Participant Modeling: The Use of a Guided Master in the Modern World of Virtual Reality Exposure Therapy Targeting Fear of Heights

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Abstract. With the percentage of mental health disorders on the rise and the cost for their treatment reaching astounding proportions, research in their treatment has also become quite extensive. Individuals suffering from the effects of their disorder constituting them incapable at various levels to lead a normal life, the need for a more effective treatment has been well established. We have focused on anxiety disorders specifically, which have mainly fear as their common denominator, and using this we decided to look into the role of the clinician in live ET sessions so as to examine whether this role can be replicated in a VRET simulation with similar or better outcomes for the patient, i.e. a more effective treatment. Our hypothesis was tested in an outpatient setting with patients being separated into two groups. We examined whether the presence of a virtual guided master using participant modeling in a virtual environment was as effective or more effective than the Standard ET method. Our VR system is based on the Full Body Immersive Virtual Reality System with Motion Recognition Camera created by Jacob Kritikos. The outcomes were gathered via the Session Rating Scale by Miller which led to the conclusion that participant modeling within a VRET approach can lead to a better treatment quality.

Keywords: Virtual reality · Cognitive behavioral therapy · Exposure therapy · Anxiety disorders · Specific phobias · Acrophobia · Motion tracking sensor · Motion recognition camera

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1 Introduction

Virtual Reality (VR) is still not ubiquitous in our daily lives, yet it seems to be so in the world of gaming and medicine. VR and its technological evolution, known as augmented reality (AR), have replaced Bandura's videotaping and adapted his theory of "guided participant modeling", in which skills during a session to treat fear and phobias are modelled by clinicians or coaches, discussed as part of the CBT session, and then practiced [1]. Videotaping was widely used in the past as a means of feedback after practice along with the modeling aspect. What was also the case in the past in therapy sessions was focusing on affective and cognitive as well as behavioral aspects of performance.

The emerging technologies of VR and AR have certainly replaced videotaping, as also the presence of actual people in a room. They are shaping a new world affecting the socioeconomic domains exerting a considerable impact observed in the terms of financial expenditure and time. According to Rotolo et al., such technology is characterized by novelty, it is fast growing, it has impact in socioeconomics, it is defined by its impact and uncertainty [2]. VR falls in this domain even today.

Classical theories of treating phobias suggest that there are a number of reasons why people avoid seeking treatment leading to social and employment issues and relapses following initial attempts which, overall, cost the US health system $193.2 billion in lost earnings per year [3]. The hesitation to do so seems to be an established fact despite the growing number of effective interventions [4, 5]. Phobic individuals view their anxiety disorder as untreatable. A great number are not aware of available treatments and interventions. Also, there is approximately 25% of phobic patients who refuse to seek treatment as it involves confrontation with the phobic stimulus, therefore avoid exposure-based treatments, i.e., Exposure Therapy [5].

In the past, treatment of fears and phobias were characterized by the widespread belief that anxiety and fear can only be treated through verbal interpretive means, essentially making CBT the most prominent form. More recently, phobic individuals may choose among cognitive therapy, systematic desensitisation, modeling, imaginal or virtual reality exposure, and direct in vivo exposure [5, 6]. In this paper, and despite the doubt Bandura et al. have voiced as regards direct treatment approaches, we are examining the widely used Exposure Therapy (ET), which is also a cognitive behavioral technique [4, 7].

The reason we used Exposure Therapy as our preferred mode of treatment is its dictionary definition by the American Psychological Association: "*it works by habituation […], disconfirming fearful predictions; and increasing feelings of self-efficacy and mastery*" [8]. In therapy, as well as in coaching, the element of self-efficacy and personal mastery hold a prominent position when it comes to developing skills and the right mentality for effective reaction to a fearful stimulus. This can be leveraged by repeated exposure that leads to eliminating anxiety over time [9, 10]. As mentioned earlier, an estimated 25% of phobic individuals avoid treatments and interventions for fear of directly confronting their phobia. ET assists in the right direction by creating a mindset that modifies the current perception of the phobia and the way it might "harm" those individuals [11].

Considering the socioeconomic issues caused by phobic individuals who have avoided the direct confrontation approach, VR has also come to assist the medical field in one more way: it offers the safety and security needed by individuals to pursue, become engaged in and complete their treatment. The combination of a most effective, yet avoided, exposure-based treatment and the emerging technology of VR has led to Virtual Reality Exposure Therapy (VRET) as being one of the most common in the past years. VRET allows for a fully immersive experience, rather similar to real life, that evokes all emotions the individual receiving the treatment would have in the physical world [12–20]. When comparing virtual reality with *in vivo* exposure, it has become clear that technology provides a greater number of benefits, including the actual intervention a clinician can offer when being "present" during a VR-based session with direct coaching on daily circumstances that affect the patient's quality of life [21].

The focus of this paper has also been the safety that VR simulated environments provide the phobic individuals, while establishing their willingness to engage in an exposure-based treatment and an open mindset that will allow them to test out new reactions as modeled by their clinician or coach. Using the principle of far transfer of knowledge, any knowledge acquired in the virtual environment can be adopted easier in the physical world [22]. Bandura, Blanchard and Ritter's beliefs are also satisfied in the sense that treatment approaches that are based on socio-learning principles have a higher likelihood of being effective in creating generalized and enduring psychological changes [4].

The most important feature that has been taken to be critical for distinguishing between CBT, Standard ET and VRET theories of safety and effectiveness is that of the guided master in the guided participant modeling element that was designed by one of our authors, Jacob Kritikos. Film modeling, peer-modeling and self-modeling have been used effectively as a treatment intervention for adults with fears [23, 27]. While designing the apparatus and systems used, the aim was to integrate the concept of the virtual presence of another individual acting as the clinician, guiding and demonstrating non-fearful behavior, thus helping the adult handle the feared stimulus. Anxiety has been seen to be reduced in the phobic individual, physiological arousal and negative thoughts minimized, and core skills are acquired that may then be transferrable in real life [28].

The purpose of this paper was to compare VRET and Standard ET in addition to CBT and establish that, in ET, the presence of the therapist in the virtual environment could be a factor that affects trust, thus increasing the sense of safety in the phobic individual, that would make VRET an effective method of treatment. Our research aimed to suggest that the presence of the clinician is essential either for providing instructions and coaching or to ensure that the participant feels safe and willing prior to engaging in the simulation [29]. Using Rosenthal and Bandura's socio-learning principles, i.e. requesting from participants to actively model behavior after they have received clear instructions, seen the non-fearful behavior by the clinician and fully comprehended the benefits of this behavior, we expect to show that the presence of the therapist leads to a reduction in ineffective reactions and increased self-efficacy [30, 31].

It is currently acknowledged that the therapist's presence and guidance throughout the ET yields higher success rates [17, 32–35]. Although we understand that the combination of CBT or Standard ET with VR and guided mastery requires further investigation, the value of the participant modeling approach has already become the focus of the scientific community for the benefits it yields.

Using technology and the system proposed by one of our authors [16, 35], we make use of the classical Bandura theory of guided participant modeling in a raw form, to the extent the simulation properties currently allow us. The design of the system helps investigate whether VRET with a virtual clinician present in the VR environment facilitates knowledge transfer, thus improving practical application in the physical world, increasing the levels of self-efficacy and confidence and, consequently, establishing the effectiveness of the technology-based intervention [28, 30, 36]. Currently, we propose that the presence of a clinician in the VR environment be added to the VRET approach as a guided master (Fig. 1) as we presume that the virtual clinician may increase the level of safety, comfort and willingness to handle fears and phobias, and, more specifically, acrophobia, which is the focal point of the present paper.

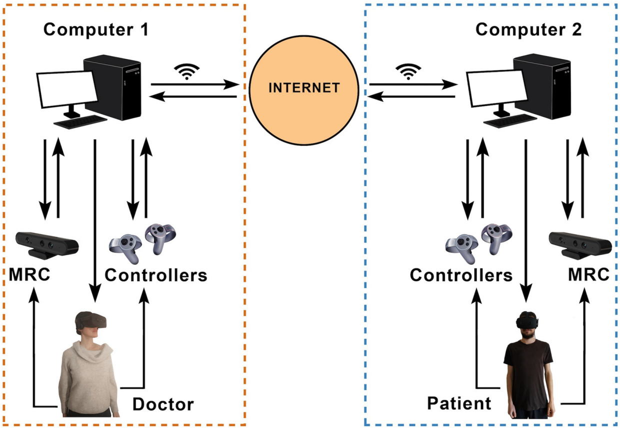

Fig. 1. System flow of the proposed system.

2 System Description

2.1 Hardware

[a] Two Desktop Computers with the following specifications: Graphics Card: NVIDIA GeForce GTX 1070, CPU: AMD Ryzen 7 2700X, RAM: 16 GB G.Skill TridentZ DDR4, Video Output: HDMI 1.3, USB Ports: 3x USB 3.0 and 1x USB 2.0. [b] Two Oculus Rift Virtual Reality Headsets with their Touch Controllers, one for each hand. [c] Two Astra Motion Recognition Cameras (MRC) designed by Orbbec, one for each Computer. The MRCs are connected to the Computers with a USB 2.0 cable. The motion tracking accuracy has an error range of $\pm$ 1–3 mm from a 1 m distance, whereas at a 3 m distance, it is estimated at approximately $\pm$12.7 mm. The optimized maximum range is about 6 m. In detail, Astra consists of 2 cameras: a Depth Camera, image size 640 * 480 (VGA) @ 30FPS and an RGB Camera, image size 1280 * 720 @ 30FPS (UVC Support), which have 60° horiz $\times$ 49.5° vert. (73° diagonal) field of view.

2.2 Software

The software used is the following [a] Windows 10 Operating System with the drivers for the Orbbec Astra MRC and Oculus Rift installed. [b] Unity 3D, which is used as the basic program for creating the virtual environment. All the hardware pieces (i.e. sensors, controllers, trackers, headset, camera etc.) are controlled by Unity 3D [c] Blender 3D Computer Graphics Software is used for creating 3D objects, animated visual effects, UV Mapping and materials integrated in Unity 3D; [d] Adobe Photoshop is used for creating images for the materials integrated in Blender; [e] OVRPlugin for the operation of the Oculus Rift equipment in Unity 3D; [f] Nuitrack SDK as the motion recognition middleware between the developed software and the MRC.

2.3 Body Recognition

The Orbbec Persee MRC can recognize 19 joints of the human body (Fig. 2). Each joint is essentially a point in 3D space represented by 3 coordinates: x, y, and z, where the y-axis is the height axis and the x-z plain is the floor on which the user moves. This topology can be seen in (Fig. 3). The MRC is placed across the user on the -z axis. Therefore, the user can walk on the x-z plain, constantly remaining within the tracking field of the MRC while still facing it.

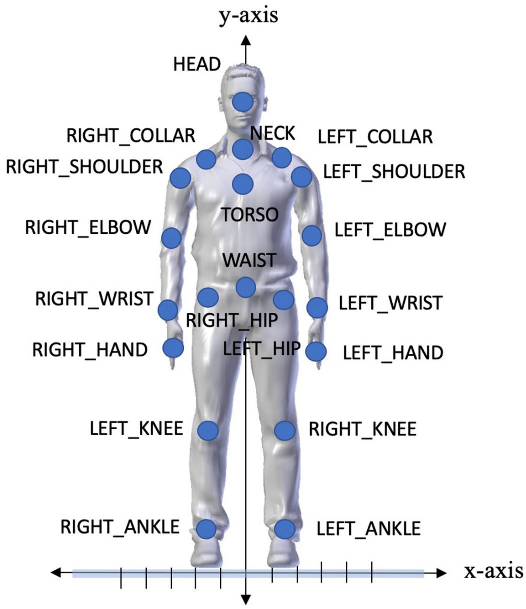

Fig. 2. The joints used to track the body.

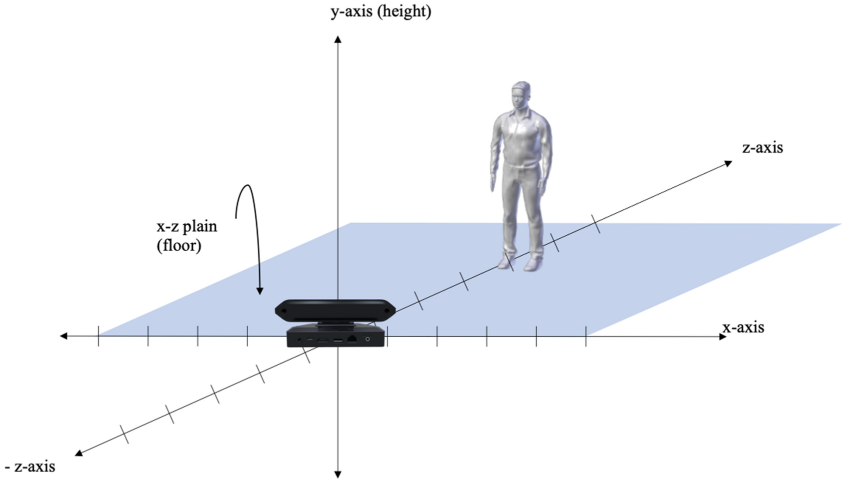

Fig. 3. Representation of the MRC recognition topology. The MRC is the reference point at (0, 0, 0) and can recognize at a range of (x, y, z > 0).

2.4 System Setup

We have two physical areas, the Area-P where the patient is placed, and the Area-D where the doctor is placed (Fig. 1). Each area consists of the same equipment: one Desktop Computer, one Oculus Rift Headset with two Hand Controllers, and one Motion Recognition Camera. Those two areas do not necessarily have to be in the same premises, but it is required for both Computers to have internet access.

2.5 Data Transmitting

In order for Area-P and Area-D to communicate, we used the UDP protocol. The Area-P Computer creates a socket in which, the Area-D Computer sends data. The Area-D Computer creates a socket in which the Area-P Computer sends the data; thereby, both Computers can exchange data. Each Computer transfers 17 data points of 4 bytes every frame. Consequently, for every 30 frames, i.e. the fps of the virtual reality simulation, we have to transmit 2.04 kilobytes per second, which complies with the HiveMQ transfer limits. A C# script embedded in Unity dispatches the data (transmitter). Then, a C# script embedded in the Unity application acquires the data and displays each other's avatar in the same virtual simulation (receiver).

3 Method

To overcome the disadvantages of exposure-based treatment that may deter phobic adults from engaging in an effective intervention, we investigated the value of a virtual clinician's presence in the Virtual Reality simulation as part of the VRET approach. We collected data from a total of 12 participants (7 men and 5 women) who were recruited after being diagnosed with acrophobia. These were randomly distributed into two groups,

Fig. 4. Virtual reality environment. The blue skeleton is the patient and the orange is the doctor.

[A] and [B]. All participants had to perform the same tasks assigned to them once they entered the VR room. Both groups were given the same instructions prior to the session. The session lasted approximately 10 min. The assigned tasks are described as follows: Each participant proceeds to Area-P in the actual room and puts on the Oculus Rift Virtual Reality Headset the moment they feel ready to engage in the session. Prior to this, they have consulted with their clinician or coach and have discussed the key benefits of the sessions, that is, to feel safe and have reduced anxiety afterwards as regards their phobia. The participant, then, enters the virtual environment, specifically designed to induce acrophobia. The environment is an apartment room located on the 5th floor of a building with an open balcony door (Fig. 4). Each participant is told that a "skeleton" figure is a reflection of their body and any move they make, consciously or subconsciously, in the real, physical world, they will see taking place as they move around the virtual environment.

The participants in both groups are instructed, during their session, to complete three consecutive tasks. They are not aware of these tasks prior to the session. The first task is to move towards the balcony, exit the open doors and step out on the balcony. They, then, need to place their hands (the Controllers) on the front railing of the balcony and remain in this state for a number of minutes. Following this, they are requested to lean forward and catch a dangling object which is at a significant distance from the railing. The final task is to return inside the apartment after they have caught the dangling object. The session is considered complete. The participants remove the Headset and the Controllers allowing them to return to the real world. A demonstration video is available here: vimeo.com/486699554.

Group-A had an additional "skeleton" figure representing the clinician. At this stage we did not add the clinician modeling the non-fearful behavior as the focus was on investigating the impact of the mere presence of a clinician in the room. Group-B had to perform the tasks with no other figure in the virtual environment. The phobic participants in Group-A were informed of the clinician being present the moment they saw his figure in the VR environment. The particular trial was approved by the Ethics Committee of the National Technical University with protocol number #9824.

4 Data Analysis

In order to evaluate the presence of the clinician in the VR simulation, we used Dr. Scott D. Miller's questionnaire (Appendix), founder of the 'International Center for Clinical Excellence', an international community of clinicians, researchers, and educators working together, in order to promote excellence in behavioral health services. Over the past few years, Scott D. Miller has created numerous rating questionnaires, which aim to provide psychiatrists with solid information on the quality of their sessions from the patient's perspective. We decided to include this particular questionnaire in our study, as opposed to other rating questionnaires, due to the fact that we considered it the most fitting for our experiment; more specifically, the questionnaire focuses on the level as well as the quality of interaction between the patient and the therapist within the VR environment throughout the course of the session, the extent to which the patient's anxiety and phobia was addressed in the VR setting with the interactive assistance of the psychiatrist, and whether the presence of the therapist in the VR environment was beneficial and constructive for the patient.

Table 1. The answers of the questions from Group A.

Participant no.	Q1	Q2	Q3	Q4
1	8	7	9	8
2	8	6	8	8
3	7	6	7	7
4	10	9	7	9
5	9	6	8	8
6	7	8	8	7

Table 2. The answers of the questions from Group B.

Participant no.	Q1	Q2	Q3	Q4
1	5	6	6	6
2	8	7	8	7
3	7	7	6	8
4	5	5	7	6
5	6	8	8	7
6	4	6	7	5

According to the answers of each participant (Table 1 and 2) the Q1 from Group A has Mean = 8.17, SD = 1.116 and from Group B has Mean = 5.83, SD = 1.47. The Q2 from Group A has Mean = 7, SD = 1.26 and from Group B has Mean = 6.5, SD = 1.04. The Q3 from Group A has Mean = 8, SD = 0.89 and from Group B has Mean = 7.5, SD = 0.89. The Q4 from Group A has Mean = 7.83, SD = 0.75 and from Group B has Mean = 6.5, SD = 1.04.

An independent sample t-test was conducted for each question. The alpha level is a = .05 and the degrees of freedom are df = 11. Therefore, according to the Table of Student t-Distribution, the critical value is cv = ±2.20. Running the t-test concerning Q1 question, the value is t(11) = 3.04, p = .012. So, the obtained t-value exceeds the critical value. Subsequently, the t-test is significant, and the two samples are -statistically- significantly different. In conclusion, participants from Group-A feel more heard and understood than the participants from Group-B. Running the t-test concerning Q2 question, the value is t(11) = .745, p = .473. So, the obtained t-value does not exceed the critical value. Subsequently, the t-test is not significant, and the two samples are not -statistically- significantly different. In conclusion, participants from both groups worked on the same degree of anxiety issues. Running the t-test concerning Q3 question, the value is t(11) = 1.93, p = .082. So, the obtained t-value does not exceed the critical value. Subsequently, the t-test is not significant, and the two samples are not -statistically- significantly different. In conclusion, participants from both groups understood approximately in the same way the virtual reality simulation. Finally, running the t-test concerning Q4 question, the value is $t(11) = 2.53$, $p = .032$. So, the obtained t-value marginally exceeds the critical value. Subsequently, the t-test is marginally significant, and the two samples are marginally statistically significantly different. In conclusion, participants from Group-A felt better about the overall experience in comparison with Group-B.

5 Discussion

The hypothesis that the presence of the therapist in the VR simulation assists patients in confronting their phobia to a greater extent has been confirmed by the data gathered from the participants' results, as these were demonstrated in the responses given to the questionnaire they completed as well as the data analysis we conducted. The questionnaire is the main source of data as it focused on emotions and thoughts on the patient's end following the VRET sessions with the presence of a VR clinician within the simulation.

Question 1 concerns the extent to which the participant felt heard and understood throughout the VR simulation. In this question, we observed a significant difference between the answers of the two groups; this was primarily due to the fact that participants in Group-A were guided by a professional therapist, whereas, in Group-B, participants had to execute the entire exercise on their own, simply by following the oral instructions given by the therapist. That means that participants in Group-A felt the presence of the therapist in a more intense manner, since they could not only hear, but also see the psychiatrist providing them with guidance to successfully complete the task.

On the other hand, question 2, which concerns the extent to which the patient's anxiety was dealt with during the session, did not present big variations between the two groups. More specifically, both groups felt that their anxiety was confronted almost equally during the simulation, with or without the presence of the clinician.

In question 3, which refers to how much the system and the process of the session made sense to the participant, we observed a difference between the two groups; however, the difference was narrow, since neither group showed difficulty in understanding the way our VR system works.

Finally, in question 4, we observed a big difference between the two groups yet again, since the question concerns the overall rating of the session. In particular, Group-A participants felt that the presence of the therapist in the VR simulation assisted them more in confronting their phobia compared to Group-B participants, who had to execute the task only by receiving oral instructions.

Moreover, it is important to point out that, the MRC tracks patients' movements, places their physical body within the virtual environment and gives them the impression that they are moving and fully interacting with that environment, as they would in the real world. This allows patients to practice tasks whilst in the virtual environment, since it can recognize the entire body and movements of its limbs. Another interesting aspect of our study was that MRCs offer a remarkable feature: the tracking of the patient's physical movements is not only useful for placing their body in the virtual environment, but also for dispatching the information obtained by their movements in real time. Measurements of the patient's movements as they executed the exercises can help draw further conclusions about the patient's performance, i.e. whether the phobic patient completed the task effortlessly or not.

One primary limitation to our study was the fact that our experiment was short in duration and consisted of only some simple tasks. Thus, we presume that the addition of more tasks could increase the feeling of the clinician's presence in the VR room even for patients who were slightly apprehensive and uncomfortable with the feel of someone else "being around" in the VR room, considering that they would gradually get accustomed to the simulation and subsequently enhance their performance.

6 Conclusion

By analyzing the results of our study, we can deduce that there was an undeniable difference between the two groups concerning their performance quality within the VR simulation. Group-A, which was offered the assistance of a professional clinician in order to complete the exercise, presented a higher quality performance compared to Group-B, since the virtual presence of the clinician offered them a greater sense of safety and understanding of the procedure. Additionally, according to the data analysis mentioned above, we can deduce that participants in Group-A evidently found their session much more efficient and beneficial, than those in Group-B; more specifically, participants in Group-A stated they felt much more heard and understood, they comprehended the treatment process with consummate ease, and, finally, they confronted their phobia in a more constructive and effective way. Therefore, we conclude that the clinician's presence within the VR environment can assist patients in confronting their fears as well as successfully executing the tasks assigned to a greater extent.

Appendix

Q1: On a scale of 0–10, to what degree did you feel heard and understood today during the Virtual Reality simulation, 10 being completely and 0 being not at all?

If the client gives you two numbers, you should ask, "which number would you like me to put?" or, "is it closer to X or Y?"

If the client gives one number for heard and another for understood, then go with the lowest score.

Q2: On a scale of 0–10, to what degree did we work on the anxiety issues that you wanted to work on through the Virtual Reality simulation today, 10 being completely and 0 being not at all?

If the client asks for clarification, you should ask, "did we talk about what you wanted to talk about or address? How well on a scale from 0–10?"

If the client gives you two numbers, you should ask, "which number would you like me to put?" or, "is it closer to X or Y?"

Q3: On a scale of 0–10, how well did the Virtual Reality simulation make sense and fit for you?

If the client gives you two numbers, you should ask, “which number would you like me to put?” or, “is it closer to X or Y?”

If the client gives one number for make sense and then offers another number for fit, then go with the lowest score.

Q4: So, given your answers on the Virtual Reality simulation, how would you rate how things were in today’s session overall, with 10 meaning that the session was right for you and 0 meaning that something important that was missing from the visit?

If the client gives you two numbers, you should ask, “which number would you like me to put?” or, “is it closer to X or Y?”.

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