# A Controlled Virtual Reality Exposure Therapy Application for Smartphones*

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Abstract: Exposure therapy (ET) is often used as a therapeutic process for the treatment of a psychological disorder. Usually, this type of therapy is challenging to apply traditionally as the therapist must expose the patient safely to the cause of the disorder. To help surpass this problem, a virtual reality (VR) application was developed to support exposure therapy. As these therapies are based on a gradual and repetitive process, with this application, the patient can be exposed to the phobic element at different levels of anxiety intensity as prescribed by the therapist. This application was designed to be used either during the therapeutic sessions or at home. While using it in therapeutic sessions, it allows the therapist to include the analysis of physiological signals, escape movements, or other reactions during the exposure. At home, as homework for the therapy sessions, it will allow the patient to keep training what was learned during therapy. It is being developed as a serious game for smartphones, and users will only need a cardboard-like VR headset.

## 1 INTRODUCTION

The evolution of VR-based technologies is allowing the application of new medical procedures that otherwise were complicated or completely impossible. Mental health is one of the areas where this technology is being applied and where this work is focusing on. Every year, anxiety disorders affect nearly 18.1% of adults and are still registered as one of the most commons mental disorders (Saloni Dattani and Roser, 2021). Anxiety can become a daily obstacle for those who suffer from it, as it introduces significant distress, with consequent impairment in the quality of life. This is also a problem for the society since, as untreated mental health disorders become more severe, social and economic costs tend to increase (Botella et al., 2011).

Numerous authors have shown that VR experiences can be compared to real ones as VR scenarios can induce some sensations similar to the ones felt in the physical world (Penn and Hout, 2018). VR is being increasingly used in behavioural therapies, in particular in exposure therapies that consist in exposing the patient to anxiety triggers, so that learning, habituation, desensitization, or other, will help overcome or, at least, help in the process of managing it in the daily life. Long term studies show the effectiveness of VR to ET in the treatment of phobias (Krzystanek et al., 2021).

Exposure therapy has proved its efficacy in the last 20 years (Botella et al., 2011; Anderson and Molloy, 2020). Nevertheless, the traditional application of this treatment does not please everyone. Some patients fear the in-real-life confrontation with phobic elements and some therapists also tend to believe that in real-life exposure can be unethical by provoking uncontrollable fear to their patients and, depending on the disorder, by not being able to maintain the sessions private and violating the patient-client boundaries (Miloff et al., 2019). Therapists also avoid *in-vivo* exposure due to the time-consuming sessions and the work around it, for instance, catching and keeping a spider in the clinic for later reuse (Hinze et al., 2021). When compared to traditional exposure therapies, virtual reality counterparts tend to be accepted by both parties, and seen as more ethical, and helpful (Botella et al., 2011). They are also considered safer, and in most cases, as effective as *in-vivo* exposures (Anderson and Molloy, 2020). Another advantage of a VRET is the fact that it can be conducted in an medical office, even if the elements to be explored cannot be physically there (Miloff et al., 2019).

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One notable disadvantage of VR systems is their high prices. The development of this technology in the past four years, has led to a cost reduction and increased quality, and that makes this issue continually less significant. With the recent release of new and more inexpensive virtual reality headsets, clinical trials are more common and find high levels of user satisfaction with VR (Anderson and Molloy, 2020). Although cybersickness is still one of the major obstacles, considerable improvements in the devices' quality make this issue increasingly less significant. Also in this respect, the careful design of applications (Patrão et al., 2015), and the fact that most exposure scenarios do not need fast displacements in the VR space, may contribute to reduce the percentage of users experiencing this type of discomfort.

It is commonly accepted that VR and ET are useful with anxiety disorders, especially for disorders such as zoophobia, aerophobia, acrophobia, among others. However, psychologists who are specialized in other disorders like eating disorders, ADHD and OCD also believe VRET can be an alternative treatment with success (Lindner et al., 2019). In the case of OCD, VR is capable of provoking symptoms such as anxiety in patients and compare the results to healthy control. So, with the help of VR, therapists can recognize OCD symptoms and diagnose this disturb easier (Van Bennekom et al., 2021). Nowadays, the main question is no longer if VRET is indeed as effective as *in-vivo* ET, but how to engage the patient to keep working on himself and not giving up for lack of interest.

Since the concept of computer games has been emerging as a powerful new economic, cultural, and educational force (Botella et al., 2011), serious games are also becoming more popular among people of all ages.

Serious games, unlike traditional computer games, are alternative educational, training, or therapeutic tools that go beyond mere entertainment (Lievense et al., 2021) and are an effective medium for creating a non-threatening and engaging learning environment (Fitzgerald and Ratcliffe, 2020). It has been proven that serious games can change behaviour (Botella et al., 2011) and reduce disorder-related symptoms (Lau et al., 2017). It actively engages the player and promotes change within a safe virtual environment (Lievense et al., 2021), eliminating both the privacy issue and the out-of-control elements that worried the therapists. Since it has an entertaining form, the ethical conflict of provoking fear in the patients is also toned down and is more acceptable between professionals. This type of game places its goal outside the game itself. According to the self-determination theory, there are two types of motivation that may influence the retention of a person in one activity - extrinsic motivation and intrinsic motivation (Lievense et al., 2021). From a gaming perspective, extrinsic motivation leads to material rewards, or cheering messages for other players. For instance, when the player receives fictional coins to purchase bonuses or elements in the game. On the other side, intrinsic motivation is based on personal interest, the final reward is related to each individual (Fischer et al., 2019). Serious games thrive on intrinsic motivation since the player must have personal goals to succeed in the game. The different levels of the serious games are achieved with the acquisition of skills or therapeutic progress (Botella et al., 2011). If the players have a clear purpose and the goals and levels of the game are clearly defined, then the game is well accepted, and the engagement is enhanced (Fitzgerald and Ratcliffe, 2020). The use of serious games and gamification principles to promote treatment for mental illness had high levels of feasibility and acceptability among both users and providers (Fitzgerald and Ratcliffe, 2020). The current problem is no longer the effectiveness of VR and the application of exposure therapy, but the user experience itself that can lead to more positive or negative results (Tao et al., 2021).

The application of VR can follow quite different approaches. Some aim to develop an application for smartphones to be used at home without the presence and/or without the consultation of a therapist. These applications can sometimes be a serious game or a selection of VR scenarios that the user needs to explore. In this case, the progress achieved is measured by the user or by the application itself. However, this can make the situation worse by exposing the user to levels of disturbing elements that he/she is not prepared to face, thus incubating the fear even more.

The problem we perceived with the current home-use application, is that it does not engage the user to come home after a day of work to use it. This is a big problem with exposure therapy, as it requires constant exposure to the anxiety source to eventually overcome the problem. Other commonly used approaches consist of the application of VR in-clinic sessions with the constant presence of the therapist that walks through all the stages with the patient, and maintaining full control of the exposure level through out the session.

## 1.1 Contributions of the Paper

This work presents the development of a immersive application to promote learning and coping with anxiety, tuned for a specific clinical case. The ultimate

goal is to facilitate the therapist work and help the patient to reach a level of well-being by overcoming constraining anxiety and/or phobias.

To this end, a serious game is proposed that allows the user to have fun while learning how to manage his anxiety in the presence of whatever triggers it. The player levels up in the game as the therapeutic goals are met and according to the therapist. This serious game will aim at not only anxiety disorders but also other disorders such as OCD and ADHD, making it possible for the therapist to personalize it to the patient needs.

## 2 DESIGNING A FRIENDLY SPACE FOR ET

The concept explored is the development of a serious game to facilitate the application of ET for both the patient and the therapist. The patient can comfortably use the application at home by only needing a smartphone, and a VR headset for smartphones, such as Google Cardboard.

The design of the VR environment can integrate ET with different types of disorders elements. VR is commonly associated with anxiety disorders. However, psychologists believe that VR can also help other non-anxiety related disorders, and this serious game aims to meet those expectations.

Due to its high popularity among all ages and its versatility, the game "Escape Room" is one example of how this serious game can present itself. The player needs to complete several tasks and gather clues to escape the current room. By changing routines and adding new clues, the patient will be constantly entertained and stimulated to maintain engagement. It allows to prevent disinterest and consequently keep the patient exposed, as if the patient loses interest, the therapeutic progress will decrease. However, as the concept of this game may, on itself, trigger some disorders like claustrophobia, it can be changed to other possible less anxiety-prone games such as treasure hunting.

The escape-room scenario creates the perfect context to contain multiple and different mini-games. The disturbing elements are to be included in those, allowing the patient to take a break between exposures without leaving the VR environment and consequently not losing any sense of presence. In the case of arachnophobia, the anxiety disorder that will serve as an example throughout the article has a phobic element, the spider, so there are mini-games that only show images of it, and others present themselves with a virtual representation of the animal. Each mini-game addresses a different anxiety level and has small therapeutic goals. Since the patient must have a gradual exposure to the phobic elements, with the mini-games the patient can be exposed slowly from images to videos to the actual virtual presence.

## 3 DESIGN AND IMPLEMENTATION OF A VIRTUAL COMFY SPACE FOR ET

The mobile application developed has to address some complex issue in terms of displacement and interaction within the game. As for the home usage, the patient will use it in a cardboard configuration, therefore no joysticks, gamepads, or other game controllers should be considered. By consequence the only possibility is to use the head orientation itself to support the interaction with the VR environment in its various aspects, as will be discussed bellow.

This limited interaction form presented some challenges in the game's development, such as playing only moving the head and avoiding any fast movements to prevent motion sickness. As reported by (Anderson and Molloy, 2020), people who suffer from mental health illnesses tend to be more prone to cyber-sickness, so this was a subject that received particular attention.

### 3.1 Interact with the VR Environment

To interact with the VR environment the patient can search for specific points that will light up to let him know that there is the possibility to interact with and a small pointing sphere will change colour to the inverted colour of the object that it collides with. The sphere simultaneously represents the point where the player is looking at in the game, and is the interaction element. In fact, its collision with the active elements of the virtual world is exploited to enable the player to select objects, move within the game space, or interact with the mini-games. Whenever the sphere is placed on top of an active element it immediately starts inflating showing the interactive control, and activating the element after a while.

Some places are important to the game flow, such as where a code can be inserted, or where the mini games are playable. Because of this characteristic, small blue moving circles are placed in those specific locals to grab the attention of the player that it is important to move at some point to that location as can be seen in Fig 1.

Since interaction is limited, and motion sickness is an issue, so travelling to different places in the room consists of a fade-in, turning the screen slowly black, and a fade-out in the correct position, turning the screen slowly back to the initial state, maintaining the rotation and the height the player was in. The player can only move in the ground plane.

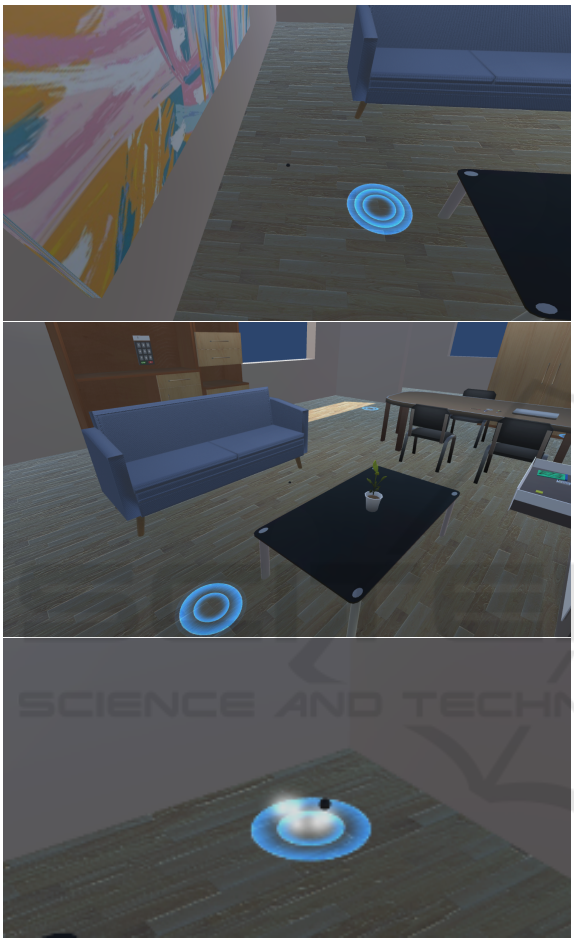

Figure 1: Teleport circle.

## 3.2 The Interaction with the Mini-games

The serious game is sequential with an exposure ladder where some have a lower anxiety level and others are more intense. In the higher difficulty, all implemented anxiety sources are present. The game itself also has some variations between plays, such as different images and random placement of the matches in the case of a memory matching game card.

Since sometimes the patient can have more difficulties in an exposure given by a specific mini-game, the therapist can request the patient to play only that mini-game without the need to play the full serious game, and for that there is the possibility playing individual mini-games.

The interaction between each mini-game also needed to be analysed to create a random yet sequential relation between them. Upon completing each one, a digital code is provided to the player and acts as a bridge between the mini-games. The codes are presented differently, forming a final colour code to unlock the last door and finish the escape room (Fig 2). The mini games also present hints once finished like where the code is or to where it is to be inserted. For instance, as can be seen in Fig 4, once the drawer is opened a line of sparkle particles flow to the correct keypad. If the code inserted is correct it will change color to green, if not it changes color to red (Fig 3).


Figure 2: Color Code Keypad and Codes found.

The static mini-games such as memory card matching and puzzles are played in a similar manner. Spark particles appear where the player is staring at and like moving, the interactive sphere increases and when full the game develops. In the case of the ”find the differences game”, the spark particles do not show and the sphere does not increase unless it is to press the hint button. However it is still necessary to wait two seconds looking ate the same spot to play. This happens to avoid giving the difference location away. On more dynamic mini-games, like the maze, the phobic element follows the interactive sphere and the game is played by controlling its location.


Figure 3: Correct and wrong color code inserted.

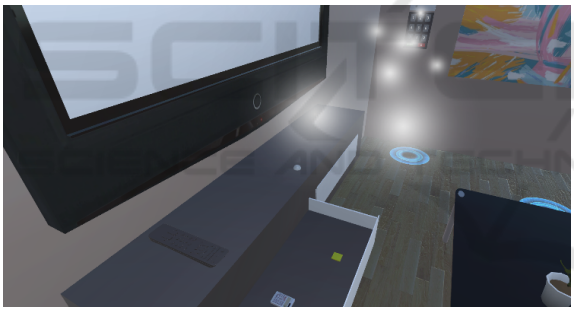

Figure 4: Hint after opening drawer.

## 4 BREAKING DOWN THE EXPOSURE INTO MINI-GAMES

The mini-games serve to expose the patient to the disorder element. The time between each mini-game act as a pause of exposure or even as a panic emergency escape. The patient can leave the mini-game, take a break wondering the virtual room and resume it when calmer, preventing the break of the sense of presence.

The serious game starts with all the mini-games hidden. When the patient inserts the codes onto the keypad, the corresponding mini-game uncover itself. Each one executes isolated, being coordinated by the main script. This format enables the therapist to require the patient to play only one of the mini games without it being necessary to play the escape room.

The chosen mini-games to develop in the concept of ”Escape Room” and arachnophobia are:

- Memory Card Matching
- Find the Differences
- Slide Puzzle
- Rotating Puzzle
- Maze

In the ”Memory Card Matching” mini-game (Fig. 5), the user has constant contact with different images of its anxiety source. When playing, if the cards turned do not make a pair, they turn themselves back. As the game proceeds, the number of images exposed increases, and the anxiety may make it harder to complete. The mini-game leads to the necessity to memorise a determined image’s position and details to correspond with its duplicate. This mini-game also allows the player to decide if he wants to see the inanimate disorder related element. In order to keep the challenge level constant between game session, each image position is randomized at the beginning of the game. After completing all the matches, a code appears in the room. This code will lead to the next mini-game.

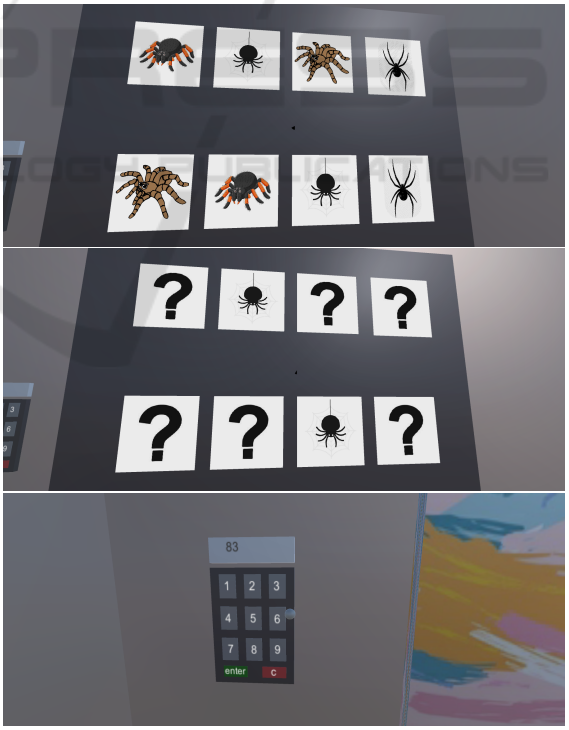


Figure 5: Memory Matching Card Game.

The ”Find the Differences” mini-game (Fig. 6) consists of two very similar images with slight differences between them which the user has to find and mark.

The game starts hidden behind a closet. After acquiring the code from the memory matching card game, the player can insert it onto the keypad, and the mini-game appears. To play, the user selects a position on either the images. After waiting two seconds, if it corresponds to a difference, a red doughnut will target the spot as found. If not, then nothing happens.

If needed, a hint feature will help the player complete the mini-game. The hint consists of the phobic element moving towards the difference's position. Depending on the level of exposure, this element can be the phobic element. In the case of arachnophobia, a spider shows the patient where one of the differences is. All the animated phobic elements show a neutral white sphere if the patient is playing the lowest intensity.


Figure 6: Find the Differences Game.

The maze (Fig. 7), according to the selected disturb, may have different aspects. For instance, to OCD, the lines are not straight, and some lights turn on and off while passing on a specific part of the path. For ADHD, distractions such as random blinking lights or sounds can easily make it harder for the patient to concentrate on the task. If it is arachnophobia or other small animal-related phobias, the phobic element follows the position of the user's head, and the goal is to lead the animal to the end of the maze without it touching the walls. The maze path shuffles between predefined paths. Along the maze there are several platforms. The phobic element must touch every platform or the final color is not provided.

The last two mini-games are two different kinds of puzzles: a rotating puzzle and a slide puzzle, but the therapeutic goal is similar, making the patient gradually assemble the image related to the anxiety source. Nine pieces of the same image constitute the rotating puzzle, and the player needs to rotate each one, 90 degrees at a time, to build the final image and complete the mini-game. The slide puzzle consists of 8 pieces of the same image and a blank spot of the same size as the other parts of the image. The player must move the pieces within the available space until the final image appears.

Figure 7: Maze Game.

## 5 THE THERAPIST ROLE ON A CONNECTED APP

The presence of a therapist in this process is of high importance. It does not need to be a constant presence, but one-off checkups. The progress made by the patient needs to be analysed, and with those conclusions, the therapist decides which level of anxiety intensity the patient plays at home. The therapist has access to the patient progress by a data base. When the patient logs in, a code provided by the therapist is inserted and that data is saved and can be accessed later by the therapist.

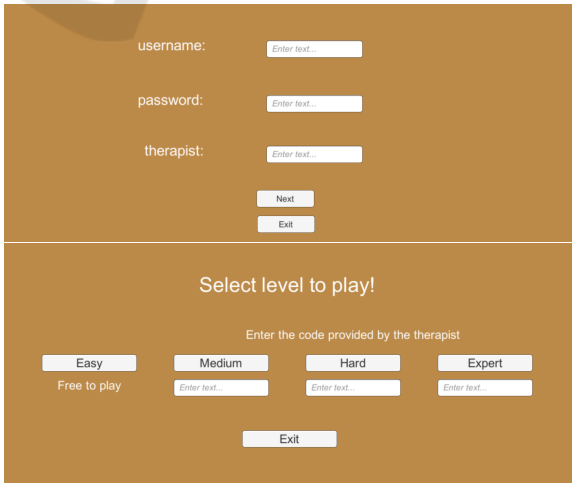


Figure 8: Login and game options.

The patient must play at least once every session for the therapist to evaluate the progress. The physiological signals such as the heart rate and galvanic skin response will also target that evaluation.

During the development of the presented work, meetings with psychologists clarified the patients point of view and how to help and not overexpose them to the anxiety source. The therapist must be able to evaluate the situation step by step so the exposure remains controlled. So, to facilitate and help keep track of the patient progress, he has access to the scores of each mini-game and the total time of play of each patient. It is then possible to know how many times throughout the time-off sessions the patient played and the difficulty they faced.

# 6 PRELIMINAR VALIDATION

## 6.1 Game / Usability Analysis

The game was tested by 10 individuals. At the end of each test, the individuals filled a User Experience Questionnaire (UEQ), a Flow Short Scale Questionnaire and an open answer questionnaire to obtain some information about the individuals.

The UEQ is frequently used to measure the user experience with a certain product. It evaluates the user experience in six different categories: attractiveness, perspicuity, efficiency, dependability, stimulation and novelty. If a category is above 0.8 it has a positive evaluation and above 1.5 is considered and excellent result. The results are presented in figure 9. It presents the average classification of each category and its standard deviation. The attractiveness, efficiency, stimulation and novelty categories were all classified as excellent, although with a high standard deviation due to the sample size. The perspicuity and dependability had slightly lower scores with 1.225 and 1.375 respectively.

Perspicuity refers to how easy it is to get familiar with the application and how easy it is to use it. The application is a virtual reality serious game and in the open answer questionnaire most of the individuals lack of experience with VR so, being an VR "Escape Room" game it was expected some difficulties in interacting with the environment at first try. Dependability refers to how in control of the interaction the user feels. The serious game is a compilation of puzzles and codes, so the fact that some individuals felt they did not had control of the situation is not far from the reality.

The Flow Short Scale Questionnaire evaluates three aspects of the application on a scale of 1 to 7:

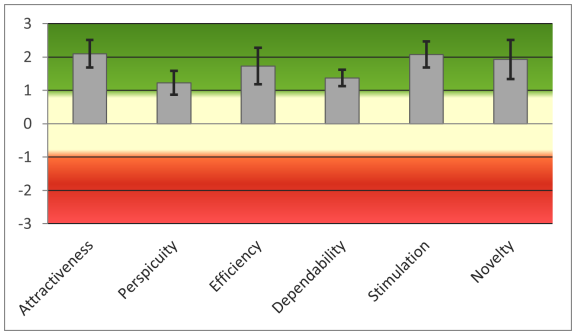


Figure 9: UEQ Questionnaire Results.

flow, anxiety level and challenge level. Flow level indicates if the user is feeling engaged while playing the game and if he feels like the activity is intrinsically interesting and takes pleasure and enjoyment while involved with it. Anxiety level translates to how much anxiety the users felt while playing the game and challenge level to how challenging it was with 1 being too easy and 7 too hard.

The results with the average and standard deviation of each category are presented in table 1. The challenge level was considered to be close to perfect (with 4 being a perfectly adequate challenge level). The anxiety level was not high but it presented a relatively high standard deviation. In the open answer questionnaire three individuals said to have anxiety problems such as anticipation anxiety. This may explain why such high standard deviation. A flow level of 5.04 indicates the users mostly enjoyed playing the game but some aspects could be improved such as adding descriptions of how the mini games are played and maybe a scene without any game to allow the user to get to know the VR environment.

Table 1: Flow Short Scale Questionnaire Results.

| | Average | Stardard Deviation |
|---|---|---|
| Flow | 5.04 | 0.527 |
| Anxiety | 3.867 | 1.124 |
| Challenge | 3.9 | 0.568 |

# 7 CONCLUSION

Exposure therapy is one of the best behavioural therapy techniques as it allows the user to explore the disorder in a safe and controlled way. This paper we presented a serious game for that purpose, that explores VR to expand the range of disorders that the treatment can reach and allow the patients to train at home and expose themselves to the anxiety source according to their therapist recommendations.

This type of application can be the starting point for many people to learn how to manage their anxiety and live life in a much better state of mind. As the chosen game design can be so multifaceted, the opportunities are endless. Not only can different disorders like arachnophobia, PTS, OCD and ADHD be improved, but the therapist can adequate the game to each patient depending on the presented disorders and the best anxiety intensity levels for each one.

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