

MAKING SELF-HELP VIRTUAL REALITY EXPOSURE THERAPY
ACCESSIBLE: HARDWARE AND DESIGN CONSIDERATIONS

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ABSTRACT

Virtual Reality Exposure therapy has proven to be as effective as cognitive behavioral therapy with in vivo exposure [1]. Since it is an efficacious and cost effective alternative to in vivo exposure therapy, it can be offered to the clients via software packages containing educational material and self-report questionnaires considering the present state of Virtual Reality technology. This paper aims to identify design considerations and constraints, knowledge of which is highly useful in developing the applications that are accessible user-friendly, require minimal or no therapeutic contact and provide self-help solution to the inaccessibility of anxiety treatment which leads to a massive number of patients being left untreated.

KEYWORDS

Anxiety, Phobia, Virtual Reality, Exposure Therapy, Vivo Exposure.

1. INTRODUCTION

Anxiety disorder is the most prevalent mental disorder. But the stigma attached to mental disorders in addition to the unavailability of proper and affordable treatment leads to it being left untreated. Virtual Reality Exposure Therapy is being studied for a long period of time and can be considered an effective alternative to cognitive behavioral therapy [2]. The major barrier in receiving any kind of treatment is the lack of its accessibility and affordability. According to a psychiatry journal, people generally seek treatment after 6 to 8 years of suffering from mood disorders and 9 to 23 years of suffering from anxiety disorders [3]. With the rapid growth of interest in VR technology, the future of VRET is promising.

As VRET becomes convenient, it will be easier to develop standalone VRET experiences but it requires consideration of design and hardware. Developing such virtual environments not only requires understanding of human side of VR but also the understanding of the specific phobias and disorders the environment is being designed. This will make VRET applications efficacious, affordable and accessible which will lead to patients seeking help leading to less delay in initial contact for treatment and delay in treatment of the disorder.

2. VRET AND ACCESSIBILITY

The common question asked regarding VRET is that why VRET is considered if the option in vivo exposure therapy is available. In vivo exposure therapy with or without relaxation is just as effective but VRET is a good alternative if not better for the following reasons:

- VRET allows the user to have more control over the situation [4]. The application that is designed a way in which the exposure is increased by using various levels and after taking subjective units of discomfort (SUDs) in account will less reluctance from patient.
- In vivo exposure can be expensive when it comes to exposing patient to environments that are usually out of reach. For instance, if patient had flight phobia, in vivo exposure will be costly [5]. There is a high chance of fear coming back after just one session. This virtually generated environment will be an aid in this situation or in a similar one.
- Refusal to initiate a treatment is a major issue when it comes to in vivo exposure. According to a survey regarding the acceptability of virtual reality

(VR) exposure, the refusal rate of initiating treatment with in vivo exposure was greater than VR exposure. Thus it can be concluded that VRET results in more people seeking therapy [6].

- Another major hindrance in seeking help is confidentiality. People like to keep the information regarding their treatment confidential. According to an article published in Journal of Health Cognitive Behaviour Therapy 2017 [7], "An ethical advantage of VRET is that you can do "in-vivo"-like exposures without leaving the office."

3. DESIGNING VIRTUAL ENVIRONMENT FOR THERAPY

For designing virtual environments, many considerations are to be made. Few of them are listed thoroughly below:

3.1. Hardware

i. Terminology

- **Head Mounted Display (HMD):** A head-mounted display is worn over head. For VR, stereo binocular HMDs are used which means that two separate images are rendered, one for each eye. In short it us the combination of two monocular displays.
- **Virtual Environment:** Virtual environment is anything that is visible to the user when he puts on head mounted display. Virtual environment stimulates mind by presenting it visuals and sometimes makes use of other senses.

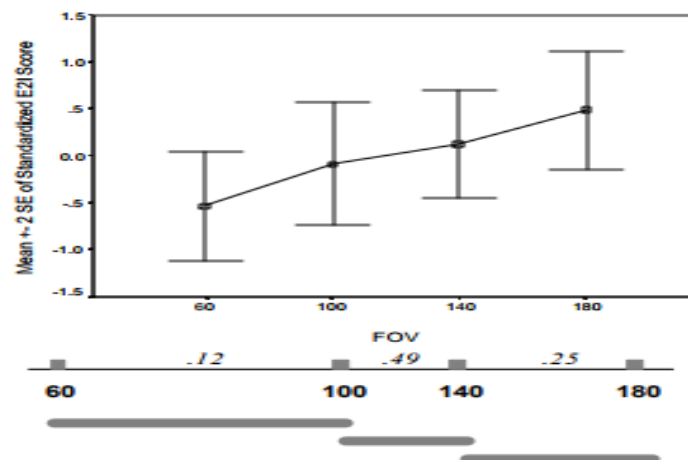


Figure 1. Mean and standard error of E²I scores [8].

- **Simulator Sickness:** Motion sickness that maybe induced by exposure to virtual environments due to badly designed experience, too much movement or prolonged use.
- **Immersion:** Immersion is the measure of presence user feels in the virtual environment.
- **Degree of Freedom (DOF):** Degree of freedom is the level of dependency the hardware allows for translation and rotation in the virtual environment.
- **Field of View (FOV):** It is the space that is visible to user at any given time in virtual reality. A research verified the relation between engagement, enjoyment and immersion graph and the field of view

[8]. The results are illustrated in the graph which is shown in figure [1]:

ii. Past Limitations of Hardware

VRET proved to be efficacious in the past but there were many hardware limitations present. It is important to specify those limitations to assist in finding the appropriate HMD for own design.

These limitations are listed below:

- **Low computational Power:** In the past, head mounted displayed had low computational power which has improved drastically with the advancement of VR technology.
- **Low Frame Rates:** Maintaining frame rate of over 75 frames per second is very important for a good virtual reality experience. With new HMDS, it is now possible to maintain that frame rate. Low frame rate also cause nausea, bad user experience and distortion of view which results in breaking of immersion. The inconsistencies in the motion of simulator and the user cause simulator sickness [9].
- **Low Resolution:** Since in VR, images are not viewed on one single flat panel screen, instead they are blown up. Low resolution results in making experience less immersive.
- **Low Refresh Rate:** Refresh rate is another factor that can potentially contribute to simulator sickness. It is the rate at which the content on the screen are updated. It is measured in Hertz. It is important to have a refresh rate of 90 Hz in VR. It is possible to have a refresh rate of 120 Hz with some of the current HMDs which was difficult to achieve in the past.
- **Inaccessibility:** HMDs are now available easily at different prices in the market. This was not the case in the past. It was difficult to find a VR system and set it up for proper use.
- **Installation:** Installation and setup of VR devices required a lot of expertise. Now it can all be done with few clicks.

These limitations were stated above in order to describe the parameters that should be considered when choosing hardware for VRET and they can be summarized as in Table 1:

Table 1. Summarized Specifications.

1	Frame Rate Per Second (FPS)	>60 fps
2	Refresh Rate	At least 60 Hz
3	Resolution	Varies with HMDs
4	Field of View	Varies with HMDs

iii. Other Considerations

Another important question to ask is whether the platform is a mobile platform or stationary VR. With 3 DOFs, head rotation is tracked by HMDs which is called orientation tracking and with 6 DOFs, head rotation with translation and movement in spaced is tracked which is called positional tracking. The hardware should be chosen considering all these parameters. This choice depends on the target

application and environment design. There are few limitations of mobile VR, for instance, computational power is low, and fewer head-tracking and user input options are available. Stationary VR systems cost more and allows user to share the experience. This advantage may help the therapist to get involved in the experience with the user.

Table 2. A Comparison of VR Platforms for VRET.

Platforms	Stationary	Mobile
Cost	High Cost	Low Cost
Monitoring of User Activity by Therapist	Easy	Only through verbal communication
Controlling Environment by Therapist	Possible	Possible
Computational Power	High	Low
Appropriateness for Self-Help VRET Applications	Moderately suitable	Highly Suitable
User Input Options	More options available then mobile VR	Limited

3.2. Personal Presence and Movement

Personal presence is the degree to which a user feels immersed in the virtual environment where as environmental presence is defined as the extent to which the environment reacts to the user's presence. Complex visuals improve the personal presence is VRET. A research done with regards to public speaking proved that user reacts more to animated public than to static public [10]. Thus a moving and interactive object or stimuli will immerse the user more than a static object.

Movements require more computational sources but in the long run it make the experience more effective. It is also discussed in a research that a realistically moving but graphically poor object is stimulates a user more than a realistically textured static object. High end graphics are not requires as long as anxiety provoking factor of motion is present [11]. Some textures in VR can also be computationally expensive. Thus, computational resources should be utilized carefully considering these results.

There is no research present that proves any effect of user movement in the virtual environments towards the stimuli. But if a virtual environments demands movement, it should be kept minimal as it may cause motion sickness.

3.3. Sound

Similar to the reality we live in, it is important in VR that sounds come from a proper source. This does not only help with interactivity but also helps in making sure that immersion never breaks at any point. It keeps the real world distractions away from the users. Few design decisions that you have to make regarding sound are:

- 2D or 3D Audio: 2D sounds are usually used for 2D screens and applications. If a VR experience has different sound sources, then 3D audio should be preferred.
- Mono or Stereo: Stereo makes a user feel that he is located in a three dimensional sound source. Mono sounds save disk space but they are better suited for 2D designs.

- **Binaural Sounds:** 3D sounds can be used to draw a user's attentions. It is particularly important in a VR experience because user can look in any direction and the source of sound must make sense to the user.

Sounds in VRET are to be carefully picked. It is proven that stereo sounds are appropriate for VR experiences. According to a research, people can differentiate between stereo and mono sounds. This result had a great effect on the developed environment [12].

Another question that arises is if 3D audio has any relation with the presence in the environment. The results presented by research state that "significant difference in spatial perception was found between 3D audio and stereo or Dolby sound, although the median score indicated a trend in favor of 3D audio" [12].

For VRET, a good design decision is to avoid using sounds that are not relevant to the environment and only to use sound that may enhance the experience. If a voice assistant is to be included, it is better to make sure that it's not adding to anxiety of the patient which may lead to patient dropping out of therapy.

Good sound decisions enhance the user's experience during VRET in following ways:

- For VRET, the exposure intensity is predominantly a measure of visuals cues but sound plays an important role in creating the illusion. For therapy to be effective, it is important to match audio with the visuals.
- If the stimulus is not chiefly visual, appropriate sound setup will increase efficacy.
- Voice assistance is an added advantage for blind and partially sighted patients [13].
- It helps in drawing attention of user to different spots within the scene. For instance, you may want the user to look down from a glass elevator for arachnophobia, thus to draw user's attention to the ground, an appropriate sound can be used.
- If mind-relaxation or other calming sounds are needed at some point in therapy, they should be played at the right moment for the right amount of time to avoid the mismatch of simulation and sound.
- Attaching 3D sounds to object is a technique that can be used through rendering engines which leads to all the sound coming from the right distance from the correct object. As the users distance from the object increased, the effect of sound decreases [14].

3.4. Degree of Interactivity

Interactivity plays a big role in increasing the presence hence improving the efficacy of VRET. The extent to which an environment can be made interactive is dependent on different variables. Some of them were elaborated in a research [15] and are listed below:

- Number of inputs that environment responds to.
- The extent to which the environment can be modified by the user.
- The extent to which environment alters during the experience.
- Ability to realistically interact with objects in virtual environment, for instance, the ability to hold and throw object with hands rather than click of a button.
- The responsiveness speed when user interacts with the environment.

Increasing the number of inputs will not have any positive effect but interactivity should be added where it is required.

3.5. User Interface

Designing UI for a VR experience is a rather challenging task. There are all kinds of options available which will be stated for assistance. But it entirely depends on how the environment is setup. Design of user interface depends on many factors. A research summarized the guidelines and preference for therapist led sessions. These are summarized as [16]:

- Therapists should be provided an automated environment.
- Provide therapists with the input from the user including SUD scores, their comments, options they choose and their current status.
- Design for error prevention by not allowing therapists to trigger inappropriate simulation events.
- Provide therapists with predefined comment flags to record events in the session.
- In a VRET environment where the position of the patient is fixed in the VR world, therapists do not need an external viewpoint of the VR world with a projection.

For self-help applications or minimal therapist contact VRET these design considerations may still be helpful. In a VR environment, user should be able to interact easily; user should be able to control the stimuli while being encouraged to continue the therapy. Another alternative is to use Subjective Units of Distress (SUDs) to choose the level of exposure which is shown in table [3]. SUDs can be self-reported and recorded through user input.

Table 3. Subjective Units of Distress Scale.

Score	Intensity of Disturbance
10	Close to a nervous breakdown
9	Losing Control
8	Alienation
7	Maintaining control with difficulty
6	Moderately Uncomfortable
5	Somewhat Uncomfortable
4	Mildly Upset
3	Feeling Unpleasant
2	Bit Bothered
1	No or Minor Distress
0	Total Relief

4. DESIGNING COMPONENTS

4.1. Progression through Levels

In therapist-led applications, therapist is given a scene-control which they can adjust as they communicate verbally with patients. Some of the controls that patients and therapist possess are:

Table 4. Scenario Controls.

Therapist's Control	Patient's Control
Check for SUD's	Input SUDs
Ask for SUD's Input	Ask therapist for help when feeling uncomfortable
Ask patient to explain fear	Suggest or go to easier scenario
Ask patient to explain scenario	Suggest or go to harder scenario
Help patient through the experience through different techniques	Use other software options e.g. volume etc.
Suggest patient to make progress	Quit

The main purpose of these controls is to make progress and gather the courage to progress to next level which is shown in table [4]. This feature can be implemented in VR through utilizing the level progression by use of SUDs. Voice assistance or other techniques can be used to encourage the user to deal with the phobia.

4.2. Rewards and Scores

Serious gaming with scores and rewards can motivate the user to make progress during VRET. Games are engaging and help user learn naturally. The feature of gamification should be added keeping the purpose of the therapy in mind. Gamifications should not create a barrier for the therapeutic effect of the system. The effectiveness of serious games in the treatment of mental illness was researched and proven [15]. VR makes it easier to develop serious games for phobia and anxiety by adding rewards and score to each level. The use of game engines available make easy translation of ideas possible.

There arises a question of increasing anxiety levels with anxiousness to make progress but a study has shown that casual games can be developed to reduce stress and improving mood [17]. Significant changes in anger, mood, confusion and fatigue were seen by playing the games designed for the study.

Thus gamification is a tool in the VRET development toolbox that should be utilized for making the experience as effective for patient as possible.

4.3. Psychoeducation

Anxiety and depression are most prevalent disorders thus there are many approaches to help patient receive the treatment that they are looking for. Psycho-education intervention during CBT is one of the approaches. Psycho-education intervention over time can help in reduction of symptoms over time which proves its efficacy [18].

In VRET, these interventions can be provided to the patient as a separate package or as assistance during the therapy. Separate learning environment can be developed for the sake of educating the user. Psychoeducation is not limited to being aware of the illness or phobia but also includes the self-care solutions, information regarding stimuli and studies regarding the illness.

5. CHALLENGES

The self-help applications available in the commercial market are of questionable quality as they are not subjected to any evaluation. There is no criteria available to rate those application or their ability to help patients reduce their symptoms. No user tests or reviews are available to prove their efficacy. It is challenge to determine what works for self-help VRET and what doesn't. There are no tests made considering those applications that could totally assess the working of them. No subtle standards are being declared that could analyze the quality and efficiency of these applications and regarding the commercial market it cannot be determined that to what extent these applications work and there is no quantitative analysis to figure the percentage of reduction of the symptoms.

Even though with the advancement of technology and abundance of smart-phones, these applications can be made readily available but in the end, the question of whether they fulfill the purpose cannot be answered for each and every application. To develop state of the art next generation self-help VRET application test and trial method is not enough; all the design considerations few of which were listed in this paper should be kept in mind before development to get a perfect application that serves the objectives.

The availability of VR tools is still rare in developing countries like Pakistan, many people don't have access to it considering the economical conditions of the people and the high cost of the tools , According to a research carried out only 17.8% of the population uses internet, while addressing the factor that VR tools are rather very costly and are considered a thing only for the rich people it would be very hard to say if it would gain popularity among countries where the ratio of access to the internet is quite low because it is supposed to target those people who couldn't bear the cost going to a psychiatrist for their anxiety issues and consider it as a taboo doing that

A highly professional team is required for the designing and development of this sort of applications. Someone having a proper insight and first degree could come up with a perfect development strategy that meets all the requirement of the design and is beneficial in every way for the patients to treat their problems while remaining in a virtual environment. Anyone developing this type of application need to perfectly understand all the design constraints and then do a provision of the most perfect solution to it. The developer is needed to develop such an environment which is extremely user friendly because as long as the user is concerned he or she must be totally comfortable with the environment in order to outmaneuver the obstacles of the anxiety problems.

Coming up with a product that is in every aspect helpful to the user is not useful that addresses this type of scenario. A number of meaningful meetings are required between the psychiatrists and the developers so they could ensure the delivery of the product that surely reduces the symptoms of the issue lingering within the user .Developers and psychiatrists are needed to indulge themselves in the meaningful conversations to come up with the required results that serves all the objectives.

6. CONCLUSIONS

Research has proven that VRET is as effective as CBT and the acceptance rate of VRET is higher in some cases than CBT. Use of these applications should not be limited therapist's office and should be made available to the public whenever it is possible.

These applications will be very beneficial in a long run if designed with keeping all the design constraints in mind. Although many design solutions are applicable but there is a subtle need of coming up with those scenarios that would help the users to overcome their anxiety challenges completely. They will be useful for the people who couldn't afford a therapist; they will be useful for the people who don't prefer going to a therapist and many other more benefits.

The main idea is to make them approachable to the laymen, and the provision of the scenarios that could serve as an all-time solution to the mental problems like phobias and anxiety without having one to put a diligent work on it. There is still a need to subject these applications to evaluation to make sure that they are fulfilling their purpose.

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