A Serious Game Development and Usability Test for Blood Phobia Treatment - PHOBOS

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Abstract: This paper addresses the development of the serious game PHOBOS, a virtual reality exposure therapy game for the treatment of blood-injection-injury phobia, also known as hemophobia. The virtual reality game which incorporates biometric sensors was upgraded from a 2018 version to perform usability tests to get the game ready for clinical trials. With this project we expect to contribute to the development of a framework that can be used by physiologists in the treatment of their patients with hemophobia.

1 INTRODUCTION

Serious games have been used for treatment of phobias, social anxiety disorder, amongst other disorders (Li, S. et al., 2022). While about 10% of the worldwide population suffer from a specific phobia, there have been further improvements on the development of VRET (Virtual Reality Exposure Therapy) and ARET (Augmented Reality Exposure Therapy) for its treatment (Albakri, G., et al., 2022; Freitas, J.R.S., et al., 2021; Jiang, M., et al., 2020, Li, S. et al., 2022). The technological evolution on game engines, virtual reality and biometric sensors provides new possibilities for the work as we can get more realistic graphics with a higher framerate producing a more immersive experience and therefore providing the user a more focused therapy (Bond, A. et al., 2017).

With this project we aim to improve the research and development of VRET serious games. The game will be combined with biometric sensors for data acquisition that will have impact in the game mechanics allowing to implement and control the exposure to blood in a dynamic and player adapted way. The aim is to develop a solid serious game for the treatment of the blood-injection-injury phobia by exposing the player to progressive and dynamic blood stimuli controled by the players' heart rate and stress levels. The player will be taught on how to avoid fainting by using applied tension exercises when he/she recognises that his/her blood pressure is getting lower (Vögele, C., et al. 2003). This game is PHOBOS, a photorealistic serious game for VRET, which addresses this specific issue, (Petersen, J. et al., 2019). This project started in 2018 having reached a demonstration version.

This paper is organized in five sections. Section 2 presents the related work which describes the work done on the subject so far, from serious games for VRET on disorders and phobias, to the specific-phobia, blood-injection-injury phobia. Section 3 describes the project development section with the funcional and non-funcional requirements sub-section, where we highlight the features of the project and its atributes, the storyboard sub-section which has a description of the narrative and the example steps the user can take on the playthrough, followed by the hardware used sub-section. Section 4 details the usability questionnaire section with the questions for

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usability tests that we intend to do. Finally, section 5 adresses the final remarks and future work.

2 RELATED WORKS

Phobias are excessive or irrational fear of an object or a situation, which can be divided in two categories, social phobias, and specific phobias. In the case of specific phobias, the irrational fear is caused by a specific object or situation (Singh, J., Singh, J., 2016). BII (Blood-injection-injury) phobia, also known as hemophobia, is a specific phobia that is characterized by the fear of blood, injury, and injections, interfering with a person's ability to function in their daily life on more severe cases (Abado, E. et al., 2021). There is a unique physiologic response pattern with this phobia, which is the rise of heart rate and blood pressure followed by the sudden fast drop which leads to faint due to the low oxygen supply to the brain (Vögele, C., et al. 2003).

Treatment methods for the treatment of BII phobia include cognitive therapy with graded desensitization, *in vivo* and imaginal exposure, and a combination of exposure therapy with relaxation (Vögele, C., et al. 2003). The most used treatment for this phobia is exposure therapy with applied tension, consisting of exposing the patient to the phobic stimuli followed by applied tension exercises (Hellström, K., et al., 1996; Öst, L., et al., 1991,). The applied tension exercise is composed by tensing their major body muscles when they detect a drop in blood pressure (Hellström, K., et al., 1996; Öst, L., et al., 1991; Vögele, C., et al. 2003).

The advances of virtual reality paved the way for VRET for the treatment of phobias, allowing a more controlled environment and exposure to the phobia (Krzystanek, M., et al., 2021) like the *in vivo* exposure therapy. There are ongoing studies on VRET, such as the virtual environment for treating multiple types of phobias by VRET on a handheld virtual reality headset (Jashwanth, K., et al., 2020), and the case study for one session treatment of BII phobia which suggests improvements in their fears (Jiang, M., et al., 2020). Following these trends, we consider that the development of a VR game with interactable objects, movement, immersion, and an adequate storyboard that measures biometric signals can improve the treatment of patients with hemophobia and be a better alternative to the virtual reality experiences done so far.

3 PROJECT DEVELOPMENT

3.1 Functional and Non-Functional Requirements

The game will be a 3D virtual reality single-player first-person game, where the player, as the user who will play the game, will be allowed to move freely through the game scenario with the rigid body of the VR set which the player controls. There will be collisions between the VR rigid body and game objects, that could be static, interactive, and movable objects. The sensor must register data with its ECG (Electrocardiography) data acquisition for future dynamic control over the phobic stimuli. There will be spatial sound objects placed on specific objects to increase immersion, for instance, the sound of the air conditioners when the player gets near them. The game will have mechanics to unlock doors, to solve puzzles made of paintings, or to grab and inspect objects. And the game must have blood objects for phobic stimuli, distributed gradually over the various rooms of the scene for gradual exposure.

For the non-functional requirements, the main requirement is that the player feels that the blood is realistic enough to trigger the phobia, followed by the immersion, so that the player can be fully committed to the exposure therapy. The game must have medium to high frames per second, preferably above 30, the sensor must have a continuous connection to the computer, the area for the VR system must be unobstructed to reduce the possibility of accidents.

3.2 Storyboard

To create a narrative that included blood it was selected, amongst other studied possibilities, a crime scene due to its probable blood/agressive character. We priviledge this option instead of others studied in the process for its logical creation of an environment that will likely show a blood exposure situation which will create a more immersive and even a surprise effect to the player.

The player is a police officer who is called to go to the game scene, a penthouse, because the neighbours reported screamings after a stranger entered the house.

The player exits the elevator, and arrives in the entryway of the house where he/she has to find a spare key hidden in one of the plant vases. In this area there is no blood stimuli, and is a place where the player can get aquainted with the controllers.

The player opens the now unlocked door and he/she sees an interactable landline phone on a cabinet with a voice message to his/her right, the living room in his/her front, two doors to his/her left and one to his/her right behind a bar counter. If the player chooses he/she can interact with the phone to hear the message and then enter the living room, Figure 1, exploring it and finding a broken glass, a small bloodstain on the carpet and a mobile phone between the couch and the center table. The level of phobic stimuli on this room is very low having only the small blood-stain. The player can interact with paintings on the left side of the room which drop another key that unlocks the next room.

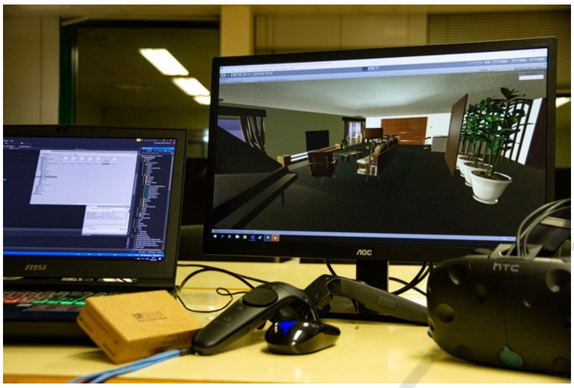

Figure 1: Phobos' living room.

As the player opens the door to the bedroom he/she is met with bloodied sheets, in the bed in front of him/her and a bloodied handprint on the sliding door of the closet to the right.

From here the player can open another door to the left which opens the bathroom where he/she is exposed to a bloodied mirror, soap and sink. There is also a key in this room that unlocks the last room, the kitchen which is the door behind the bar in the living room.

This last room is the one with the highest exposure to blood as there is a bloodied knife and blood drag marks on the ground that lead to the dispenser, although it is unusually clean.

There are no bodies so that the exposure is not to heavy and also not to break immersion because of the technical dificulties of creating a good photo-realistic 3d model. The main focus is the gradual exposure of the player to its phobia and it should be followed by a physician for any questions about the phobia or about the AT exercise, which if the player should let physician know if he/she is about to faint, so theres less risk of injury if the exercise doesn't work.

3.3 Hardware Used

For the HMD (Head Mounted Display) it was selected the HTC Vive, Figure 2, due to the graphic processing power with the 1080x1200 Dual AMOLED 3.6" screens supporting more realistic graphics with higher frames per second.

Figure 2: Playthrough with HTC Vive.

The computer has a Nvidia® GeForce® RTX 2080 8gb GDDR6, 32gb RAM (Random Access Memory), Intel® Core™ i7-8750H CPU (Central Processing Unit) @ 2.20GHz and the windows 11 OS (Operating System). The use of headphones while playing the game for the spatial sound design is recommended, although the use of the computer embedded speakers also work.

For the sensors, it was selected the PLUX Biosignals BITalino ®evolution Board Kit, due to its capabilities and performance versus the standards (Batista, D., et al., 2019), where for the moment we are only using the ECG sensor as seen in Figure 3, but the board has the capability of performing the following data acquisitions opening the possibility of multi-modal signal acquisition (da Silva, H. P., et al., 2014) for more accurate measures of the phobias' reaction, EMG (Electromyography), EDA (Electrodermal Activity), EEG (Electroencephalography), ACC (Accelerometer) & LUX (Light) sensors.

After some more testing it was possible to find that the placement of the ECG sensor in the wrist was causing unnecessary noise and that it provided more accurate readings when placing the sensor on the chest of the player because of the muscles activated during gameplay.

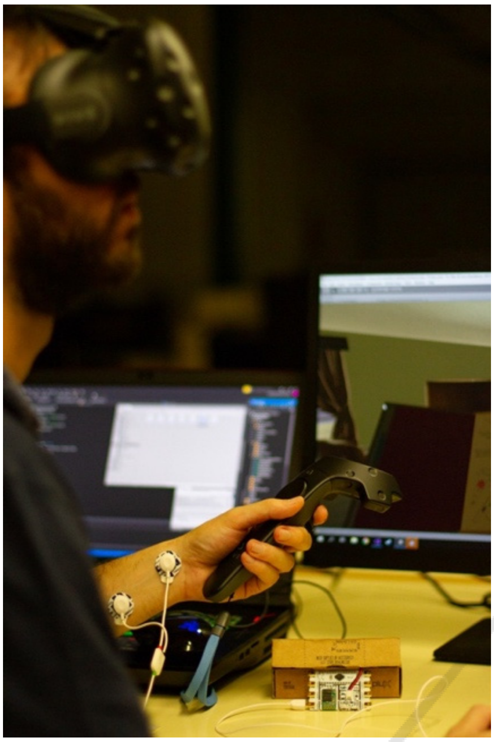

Figure 3: First location of the ECG sensor.

4 USABILITY QUESTIONNAIRE

To gather results, usability tests will be driven followed by self-report questionnaires after multiple relevant questionnaires on user engagement and experience satisfaction combined with some questions that we consider relevant. The main questionnaire studied was the questionnaire of a similar virtual reality project for HRC (Heart-Rate Controlled) interaction game, (Houzangbe, S., et al., 2020), the UES (*User Engagement Scale*) (Wiebe, E. N., et al., 2014) and GUESS (*Game User Experience Satisfaction Scale*) (Phan, M. H., et al., 2016).

The self-report questionnaires are subdivided in four categories.

The first category, as seen in table 1, is information about the user who did the test, for demographic segmentation. This information is relevant because it's the baseline to make the necessary adjustments in the game, from the information shown to the player, be it more technical or more common written, to minor tweaks in game mechanics to improve the playability and usability of the game.

The second category, as seen in table 2, gathers information about the previous experience of the user with playing digital games, and VR games. This follow-up of the baseline will inform us if some of the difficulties found in the game were due to the lack of experience, or the opposite, if the game is in a state of usability that even a person without prior experience can easily learn to play.

The third category, as seen in table 3, gathers information about the equipment, both the sensor and the VR set. This information will lead us to adapt the hardware used depending on the answers, we might change to a wireless HMD or even one with less weight.

The fourth and final category, as seen in table 4, gathers information about the gameplay, in this category the usability of the game, the intuitiveness of the game mechanics, the visibility of the objects and features by the user are measured as well as the discomfort, if any, felt whilst playing the game.

This questionnaire will allow us to assess the scope of the player, the friendliness of the sensor, the comfortability of the virtual reality head mounted device and the usability factors of the game.

The usability tests are of the upmost importance, as they provide feedback to improve the game to a state where the players will feel comfortable and natural in the virtual environment. They will also aid us in fixing motion sickness related issues, which are very common in virtual reality games but are not acceptable for phobia treatment since they are an external factor that the patients shouldn't have to experience for their treatment.

Table 1: Demographic segmentation questions of the usability test questionnaire.

Question	Possible answer(s)
What is your genre?	Female; Male; Prefer not to disclose; Other.
Choose your age from the options given.	<15; 15-20; 21-30; 31-40; 41-50; 51-60; >60.
What are your academic qualifications?	Under four years of scholarity; Pre-school; Middle school; Highschool; Bachelor; Master; PhD; Prefer not to disclose.

Table 2: Users' previous experience questions of the usability test questionnaire.

Question	Possible answer(s)
Do you usually play digital games?	Yes; No.
Have you ever played a Virtual Reality game before this one?	Yes; No.

Table 3: Equipment questions of the usability test questionnaire.

Question	Possible answer(s)
Did you find the sensors' placement invasive?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did the sensors' placement obstruct your movements?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you find the virtual reality gear uncomfortable?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
If you felt any discomfort using the virtual reality gear, choose from the following answers those that apply.	Due to the weight; Due to the cables; Due to the lenses; Due to the controllers; Other.

Table 4: Gameplay questions of the usability test questionnaire.

Question	Possible answer(s)
Did you find the controls of the game to be straightforward? (GUESS)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you always know how to achieve the objectives/goals of the game? (GUESS)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you find the blood exposure difference evident between the various rooms?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you feel the game gave you enough freedom to act how you want? (GUESS)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you feel that the game's audio (e.g., sound effects, music) enhanced your game experience? (GUESS)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you think the game was visually appealing? (GUESS)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
When you were playing the game, you lost track of the world around you? (UES)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you feel frustrated playing the game? (UES)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you feel like you were able to interact with the environment the way you wanted? (HRC)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you find that the environement was responsible to the actions that you initiated (or performed)? (UES)	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
Did you find the puzzle on the painting in the living room?	Yes; No.
Did you find the mobile phone on the ground in the living room?	Yes; No.
Did you interact with the landline phone?	Yes; No.
Did you feel motion sickness during the gameplay session?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree
If you felt motion sickness, choose the reason from the following answers.	Due to the graphics; Due to the movements' velocity; Due to the movement mechanics; Other.
Would you play this game again once it's fully developed?	Likert scale 1-7 1- Strongly Disagree 7 – Strongly Agree

5 FINAL REMARKS AND FUTURE WORK

This paper addresses the development of the serious game PHOBOS, a virtual reality exposure therapy game for the treatment of blood-injection-injury phobia, also known as hemophobia, providing the necessary tools with the safe virtual environment to overcome the phobia and prevent fainting. The project started in 2018 and in this paper, we present the updated version of the game and project progress.

We've upgraded the game engine, replaced the deprecated plugins, and reworked from the ground up some of the game features to make use of the latest technology. The game is still in development, close to the alpha phase to do the usability tests. Although there are more studies on VRET, ARET and serious games for phobias and disorders, there is still much research to be done on BII phobia, that motivates us to go deeper into this subject.

As future work we intend to do the usability tests, followed with an iteration of the development supported by the feedback gathered, making the adjustments necessary to be able to do clinical trials to see the viability of the games' VRET. We also aim to continue to improve the development of the game once it reaches the alpha phase as well as the sensor interplay for it to reach a minimum viable product stage, where it can be recognized as a viable option for the treatment of BII phobia.

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