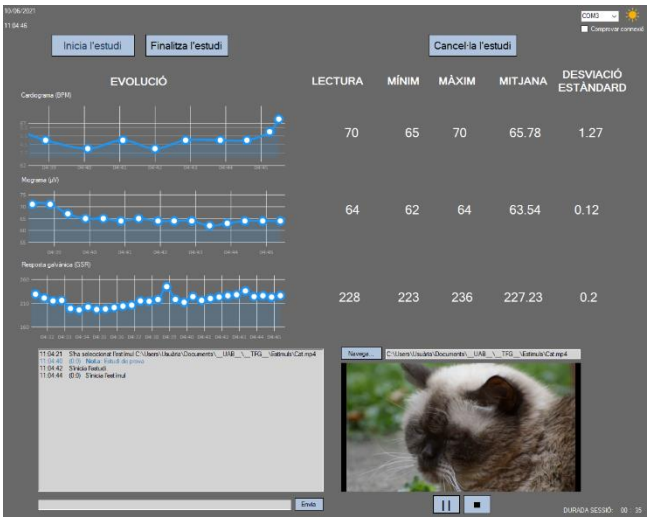

Illustration 7 - Therapist window in dark mode

In the event that the program is started without having the Arduino connected through the USB port, an error message appears informing it:

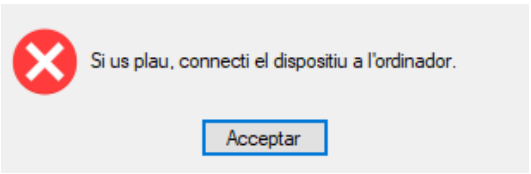

Illustration 8 – Error message #2

5.2.2 Patient window

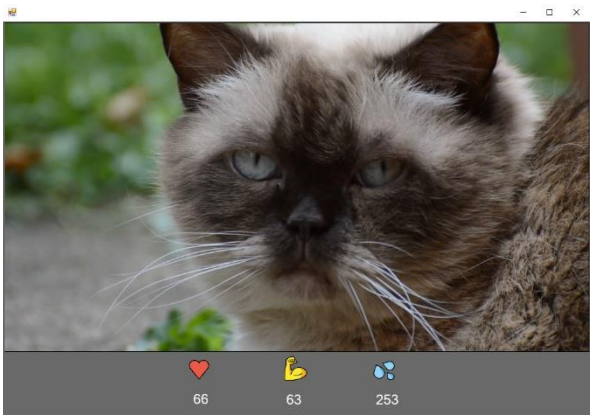

Illustration 10 - Patient window

In the patients' view only the stimulus chosen by the therapist and the values measured by the sensors are shown. It does not have control buttons because the start, pause, restart and stop of the stimulus are made when the therapist uses the control buttons mentioned in point 7 of the previous section.

This window is intended to be attached to a second monitor or projector for more convenience.

The Emoji at the bottom are open source, free to use and designed to intuitively communicate the meaning of the data shown below.

5.2.3 Database

Below there is a representation of the DB design made with MySQL Workbench:

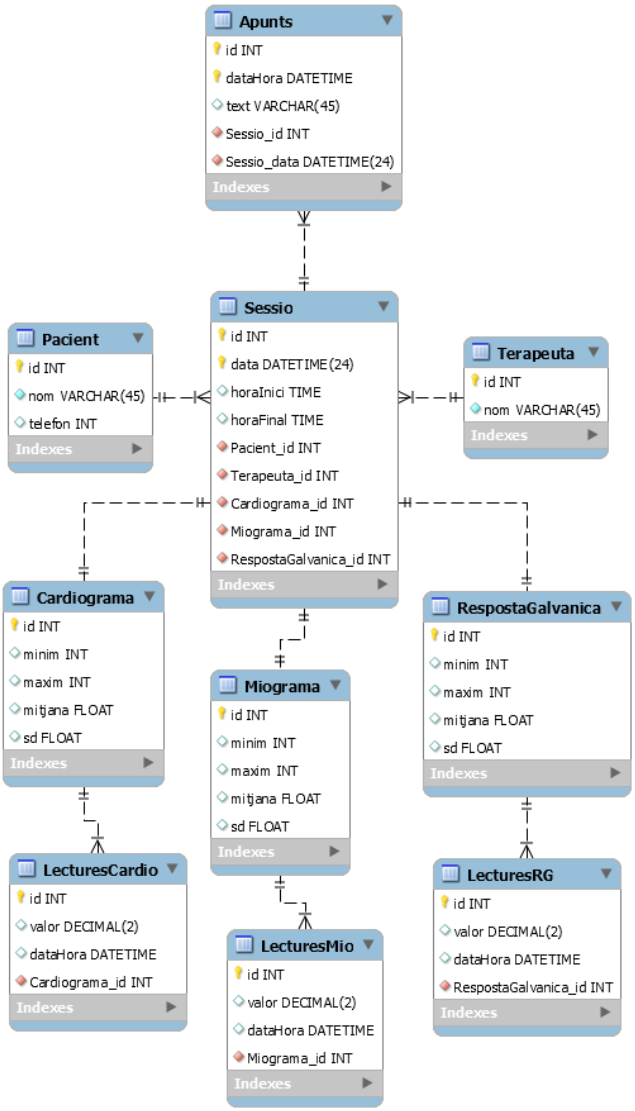

Illustration 9 - BD class diagram

5.2.4 Design of a web page

To add value to the project, a study has been made on what should be done to achieve a website that aims to create an environment in which the therapists who use the product can both provide new stimuli to the community and obtain new ones from the common library .

In this library it is intended that the stimuli can be ordered, filtered and reported on the effectiveness and the number of uses of each one.

This web page would look similar to the following draft:

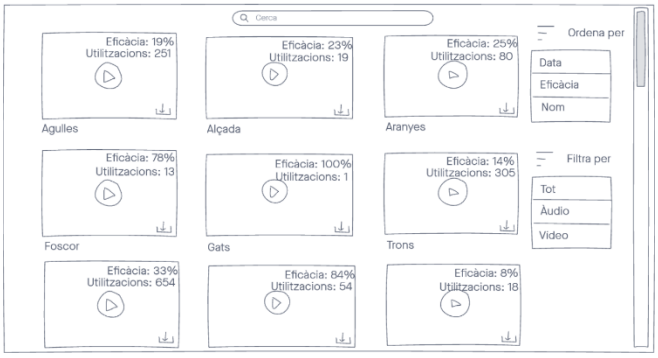

Illustration 11 – Webstie design

To make a web page a service is needed to run a web client and a DB. The web client would serve to display the data and the DB to save them.

As it is necessary for this system to be scalable to achieve its objective, the service that Amazon proposes for the creation of web pages would be hired, which is called Amazon Web Services (AWS).

AWS offers several solutions, which are suitable for various types of web pages.

For this project, the one called *Amazon Elastic Compute Cloud (Amazon EC2)* would be chosen, given its scalability and flexibility in data storage.

5.3 Interviews

To add value to the project, four people have been summoned to test the prototype and they have been given a semi-structured interview to measure their satisfaction and the usefulness they think the final product could have.

The rubric of the interview can be seen in Annex I of the Progress Report II.

The interview asks to assess the utility, usability and comfort and possible proposals for improvement of various aspects of the prototype, such as the following:

- The project in general
- The clear interface
- The dark interface
- The graphs
- Individual statistics (from the local application)
- Comparative statistics (the web application)
- The therapist's view
- The patient's view
- The hardware

Four subjects representing the four main areas in which the final product could be directed have been sought. The subjects interviewed were the following:

- Àngela Toscas de la Fuente: psychologist
- Martí Espín Baldebey: physiotherapy student
- Judit Bordas Rovira: medical student
- Roser de Casademunt Porta: nurse

5.3.1 Quantitative analysis

Negative	0: Not at all 1: A little
Positive	2: Quite a lot 3: A lot

AREA		Ease of use / comfort	Light mode interface	Dark mode interface	Graphics	Individual statistics (local application)	Comparative statistics (web application)	Therapist view	Patient view	Hardware	
Psychology	UTILITY	-			3	3	3			3	3.00
	USABILITY	3									3.00
	COMFORT		3	1		3			3	3	2.60
Physiotherapy	UTILITY	-	2	3	3	3	3	3	3	3	2.88
	USABILITY	2									2.00
	COMFORT		2	3							2.50
Medicine	UTILITY	-	3	2	3	3	3	3	3	3	2.88
	USABILITY	3	3	2	3	2	3	3	3	3	2.78
	COMFORT	3	3	3	3	3	3	3	3	1	2.78
Nursery	UTILITY	-	3	3	3	3	3	3	3	3	3.00
	USABILITY	3			3	3	2				2.75
	COMFORT	2				3	3				2.67
	UTILITY	-	2.67	2.67	3.00	3.00	3.00	3.00	3.00	3.00	2.92
	USABILITY	2.75	3.00	2.00	3.00	2.50	2.50	3.00	3.00	3.00	2.75
	COMFORT	2.50	2.67	2.33	3.00	3.00	3.00	3.00	3.00	2.00	2.72
		2.6	2.8	2.3	3	2.8	2.8	3	3	2.7	2.80

Illustration 12 - Quantitative analysis

5.3.2 Qualitative analysis and proposals for improvement

In this analysis, positive comments, negative comments and suggestions for improvement have been collected from the interviewees. However, in this section only negative comments and proposals for improvement are analyzed because they are what lead to new ideas to improve the prototype. Tables containing all the contributions of the interviewees, including positive comments, are shown in the Appendix.

On the one hand, negative comments are in the red boxes and the improvement proposals are in orange.

Topic [priority]	Comment	Analysis
Dark mode interface Medium priority	Graphs look worse.	Changing the font color could be appreciated.
	It requires her to wear glasses.	It could be considered to make a version adapted to people with visual difficulties.
Graphs Low priority	Each graph could be a different color to make it easier to distinguish.	It could be valued. It is an aesthetic or comfort element.
•**Graphs** •**Individual statistics**	It could be added a new functionality consisting of giving to the therapist the option of	It could be assessed, but it should be accompanied by an analysis of which are the

Topic [priority]	Comment	Analysis
(local app) Prioritat mitjana.	generating a summary of the progress of all the sessions at the end of the therapy. This would be useful in case a multi-disciplinary therapy is done, for example combining psychiatry and psychology. A comparison with the subjective vision of the patient could also be done.	necessary and sufficient variables that should be collected in each session.
Comparative statistics (web) Medium priority	Difficulty in measuring the efficacy.	It would be necessary to make an operational definition of the concept of effectiveness and establish the measurement variables.
	It should be verified that the data provided on the website has been collected by qualified personnel.	A method of identifying or validating the user using the application could be implemented.
	The web could have an option to create lists of favorite stimuli, so that the therapist can access them more quickly.	It could be useful in the long run, when the volume of stimuli is difficult to manage.
Therapist's view Low priority	It has been difficult for him to find the button that is used to choose a stimulus.	A brief manual or tutorial could be shown the first time the application is started.
	A functionality could be added that associates a set of sessions based on some variable (e.g. phobic patients who are men).	It could be assessed, but it should be accompanied by a careful analysis of what are the necessary and sufficient variables that should be collected in each session.
	The user could also see the information from previous sessions during the current session.	
Patient's view Low	In case only an audio is played, make the Emoji and the relevant values	Es podria valorar. És un element estètic o de con-fort.

Topic [priority]	Comment	Analysis
priority	occupy the center of the screen.	
•Therapist's view **• Patient's view** High priority	The raw value presented by the sensor does not provide enough information. The subject would need that to be on a scale with a minimum and a maximum value. Example: percentage, grade from 0 to 10 or color gradient.	Cal definir l'escala i situar-hi els valors.
	Use a color gradient and, for example, make the value redder as it approaches the limit of normality.	
	Place the values of the sensor readings within a range with a minimum and a maximum value that represents normality.	
Hardware Low priority	It is difficult to decide which muscles the electrodes should be attached to.	This information is linked to the profession of each user. In any case, this information could be added in the tutorial or in the user manual.
	For obsessive patients, this should be accompanied by additional hygiene guidelines prior to skin contact.	
	She thinks the measure of respiratory constant should be added, as anxiety can lead to hyperventilation.	Es podria valorar.
	She would like a single electrode to have all the sensors integrated to minimize the volume of the hardware and facilitate the connection to the patient's skin.	Aquesta proposta no sem-bla viable però caldria fer un estudi exhaustiu.
Utility in the area Low	As doing a treatment with a biofeedback requires work that must be	This information is linked to the profession of each user. In any case,

Topic [priority]	Comment	Analysis
priority	done before surgery, it is suitable for scheduled patients, but it is not applicable to patients who have an urgent intervention.	this information could be added in the tutorial or in the user manual.

Table 1 - Suggestions for improvement and negative comments proposed by the interviewees

In addition, the student's suggestions for improvement are as follows:

Topic	Comment
Therapist's view Medium priority	An advanced configuration section in which aspects such as the following could be added in: • The number of readings per second of the muscle sensor and the galvanic skin sensor • Remember how to start the application whether in light or dark mode. • Give the option to remember the permission to deliver information to the cloud
	Provide the link to the cloud webpage.
	In addition to the *Browse...* button, give direct access to the cloud library.

Table 3 - Proposals for improvement of the student

5.3.3 Conclusions of the interviews

Based on the quantitative evaluation criterion, all the mean values of the evaluated scales exceed the score of 2 (quite a bit). This suggests that the product is well valued but, obviously, there are aspects for improvement, which qualitative analysis offers.

The qualitative analysis shows that the interviewees made positive comments, negative comments and proposals for improvement.

Regarding negative comments and proposals for improvement, the order of approach would be made from the perceived priority, starting with those tasks with high priority and ending with those considered medium and low, in this order. Therefore, the first proposal to be implemented would be to define a scale, either numerical, percentage and/or a color gradient to place the values of the sensor.

5.4 Calculation of the costs of mass production

5.4.1 Application conditions

The calculation takes into account:

- The production of 36 units
- Prices are approximate and are rounded
- A plate packaging (box printed with a 3D printer)

The calculation does not contemplate:

- The price of delivery of the goods
- Quantity discounts (rappel)
- A package for the sensors
- Taxes (VAT and personal income tax)
- The statements
- The costs of administrative and commercial management, as the cost of production is being studied.

5.4.2 Cost table

Product	Unit price	Quantity	Fixed cost	Variable cost
Printed circuit (manufacturing)	25 €	36		900 €
Printed circuit (components)	30 €	36		1080 €
Printed circuit (soldering)	15 €	36		540 €
Sensor1	20 €	36		720 €
Sensor2	31 €	36		1116 €
Sensor3	9 €	36		324 €
3D box	10 €	36		360 €
Software implementation	25 €/h	180	4500 €	
Hardware design	25 €/h	20	500 €	
Firmware implementation	25 €/h	40	1000 €	

Product	Unit price	Quantity	Fixed cost	Variable cost
Software update	25 €/h	100		2500 €
AWS EC2 50GB (1 year)			200 €	

Total	**13740 €**		**6200 €**	**7540 €**
Unit cost	**382 €**			

Table 2 - Cost table

As for the three-dimensional box, it has been assumed to be manufactured with a 3D printer with polylactic acid (PLA).

6 Conclusion

From the point of view of the project, the objectives set out as follows have been achieved:

1. There is a microcontroller that communicates with the computer and with three sensors: one that measures the heart rate, another that is responsible for muscle tension and one that measures skin sweating.
2. A user interface for the therapist has been implemented that includes the following functionalities:
   a. It has three graphs that show in real time the measurements of the sensor that corresponds to each one.
   b. The value of the readings is shown and the minimum, maximum, average and standard deviation are calculated, also in real time.
   c. There is a miniature of the reproduction of the stimulus that the patient sees. This is especially useful if the stimulus is a video.
   d. A notebook is available where various data are recorded, such as the start of the session, the moment the stimulus starts or pauses, among others, as well as possible comments that the therapist wants to write down throughout the session.
3. A patient-oriented interface has been developed, showing the stimulus in full screen and real-time measurements.
4. The calculations of the maximum and minimum values, the means and the standard deviations

pertinent to each sensor throughout each session have been programmed and are saved in a portable database that is integrated into the program itself, so that the end user does not have to configure anything because the data is saved correctly.

5. The prototype has been tested with people and they have been asked to participate in a semi-structured interview that measures user satisfaction and the usefulness of the product.
6. Two versions of the graphical part of the application have been made so that users can use the one they like best.
7. The microcontroller and wiring have been placed inside a three-dimensional box.
8. A study on the costs involved in mass production of this project has been carried out.

From the point of view of the final product, as a complementary aspect of the work, the following points need to be highlighted:

1. The patient has the measures of his physiological response available and, therefore, he or she is able to put into practice subtle strategies to modify it, as shown by the study [3] in the second paragraph.
2. As the design of the application works for sessions and saves its history in the DB, it can be considered that a base structure that would allow the implementation of a design of therapeutic plans, in case one wants to convert this protip into a marketable product, has already been created.

7 PROSPECTING

Now that the information that has appeared during the completion of this work has been analyzed (which goes beyond the possibilities of this TFG), the following actions would be taken if this project had to be continued:

- Implement proposals for improvement that are assigned a high and medium priority.
- Make the software compatible with other operating systems other than Windows.
- Specify lines of future action in reference to hardware optimization and free potential with other disciplines such as artificial intelligence, mass data analysis and virtual reality.

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APPENDIX

A1. Quantitative analysis and proposals for improvement

- **Positive comments**
- **Negative comments**
- **Improvement aspects**

Psychology

Objectives of use	Utility in the area		Light mode interface	Dark mode interface	Graphs	Individual statistics (local application)	Comparative statistics (web application)	Therapist view	Patient view	Hardware
With phobias, post-traumatic stress, generalized anxiety and panic attacks.	Not all candidates are suitable, so the emotional part is not covered (everything is physiological). Best candidates: people who want to have a high capacity for control.	**UTILITY**			Very visual, basic and deductible.	Provide necessary and sufficient information.	It should be verified that the data provided on the website has been collected by qualified personnel. Difficulty in measuring effectiveness.		Aporta informació necessària i suficient.	It is a must.
		USABILITY		She whould use it in dark environments.						
		COMFORT	More comfortable than dark mode because she can see it better.			She likes the organization.		The raw value presented by the sensor does not provide enough information. The subject would need to be placed within a scale with a minimum and a maximum value. Example: percentage, grade from 0 to 10, or color gradient.		It is not invasive because the patient does not have to undress or prick. As it does not stress, it does not interfere with the physiological response. For obsessive patients, this should be accompanied by additional hygiene guidelines prior to skin contact.

- Positive comments
- Negative comments
- Improvement aspects

Physiotherapy

Objectives of use	Utility in the area		Light mode interface	Dark mode interface	Graphs	Individual statistics (local application)	Comparative statistics (web application)	Therapist view	Patient view	Hardware
A fear confrontation with the machine can help overcome the real treatment later. It can also be useful to see the vital signs when making the muscle contractibility and to verify that if it activates or contracts well, comparing it with the response of the muscle on the other side.		UTILITY			They are very understanding and allow you to quickly understand behavior and trend.		It allows to understand and isolate specific fears to be able to treat in a specific way.	You can see at the same time the vital constants and the facial or body reactions of the person.	The patient can quickly understand which constant to try to lower or what the goal is.	It is a must.
		USABILITY								
		COMFORT		The "Browse..." button is better visible. Everything, in general, is seen more clearly because there is more contrast. He likes this interface better.		They are quickly understood.		It has been difficult for him to find the button that is used to choose a stimulus.		The size of the electrodes is correct, although in physiotherapy they are usually a little bigger.

- **Positive comments**
- **Negative comments**
- **Improvement aspects**

Medicine

Objectives of use	Utility in the area		Light mode interface	Dark mode interface	Graphs	Individual statistics (local application)	Comparative statistics (web application)	Therapist view	Patient view	Hardware
It is applicable in the field of psychiatry and also in people who have been hospitalized for a long time, because this generates anxiety. It can help keep track of fears. It works well to objectify anxiety or fear.	Fears can be treated in psychiatry and in other areas, such as hospitalization.	UTILITY			They are very visual and easy to interpret. She likes that they update in real time.	They are useful for narrowing (making an exact study) but they are not essential for interpreting the data.	Very useful, especially if there is more than one video of the same stimulus, as you could see which is the most effective.		Emojis make it easier to understand values and they are fun.	It is a must.
		USABILITY	She would use it in a light environment (in most situations).	She would use it in a dark environment.	A functionality could be added that, at the end of the therapy, would give the option to generate a summary of the progress of all the sessions. This would be useful in the event of multidisciplinary therapy, for example combining psychiatry and psychology, and being able to make a comparison with the patient's subjective view.		The web could have an option to create lists of favorite personal stimuli, so that the therapist can access more quickly.	Use a color gradient and, for example, make the value redder as it approaches the limit of normality.	In case only an audio is played, make the Emoji and the relevant values occupy the center of the screen.	It is difficult to decide which muscles the electrodes should be placed on. She thinks the measure of respiratory constant could be added, as anxiety can lead to hyperventilation.
		COMFORT	It is very pleasing to the eye. The graphs look better.	It conveys tranquility. Statistical values are better seen. The graphs look worse.		She likes that the values are aligned with the relevant graph.	She likes that the efficiency and the number of uses are within the box of the video thumbnail and that they are seen directly, without having to put the cursor over, for example.	It is very neat.		She would like a single electrode to have all the sensors integrated to minimize the volume of the hardware and facilitate the connection to the patient's skin.

- Positive comments
- Negative comments
- Improvement aspects

Nursing

Objectives of use	Utility in the area		Light mode interface	Dark mode interface	Graphs	Individual statistics (local application)	Comparative statistics (web application)	Therapist view	Patient view	Hardware
Avoid certain patient responses to stimuli that may stress them. In some cases it can avoid problems such as body tension surge.	It might be interesting for some people to have prior preparation for surgery. As doing a treatment with a biofeedback requires work that must be done before surgery, it is suitable for scheduled patients, but it is not applicable to patients who have an urgent intervention.	UTILITY		As it is relaxing, it would be a good idea to use it in case the therapist spends many hours in front of the screen.	It allows to see if the values are stable or there are alterations.	Provides necessary and sufficient information.	The percentage of effectiveness allows to discriminate certain stimuli and choose what is considered the most convenient.			
		USABILITY								
		COMFORT	She would use it in case of not wearing the glasses.	It conveys tranquility. It requires her to wear glasses.	They are seen very clearly. Each graphic could be a different color to distinguish them more easily.			It is very easy to understand. A functionality that associates a set of sessions based on some variable (e.g. phobic patients who are men) could be added. Information from previous sessions during the current session could also be viewed. Place the values of the sensor readings within a range with a minimum and a maximum value that represents normality.		