Treating Height Phobias using a Smartphone Virtual Reality System

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Abstract— **Behavioral therapy is one common approach to treating phobias. It works by forcing the patient to confront the environment or situation they fear most. Meanwhile, there is a means of creating virtual environments in three dimensions: virtual reality. It therefore follows that in order to create a secure situation where patients can be exposed to their fears, virtual reality might have a crucial role to play. This study therefore offers a system of virtual reality which makes use of a smartphone application to address the fear of heights. The system itself comprises both hardware and software and due to its simplicity is suitable for use in the home. In this study, the effects of user involvement on both realism and the fear of heights was examined with the assistance of 30 sample participants. T-testing of paired samples revealed that the participants' influence upon building height was significant, as was the participants' influence upon both realism and their fear of heights upon sound activation.**

Index Terms— **Height exposure, Virtual reality, Smartphone application, Virtual reality glasses, Remote controller.**

I. Introduction

VIRTUAL reality (VR) involves the use of computers to generate virtual environments in three dimensions. Users are induced to believe that they have fully entered a virtual world, in which their real life actions can allow them to interact with their new surroundings [1]. VR has been increasing in popularity since its inception in 1990. It has found applications in numerous fields, including those as diverse as medicine and entertainment [2].

Phobias are a form of severe anxiety which in some cases can cause problems for sufferers in terms of the impact on their daily lives. Patients have irrational fears of particular circumstances or items, which occur regularly and cannot be ignored or stopped. Patients must take measures to avoid the object of their fears, which can make their lives very difficult in some cases [3]. Some of the better-known phobias include the fear of heights (acrophobia) [4], fear of dogs (cynophobia) [5], fear of spiders (arachnophobia) [6], and fear of tightly enclosed spaces (claustrophobia) [7].

Treatment of phobias can be performed using behavioral therapy, in which patients are placed in situations where they must directly face their fears. The use of virtual reality to create the fear-inducing situations can be effective since it allows patients to feel as though the situation is real, and that they are facing their fear in reality.

Patients can be treated through immersion in a virtual environment created through computers. The virtual environment can be experienced using a head-mounted display (HMD) device or the more extensive computer-assisted virtual environment (CAVE) in which the virtual world surrounds the user. It is possible to both develop and manage the situation that induces the fear in the patient through the use of computers. The patient can then confront the situation they fear without actually facing the real risk that would occur in the non-virtual world [8].

A pilot study of acrophobia treatment using VR was presented by Hodges et al. [9]. In this case, the patients responded to the virtual environment, which caused differing levels of anxiety as various situations arose for the patient to confront. The theoretical background to emotional processing suggests that the patients' fear structure clearly indication a reduction in the anxiety level as the patients became accustomed to the situations. The findings confirmed that it is possible to alter the fear structure through VR treatment.

Virtual reality was suggested as a treatment approach for phobias by Haworth et al. [10], who focused on acrophobia and arachnophobia. Their VRET (virtual reality exposure therapy) system was both cheap and widely available in terms of its components, and was able to track the body of the patient using Kinect. It was necessary to maintain internet connection at all times to allow patient/clinician communication.

VR technology was also used by Schafer et al. [11] in the form of an avatar for the patient and a virtual environment which would allow acrophobia to be addressed. Their experiments involved 42 patients in two groups in order to test the differences between patients using an avatar, and those using the system without the avatar. Significant differences were observed in the outcomes.

This study is presented as follows. An introduction to the fear of heights is first provided, along with a short description of how VR can be used to treat phobias. Section 2 describes the necessary hardware and software. Section

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3 explains how the smartphone application was developed, while section 4 shows the results of the experiments conducted. The conclusion is finally given in Section 5.

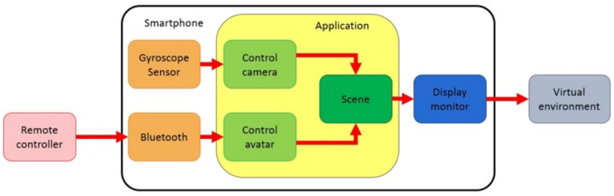


Fig. 1. Block diagram of system process.

II. System

Both hardware and software components are required for the system, and these combine to generate the virtual world for the user. The system involves a smartphone which works with a head-mounted display to show the virtual environment. A wireless remote controller is employed to manage the avatar in the virtual environment.

a. Hardware selection

Fig. 1 depicts the VR hardware employed in the study. Four devices were required: the gyroscope sensor, display monitor, VR glasses, and remote controller. These devices are described in greater detail as follows:

1) Display monitor

A smartphone operating through Android is used as the display. This is convenient due to the high prevalence of Android phones among the population. It was reported by Google in 2015 that there were 1.4 billion Android devices in use around the world [12]. The Android SDK (software development kit) is open source software which can be used by developers. The cardboard SDK used by Android allows an integrated development environment (IDE) to be created readily through the adaptation of current three-dimensional applications for use in VR situations.

2) Gyroscope sensor

The smartphone contains a gyroscope sensor which is able to measure rotation rates (measured in radians/sec) around the axes of a device in three dimensions. Positive rotation follows a counter-clockwise direction from the perspective of an observer considering a device location at the origin on the axes. This definition is the standard used in mathematics for positive rotation, but differs from the roll definition applied by an orientation sensor. In this study, the gyroscope provides the input values which control the view from the camera in the application.

Fig. 2. 3D VR glasses.

3) Virtual reality glasses

In its simplest form, a pair of VR glasses can be a display mounted on the head and capable of displaying a pair of images provided by a smartphone, each of which will be seen respectively by the left and right eyes of the patient. The VR glasses have a pair of polarized lenses which allow adjustment of the eyes' focus. This study uses 3D VR Glasses which can be seen in Fig. 2.

4) Remote controller

The devices used as basic controllers work conveniently with Android smartphones, and are able to communicate using Bluetooth. A universal wireless remote controller is shown in Fig. 3, and is used to manage the avatar movements around the virtual environment.

Fig. 3. Universal wireless remote controller.

b. Software selection

Unity 5.3.2 serves as the engine used to develop the application. Unity can import Cardboard SDK can be imported by Unity to support the development of a VR application which can be used with various different smartphone types and platforms. SDK makes a number of tasks relatively simple:

• Current3D applications can be adapted using a mobile application display which follows the Unity 3D application.

• Existing Unity 3D application can be adapted to create VR applications.

• The camera view can be controlled for compatibility with head tracking.

(a) (b)

Fig. 4. User avatar model (a) Male avatar model, (b) Female avatar model.

Unity can be used to create VR game applications downloadable from Play Store, such as RollerCoaster, Zombie Run, and Crazy Swing created by FiBRUM, as well as VR Roller Coaster, VR Volcano Flythrough, and VR Cave Flythrough developed by Frag. Some previous studies have shown how Unity can be used in other contexts, such as one which helps severely autistic patients to learn about travel through VR [13], a video game which uses motion capture to support rehabilitation with VR and EMG analysis [14], and a system of immersive VR which permits interaction in a natural manner with a haptic interface in order to accomplish shape rendering [15].

III. Proposed Methodology

a. Model selection

In this section the attributes of the models appearing in the scenes are considered in order to create a realistic impression in the virtual environment. The models below are chosen for this purpose.

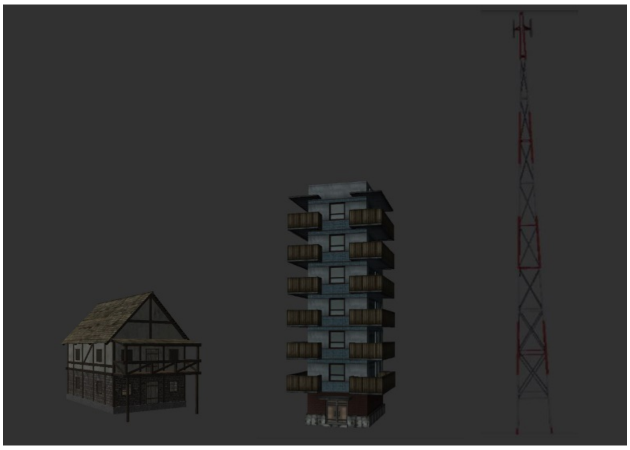
(a) (b)

Fig. 5. Teleport effect (a) Green teleport effect, (b) Orange teleport effect.

• The avatar is created using First Person Lover published by ISBIT GAME [16, 17], as can be seen in Fig. 4.

• The Teleport Effect depicted in Fig. 5 is generated by the KY Magic Effect published by Kakky [18].

• Fig 6 presents the buildings which were used to provide height exposure include Medieval Buildings published by 7th Dimension [19], Block Building Pack published by CGY (Yemelyan K.) [20], and Radio Tower - Low Poly published by VR [21].



(a) (b) (c)

Fig. 6. Building model (a) Building Level 1 balcony & roof, (b) Building Level 2 seventh floor springboard, (c) Building Level 3 peak tower.

b. Map design

The aim in this study is to create a virtual environment through a VR application which can be used to allow patients with a fear of heights to confront their phobia through exposure to varying heights. The virtual environment places an avatar within a cityscape. The patients can then move the avatar around the environment. Three buildings are placed in the scene, and the avatar can be manipulated to move to the top of these buildings, of varying heights. The movement is achieved by teleporting, which appears to the patient as a green-colored effect. As the avatar moves into the green teleport, it is then moved upwards to reappear at the top of the building to a specified location. Moving into the orange teleport allows the avatar to move back to the starting location. Meanwhile, the three buildings in the scene have the characteristics as follows:

• Level 1 balcony and roof: The first building has two floors and includes a balcony, as can be seen in Fig. 6 (a).

• Level 2 seventh floor springboard: This building is taller and has 7 floors. There is an open roof space at the top as shown in Fig. 6 (b).

• Level 3 peak tower: The final building is very tall, as can be seen in Fig. 6 (c).

Within the scene are other items such as buildings or trees, which are present in order to increase the realistic impression created. Fig. 7 presents the map perspective from above.

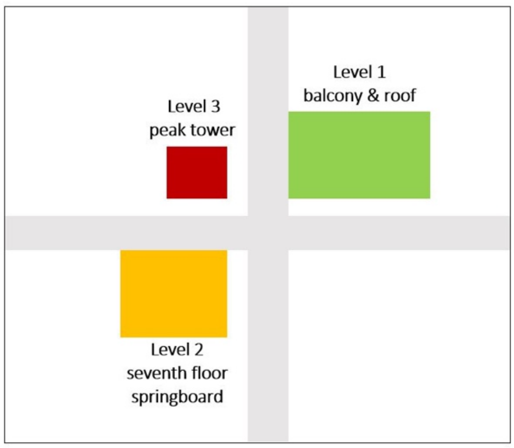


Fig. 7. Top view of a map.

c. Avatar design

The object character controller from Unity is used to develop the avatars for the participants. The shape of the avatar is that of a capsule and its dimension (measured in Unity units) are height 6 and radius 1.5. A camera is situated on the top of the capsule in order to provide the output display, while the capsule radius keeps the main camera on a capsule collider by using this value. A script provided for the character controller governs the avatar movement, thereby allowing actions such as jumping or rotating to follow the view of the camera, as Fig. 4 indicates.

d. Teleport design

Teleporting is a means of moving between locations. To move the avatar to a location which the user would be unable to reach through normal movements, teleportation can be used. The top of the tower, for example, could be reached in this manner. Two forms of teleports are used: green and orange. The user can enter a green teleport (as indicated in Fig. 5 (a)), allowing the avatar to be translated to the roof of the building. To return to the ground, the user can enter the orange teleport (shown in Fig. 5 (b)), which will bring the avatar back to its starting point. The teleport script comprises x, y, and z inputs which allow the translation of the avatar when these values are combined with the input x, y, and z data.

IV. Results and Discussions

a. System Result

A VR system was constructed to provide patients with exposure to varying heights. The system uses a display which is worn on the patient's head. The patients can control their avatar characters through the use of a wireless remote control, which is shown in Fig. 8. The VR application uses provides two display paths, since one must be provided for each of the patient's eyes. Upon commencing the application, the avatar is placed at the starting position in the virtual environment, as indicated in Fig. 9. At the same time the patient sees a menu which is shown in the display, and

Fig. 8. The System.

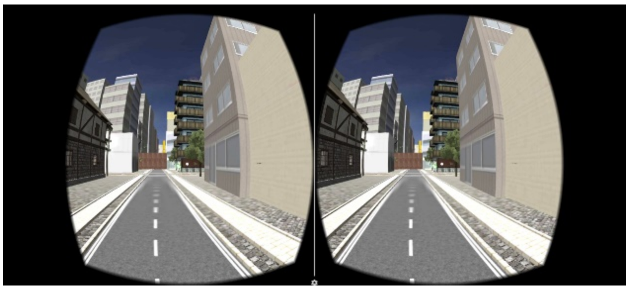
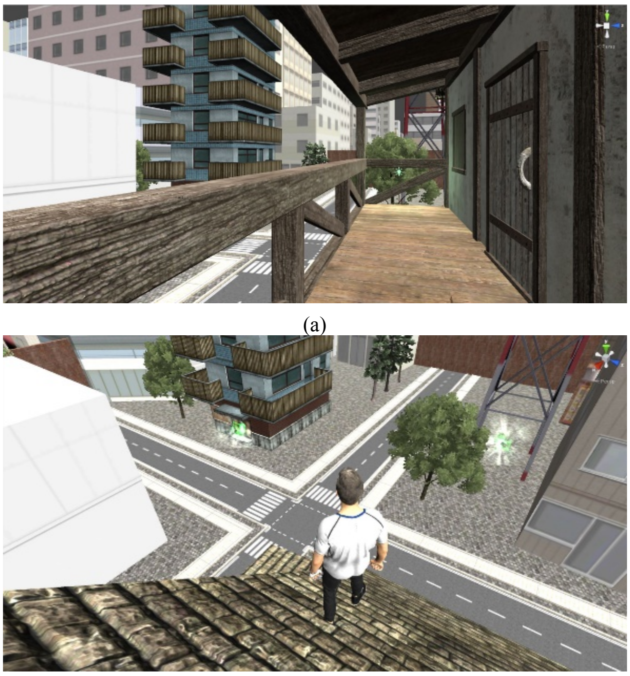


Fig. 9. Display output in virtual reality model.

which allows the patient to control the movements and actions of the avatar, including the ability to teleport to the building rooftops in order to confront the fear of heights.

Fig 10 (a) shows the Level 1 balcony and roof. The avatar can be teleported upwards to reach the house balcony, which has a safety fence and is not particularly high. From here, the patients can teleport the avatar higher to reach the roof of the house. There is no railing provided for safety, but the roof is still relatively low, as Fig. 10 (b) indicates. Heights of the buildings in the virtual reality system are estimated using the practical standard height. The heights of each floor, balcony, and roof are around 10.5 feet (3.2 meters), 15 feet (4.5 meters), and 25 feet (7.5 meters) respectively.



(a)

(b)

Fig. 10. Level 1 (a) Scene of balcony (b) Scene of roof.

In this scene, there are 3 scripts for controlling the game, including a PlayerController script, GameController script and TeleportController script, shown in Fig. 11.

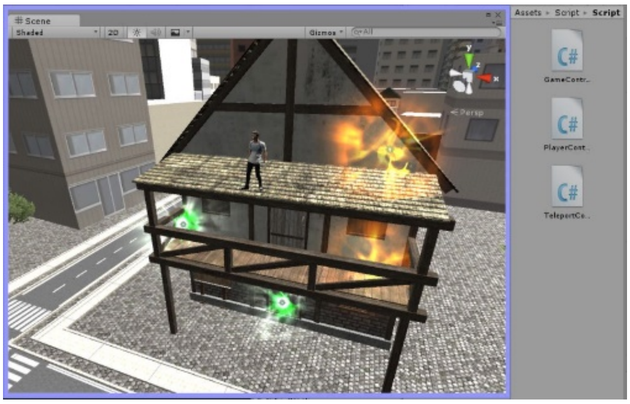
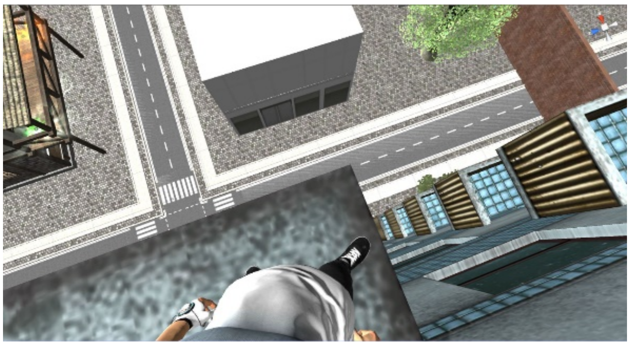
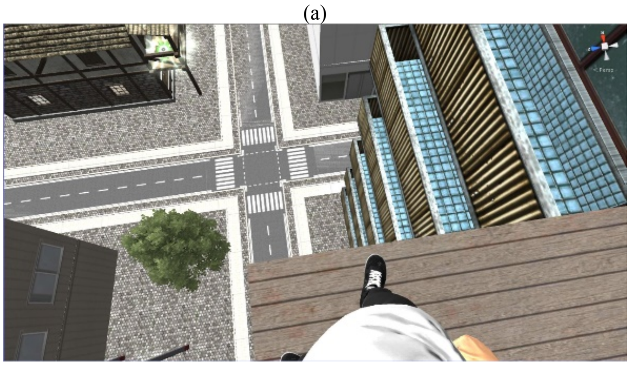


Fig. 11. Scripts of the first scene.

Level 2 seventh floor springboard: As the participant uses teleporting to move upwards, the avatar remains on the edge of the terrace, as can be seen in Fig. 12 (a). On the terrace there is a platform stretching outwards similar to a springboard. On the seventh floor is a small platform which has no safety railing. As the participant rises to the roof of this building, as Fig. 12 (b) indicates, the sound effect heard is that of the wind. The sound effect is turned on at during the different experimental setting. The height of the seventh floor is about 75 feet (22 meters), which is 50 feet higher than the roof's height of the level 1.



(a)



(b)

Fig. 12. Level 2 (a) Scene of the terrace (b) Scene of seventh floor springboard.

The second scene has more control scripts than the first scene, as follows: a PlayerController script, a GameController script, a SoundController script and a TeleportController script. For a script that has been added is the SoundController script for controlling an audio. Scripts in this scene are shown in Fig. 13.

Fig. 13. Scripts of the second scene.

Level 3 peak tower: When the participant teleports to the top of the tower, the avatar will be positioned in a very small area at a great height, as can be seen in Fig.14. The sound effect as the avatar moves to the top of the tower is the sound of the wind. The height of the radio tower is 180 feet (55 meters) approximately which is 105 and 155 feet higher comparing to the 7th floor in level 2 and the roof in level 1.

Fig. 14. Scene of top of the radio tower.

Figure 15 shows scripts of the last scene, Scripts has same like the previous scene, including a PlayerController script, a GameController script, a SoundController script and a TeleportController script.

Fig. 15. Scripts of the last scene.

b. Results of the Evaluation

In order to evaluate the performance of the proposed system, a questionnaire survey will be conducted and given to 30 participants to fill out. There are two sections in the questionnaire. The opening section comprises demographic items covering gender, age, previous experience with VR, and severity of acrophobia. The second section encompasses 16 items which serve to assess the extent to which the participants might experience the realism of the situation presented through VR and their fear of heights.

TABLE I
Participants

Characteristics		Frequency	Percentage
Gender			
	Male	18	60
	Female	12	40
Age			
	15 - 19	3	15
	20 - 24	21	70
	25 - 29	5	16.7
	35 - 39	1	3.3
VR experience			
	Always	1	3.3
	Sometimes	5	16.7
	Never	24	80
Fear of heights			
	Yes	4	13.3
	No	26	86.7

Thirty people participated in the study, comprising 18 males and 12 females in the age range of 18-40. Of these 30, six had previously used VR technology, while 4 considered themselves to have a fear of heights, as Table I indicates.

TABLE II
Descriptive

Score of (1 - 4)	Frequency	Mean	SD
Realism of virtual environment	30	2.3667	0.66868
Fear of heights at building level 1	30	1.1333	0.43417
Fear of heights at building level 2	30	1.8667	0.68145
Fear of heights at building level 3	30	2.3333	0.83666
Realism when sound activated	30	2.7000	0.65126
Realism when sound deactivated	30	1.6333	0.71840
Fear of heights when sound activated	30	2.500	0.77682
Fear of heights when sound deactivated	30	1.7333	0.73968
Realism when user's avatar activated	30	2.8000	0.85836
Realism when user's avatar deactivated	30	2.0333	0.73968
Fear of heights when user's avatar activated	30	2.5000	0.82001
Fear of heights when user's avatar deactivated	30	2.1667	0.79148
Realism when using avatar model suitable with user	30	2.4000	0.92786
Realism when using avatar model unsuitable with user	30	2.0333	0.80872
Fear of heights when using avatar model suitable with user	30	2.2333	0.89763
Fear of heights when using avatar model unsuitable with user	30	1.7667	0.93526

TABLE III
Paired samples t-test

Pairs	t	df	p
Fear of heights at building level 1 - Fear of heights at building level 2	-5.809	29	0.000
Fear of heights at building level 2 - Fear of heights at building level 3	-3.791	29	0.001
Realism when sound activated - Realism when sound deactivated	9.133	29	0.000
Fear of heights when sound activated - Fear of heights when sound deactivated	6.185	29	0.000
Realism when user's avatar activated - Realism when user's avatar deactivated	3.751	29	0.001
Fear of heights when user's avatar activated - Fear of heights when user's avatar deactivated	1.836	29	0.077
Realism when using avatar model suitable with user - Realism when using avatar model unsuitable with user	3.010	29	0.005
Fear of heights when using avatar model suitable with user - Fear of heights when using avatar model unsuitable with user	3.751	29	0.001
Fear of heights at building level 1 - Fear of heights at building level 2	-5.809	29	0.000
Fear of heights at building level 2 - Fear of heights at building level 3	-3.791	29	0.001
Realism when sound activated - Realism when sound deactivated	9.133	29	0.000
Fear of heights when sound activated - Fear of heights when sound deactivated	6.185	29	0.000
Realism when user's avatar activated - Realism when user's avatar deactivated	3.751	29	0.001
Fear of heights when user's avatar activated - Fear of heights when user's avatar deactivated	1.836	29	0.077
Realism when using avatar model suitable with user - Realism when using avatar model unsuitable with user	3.010	29	0.005
Fear of heights when using avatar model suitable with user - Fear of heights when using avatar model unsuitable with user	3.751	29	0.001

Analysis is carried out on the data obtained from the questionnaires. The questions were answered using a scale of 1-4, where 4 = very much, 3 = quite a lot, 2 = average, and 1 = few. The scores for every question were compared using paired samples t-testing with a reliability level at 95%. The findings revealed that when the participants were working in tall buildings, they experienced a significantly greater fear of heights as the building height increased. Comparison of building level 1 with level 2 generated $t = -5.809$, $p = 0.000$), while comparison of building level 2 with level 3 generated $t = -3.791$, $p = 0.001$. The scores for realism and fear of heights were compared both with and without sound effects, with the findings revealing that scores were significantly higher when the sound was turned on that when it was absent (realism $t = 9.133$, $p = 0.000$; fear of heights $t = 6.185$, $p = 0.000$). Furthermore, when participants were able to see their avatars, the realism score was significantly increased in comparison to when they could not ($t = 3.751$, $p = 0.001$). In cases where the avatar was selected with the gender to represent the participant, the fear of heights score significantly increased (t = 3.751, p = 0.001). However, the gender of the avatar when the gender of the participant was taken into account did not significantly affect the realism experienced (t = 3.010, p = 0.005), and scores for fear were not different regardless of whether the participants could see their avatars or not (p = 0.077).

It can therefore be concluded that building height, sound effects, and gender-appropriate avatar use have an influence upon the scores for fear of heights, while the use of sound effects and the ability of the participant to see their gender-appropriate avatar influences the scores for realism. When immersed in the virtual environment, the participants' fear of heights is not affected by the ability to see their avatars. The mean results for each of the topics are shown in Table II, while the paired samples t-test comparison results are presented in Table III.

When the realism score for the virtual environment created by the application is compared to a value of 2 with 95% reliability (alpha = 0.05), the result significantly exceeds 2 (p = 0.005). The realism score for the virtual environment produced by the application achieves ranking at the highest level as presented in Table IV.

The Independent sample t-test is used to analyze the participant's general information: gender, age, virtual reality experience and fear of heights. Table V shows the result of the Independent sample t-test with the scores of question number 1 to 16 (Q1 to Q16 in the table) and gender. According to the result, there is no relation regardless of gender.

TABLE IV
Descriptive

Score of (1 - 4)	t	df	p
Realism of virtual environment	3.003	29	0.005

TABLE V
Independent sample t-test of age

Questions	Levene's Test for Equality of Variances		Equality of Variances	t-test for Equality of Means	
	F	p		t	p
Q1	0.584	0.451	Assumed	-3.641	*0.001
			Not assumed	-4.330	0.003
Q2	3.769	0.062	Assumed	-1.540	*0.135
			Not assumed	-1.242	0.271
Q3	10.123	0.004	Assumed	-0.473	0.640
			Not assumed	-1.072	*0.294
Q4	3.049	0.092	Assumed	0.288	*0.775
			Not assumed	0.446	0.664
Q5	3.835	0.060	Assumed	-1.972	*0.059
			Not assumed	-2.521	0.036
Q6	0.154	0.698	Assumed	-2.034	*0.052
			Not assumed	-1.716	0.147
Q7	4.688	0.039	Assumed	-2.378	0.024
			Not assumed	-3.348	*0.008
Q8	1.046	0.315	Assumed	-2.378	*0.024
			Not assumed	-1.903	0.117
Q9	0.272	0.606	Assumed	-0.659	*0.515
			Not assumed	-0.586	0.582
Q10	1.252	0.273	Assumed	-1.837	*0.077
			Not assumed	-1.516	0.191
Q11	0.000	0.987	Assumed	-2.230	*0.034
			Not assumed	-2.081	0.088
Q12	0.420	0.522	Assumed	-0.101	*0.920
			Not assumed	-0.078	0.941
Q13	0.455	0.505	Assumed	-1.150	*0.260
			Not assumed	-1.243	0.259
Q14	0.626	0.435	Assumed	-1.779	*0.086
			Not assumed	-1.589	0.170
Q15	0.095	0.760	Assumed	-1.586	*0.124
			Not assumed	-1.644	0.152
Q16	0.498	0.486	Assumed	-1.713	*0.098
			Not assumed	-1.412	0.218

TABLE VI
Independent sample t-test of gender

Questions	Levene's Test for Equality of Variances		Equality of Variances	t-test for Equality of Means	
	F	p		t	p
Q1	0.525	0.475	Assumed	-0.888	*0.382
			Not assumed	-0.955	0.348
Q2	6.725	0.015	Assumed	-1.211	0.236
			Not assumed	-1.035	*0.319
Q3	0.498	0.486	Assumed	-1.449	*0.159
			Not assumed	-1.449	0.160
Q4	0.915	0.347	Assumed	-1.072	*0.293
			Not assumed	-1.041	0.309
Q5	0.010	0.919	Assumed	-.913	*0.369
			Not assumed	-.882	0.388
Q6	0.494	0.488	Assumed	.306	*0.762
			Not assumed	.315	0.755
Q7	0.034	0.855	Assumed	.473	*0.640
			Not assumed	.472	0.641
Q8	0.225	0.639	Assumed	.904	*0.374
			Not assumed	.935	0.359
Q9	1.493	0.232	Assumed	-.342	*0.735
			Not assumed	-.333	0.742
Q10	0.296	0.591	Assumed	-.598	*0.555
			Not assumed	-.606	0.550
Q11	1.683	0.205	Assumed	.000	*1.000
			Not assumed	.000	1.000
Q12	0.161	0.691	Assumed	-.940	*0.355
			Not assumed	-.946	0.354
Q13	1.348	0.255	Assumed	-.636	*0.530
			Not assumed	-.668	0.510
Q14	2.684	0.113	Assumed	-.272	*0.788
			Not assumed	-.306	0.762
Q15	1.296	0.265	Assumed	-.082	*0.936
			Not assumed	-.086	0.932
Q16	1.595	0.217	Assumed	.078	*0.938
			Not assumed	0.084	0.934

On the other hand, when applying the independent sample t-test, with the scores of question 1 to 16, to participant's ages, which are categorized into 2 groups: under and above 25 years old, there is a relation regarded ages. The differential between scores and ages is related to some significations, which are the realism score of the virtual world in the application (t = -3.641, p = 0.001), the scores of fear of heights through the deactivated sound (t = -2.378, p = 0.024) and score of fear of heights through the activation of the user's avatar (t = -2.230, p = 0.034), as shown in Table VI.

The result shows that the participant's VR experience does not affect the differential of scores in each question. However, there is an exception; the realism scores through the deactivation of user's avatar are different significantly (t = 3.089, p = 0.004), as shown in the Table VII. The result of using the independent sample t-test, with the scores of question 1 to 16, to the participants' fear of height is also presented by the Table VIII. The only significant differential found to be the score of fear of heights through the activation of sound (t = -3.167, p = 0.004).

c. *Discussions*

The VR approach proposed in this study is inexpensive, accessible, and also user-friendly, due to the convenience of the system employed. Haworth et al. [10] note that a monitor and Kinect could be used respectively as the devices for display and input, respectively. When our proposed approach is compared to that of Haworth et al., it can be seen that their use of Kinect results in a smaller area being used, while our VR approach is not limited in this way. In addition, our approach is also superior to the

TABLE VII
Independent sample t-test of virtual reality experience

Questions	Levene's Test for Equality of Variances		Equality of Variances	t-test for Equality of Means	
	F	p		t	p
Q1	5.126	0.032	Assumed	0.814	0.422
			Not assumed	1.127	*0.279
Q2	3.473	0.073	Assumed	0.837	*0.410
			Not assumed	1.696	0.103
Q3	1.069	0.310	Assumed	0.799	*0.431
			Not assumed	0.696	0.510
Q4	0.385	0.540	Assumed	0.430	*0.670
			Not assumed	0.470	0.650
Q5	0.181	0.674	Assumed	0.837	*0.410
			Not assumed	0.952	0.366
Q6	1.400	0.247	Assumed	0.502	*0.620
			Not assumed	0.612	0.554
Q7	0.000	1.000	Assumed	0.000	*1.000
			Not assumed	0.000	1.000
Q8	0.165	0.688	Assumed	0.860	*0.397
			Not assumed	0.784	0.459
Q9	0.974	0.332	Assumed	0.847	*0.404
			Not assumed	1.143	0.273
Q10	0.190	0.667	Assumed	3.089	*0.004
			Not assumed	3.639	0.005
Q11	2.592	0.119	Assumed	0.550	*0.587
			Not assumed	0.751	0.466
Q12	0.182	0.673	Assumed	1.795	*0.083
			Not assumed	1.704	0.131
Q13	5.253	0.030	Assumed	1.086	0.287
			Not assumed	1.405	*0.186
Q14	0.130	0.721	Assumed	1.884	*0.070
			Not assumed	2.390	0.035
Q15	1.145	0.294	Assumed	1.231	*0.228
			Not assumed	1.390	0.198
Q16	2.344	0.137	Assumed	1.283	*0.210
			Not assumed	1.853	0.083

TABLE VIII
Independent sample t-test of fear of height

Questions	Levene's Test for Equality of Variances		Equality of Variances	t-test for Equality of Means	
	F	p		t	p
Q1	1.392	0.248	Assumed	-0.369	*0.715
			Not assumed	-0.272	0.801
Q2	2.079	0.160	Assumed	-0.653	*0.519
			Not assumed	-1.690	0.103
Q3	1.383	0.249	Assumed	-0.362	*0.720
			Not assumed	-0.272	0.801
Q4	0.835	0.369	Assumed	-0.126	*0.900
			Not assumed	-0.089	0.934
Q5	0.703	0.409	Assumed	-1.517	*0.140
			Not assumed	-1.849	0.127
Q6	0.658	0.424	Assumed	-0.393	*0.697
			Not assumed	-0.297	0.783
Q7	1.411	0.245	Assumed	-3.167	*0.004
			Not assumed	-2.241	0.101
Q8	0.571	0.456	Assumed	-0.671	*0.508
			Not assumed	-0.519	0.635
Q9	1.972	0.171	Assumed	-0.661	*0.514
			Not assumed	-0.463	0.672
Q10	0.254	0.618	Assumed	0.526	*0.603
			Not assumed	0.723	0.499
Q11	3.158	0.086	Assumed	1.327	*0.195
			Not assumed	0.801	0.478
Q12	0.502	0.485	Assumed	0.222	*0.826
			Not assumed	0.191	0.859
Q13	1.089	0.306	Assumed	-0.845	*0.405
			Not assumed	-0.582	0.597
Q14	3.040	0.092	Assumed	-0.087	*0.931
			Not assumed	-0.053	0.961
Q15	3.572	0.069	Assumed	-1.164	*0.254
			Not assumed	-0.728	0.515
Q16	2.323	0.139	Assumed	-0.038	*0.970
			Not assumed	-0.025	0.981

Oculus Rift system created by Schafer et al. [11] on account of the stand-alone nature of our system whereby no wires are required, and its greater economy. Our system does, however, present certain disadvantages in comparison to other approaches, one of which is that our system is only able to track the head, while another is that our system resolution is low since it is dependent on the smartphone display resolution.

The paired sample findings suggest that sound effects should be included as part of the virtual environment since it enhances the feeling of reality the participants experience. Scores for both realism and fear of heights are increased in VR environment which feature sound effects when compared to those which do not. The use of an avatar, which allows gender representation, also has the effect of increasing realism scores. However, when participants are able to view their avatars when immersed in the virtual environment, the fear of heights scores are not increased despite the greater realism. It is possible that this occurs because fear of heights is related to the inability of users to see their own legs; when the leg is not seen to be touching the floor it can lead to a sensation of falling.

Sample t-testing of experimental data confirms that while the VR realism scores exceeded half, this is not sufficient. In order to increase the scores in this category, a 360-degree camera might offer a more realistic experience leading to better results.

The result of the independent sample t-test indicates that the genders of participants do not affect the scores, either male or female can use the application. Yet, it is different when comes to the ages of participants. The scores of realistic, sound effects, and utilization of user avatars among the participators, who are older than 25 years old, are higher than the participators aged under 25 years old. The reason of this matter may come from the virtual 3D environment experiences. The under 25 years old participants may have familiar with such the environment through video games or 3D movies. For the virtual reality experiences and fear of height of the participants, there are only few questions which scores with significant difference. The result indicates that this application is suitable for participants who are either experienced or inexperienced with the virtual reality, and both who fear and those do not fear of height

V. Conclusion

This study presented a smartphone VR application which can be used to simulate exposure to heights. Smartphones are widely used, making this approach very convenient. All that is needed are a few additional inexpensive accessories which allow the creation of the virtual environment: VR glasses and a wireless remote controller. Having acquired the system, patients would be able to use it from home, allowing them to confront their fear of heights whenever they wish. This study therefore examines the factors which influence the fear of heights and the degree of realism experienced by the patients through analysis of questionnaire data.

The hardware involved in the system includes a stand-alone VR display worn on the head and not attached to any wires. A smartphone and remote controller are also required. The software generates the virtual environment which is displayed for the user via the smartphone. Within our virtual environment, there are three different heights which can be experienced by the patient. It is possible to begin at lower heights and then move higher if the patient feels comfortable to do so. The application scenarios are generated using Unity engine, whereby object models are placed in simple and user-friendly scenes which provide a realistic environment.

The evaluation phase involved data gathered from questionnaires completed by the 18 male and 12 female participants after using the VR system. Statistical analysis was then performed using the data, leading to the conclusions that the building height, the inclusion of sound effects, and the presence of the avatar with the characteristics of the participant can influence the scores for fear of heights. Meanwhile, he inclusion of sound effects and the use of the avatar had a positive effect on the scores given for realism. The realism scores exceeded half, at a statistically significant level.

In future studies, it is expected that we will investigate the use of a new controller type which would increase the level of interaction with the virtual environment. It would also be possible to provide online connectivity for the application so that mental health specialists and patients could be connected during use of the application so advice and support could be provided by the specialist within the virtual scenes.

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