How real is Virtual Reality Therapy (VRT)?
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ABSTRACT
This report illustrates that since the early 1990’s professionals have researched into using virtual environments as a form of therapy. It explores how Virtual Reality Therapy (VRT) has been applied to two different areas. The successes and problems of this form of treatment are discussed.

Firstly the way VRT has been used to treat various phobias is discovered. The report looks at the technology behind treating acrophobia, aerophobia and claustrophobia. By using case studies it becomes apparent that there is an established technique when applying VRT to aid individuals to successfully overcome their phobias. Next the use of VRT to aid individuals with physical defects is explored by looking at three examples in detail. Controlling different physical defects which have arose from cerebral palsy, strokes and amputations creating the need for prosthetic limbs are specifically looked into. From the discussion it is apparent that there are many more issues surrounding this application of VRT, than applying it to aid phobias.

The issues, successes and conclusions defined within each of the studies are examined. From this it becomes clear that, at this moment in time, VRT is more effective at overcoming phobias than aiding with physical defects. However, due to future technological advances, the reducing cost of tools and more detailed research VRT will become more able at treating areas other than phobias.

Categories and Subject Descriptors

General Terms

Keywords
Experimentation, interactive multimedia, medical profession, olfactory, phobias, rehabilitation, strokes, virtual reality, virtual reality therapy, virtual worlds

1. INTRODUCTION
A Virtual Reality (VR) is a “multimedia environment” in which users interact with a computer-generated reality; this reality is different from their own reality [1]. After initial research was carried out into VR’s, different applications of the technology became apparent. The use of VR in the medical profession, for aiding both mental and physical difficulties, was being explored. Thompson [2] shows how in the early 1990’s researchers were anticipating VR’s being used as a form of treatment therapy for various disciplines; this lead to the evolution of Virtual Reality Therapy (VRT).

VRT immerses an individual into a virtual environment, this environment is computer generated. Typically VRT makes use of head mounted displays (HMD) or a room which is computerized. VRT can also be known as Virtual Reality Exposure Therapy (VRET) because it exposes the user to a simulated realism as a form of therapy [3]. VRT combines in vivo therapy (using real stimuli) and in imagino therapy (imagined therapy) to try and produce the best technique [4]. Many studies have been carried out into using VRT to treat mental difficulties, such as phobias, and to aid various physical rehabilitation techniques within the medical profession.

This paper will look at different ways VRT is used and evaluate the appropriateness of this type of therapy in different fields. VRT has been applied to help people overcome phobias and has also been used to aid rehabilitation after medical problems, which cause physical defects. The way VRT is applied to each of these areas, and the technology used, will be discussed and the success of the therapy will be assessed using case studies. Problems and limitations of VRT will be considered to decide whether it is a worthwhile approach to therapy. The ethical issues surrounding using VRT will be outlined and their implications made clear.

2. APPLICATION OF VRT
This section of this report will look into how VRT has been applied to help individuals overcome their phobias and physical defects. Different case studies will be used to help demonstrate and evaluate the effectiveness of these two applications of VRT.

2.1 Treatment of Phobias
Currently counselling, psychotherapy and cognitive behavioural therapy (CBT) are used as forms of treating phobias. These treatments involve the sufferer talking through their phobia, discovering the cause and formulating methods to cope with their phobia [5]. These treatments help the phobic cope with their phobia, but they do not address the phobia directly to ensure it is overcome completely.

In some cases, exposure therapy is used; which exposes the individual to their fear [6]. However, this can only be used in certain situations. Arachnophobia, the fear of spiders [7], has been successful with this type of therapy. If the individual becomes too distressed the spider could simply be taken out of the room to stop further anxiety. Other phobias are less applicable due to problems which could be encountered when being exposed to the fear. An example can be seen by acrophobia, the fear of heights [8]. Psychologists cannot knowingly put an individual in distress by placing them at a height as they cannot immediately stop the situation if the individual was to become too distressed.

The following sections will explore how VRT has been applied as an ethical and controlled method of exposure therapy to aid various phobia sufferers; those suffering from acrophobia, aerophobia and claustrophobia. The effectiveness of applying VR to treat phobias will be analysed using the case studies discussed for each phobia.
2.1.1 Acrophobia
Acrophobia is an extreme fear of heights; people with acrophobia become distressed in any situation where they are aware they are at a height [8]. Acrophobia is a classified mental disorder within the “Diagnostic and Statistical Manual of Mental Disorders”. It interrupts a sufferer’s day-to-day functioning making their lives very difficult [9].

In 2002 a group of researchers carried out a study to evaluate how effective using VRT for acrophobia would be. This study looked into producing a cost-effective way of overcoming acrophobia [10]. This new therapy puts the sufferer in a virtual lift which has a bungee jump at the end. For this to occur, three-dimensional (3D) modelling tools were used to create real-time scenes for the VR. To create scenes with high validity, they were “enhanced by texture mapping” which results in high-quality picturing. The program was created using C++. This allowed for audio to be added to the program so that the participant felt more absorbed in the virtual environment. To display the imagery to the participant a head-mounted display (HMD) was used as well as an electromagnetic head tracker.

The VR produced was tested using a participant who had acrophobia which was so severe he couldn’t visit relatives as they lived on the 10th floor of a block of flats. This participant had to rate his anxiety levels each time he had a session. He was also attached to monitors that recorded his blood pressure, pulse and respiration rate. For ethical reasons a psychiatrist had to be present to relax the participant if he became too fearful. The study was expected to take 8 sessions to get the participants anxiety levels down. However, after 6 sessions the participant became less fearful and was able to go to the top floor of a 63 floor high building; showing how successful this therapy is. A further achievement was that the researchers had produced a VRT therapy that worked to treat acrophobia which was much cheaper than existing ones. Subsequent studies all resulted in the same conclusion. This shows how VRT can be applicable for treating individuals with acrophobia.

This form of treatment has obvious advantages over traditional methods. It has been shown that acrophobia cannot be treated by traditional exposure therapy as the situation cannot be exited if the phobic becomes too distressed. By using VRT the psychiatrist can turn off the VR in the event that the phobic becomes too distressed.

2.1.2 Aerophobia
Aerophobia describes people who are scared of flying. Having such a phobia can cause many difficulties for a person; especially if their job necessitates them flying to different work locations. Many people with aerophobia feel anxious when they have to carry out flying related actions; such as booking tickets or taking someone to the airport [11]. Researchers are careful to diagnose aerophobia because sufferers may be scared of flying for other reasons than the situation that flying puts them in. For example, someone suffering with acrophobia will be scared of flying because they are scared of heights, not because of the situation they are in. This makes treatment of aerophobia more difficult. Before VRT, treatment of aerophobia was only carried out by well-equipped psychologists and was extremely expensive. Hodges et al were the first group to consider using VRT for treating aerophobia [12]. The authors of the case study discussed in this section noticed the validity of what Hodges et al proposed.

The study carried out by Alcañiz et al [13] looks at the benefits of using VRT to treat aerophobia over traditional methods. They used four participants to evaluate the effectiveness of VRT. All participants met the DSM-IV classification for aerophobia [9]. The researchers used Microsoft Windows as their Operating System (OS) and also made use of a head-mounted display (HMD) to immerse participants in to their virtual world. A three-dimensional (3D) digitizer and stereoscopic technology was used within the HMD to give the illusion of depth to the images the participant’s experience. As well as using 3D technology they ensured audio was present to make the experience more realistic. PYTHON was used to produce such a piece of software. This software was programmed to have three different levels to immerse the participants into. The first level is to plan the trip, second to be at the airport and third to be on board the plane. At each stage the participant is able to virtually interact with objects, listen to surrounding audio, as well as visually being involved in the scenario. All of the participants felt anxious when they were interacting with the VR; showing the realism that it generates.

A total of 8 sessions were given to each of the participants. At each session, a psychiatrist assessed the amount of fear displayed by each participant and the participant filled out self-assessment forms as to how fearful they were. All four participants showed a positive result after undergoing treatment. At the beginning of the study each participant rated the severity of their fear from 1-10 (10 being petrified) as 7 or 8. By the end of the study every participant rated their fear as being between 1 and 2 on the 1-10 scale. To further illustrate the effectiveness that VRT has for overcoming aerophobia, all of the participants were able to partake in a real flight and only experienced trivial anxiety after undergoing VRT.

CBT for treating aerophobia try and figure out coping mechanisms for the phobic. On-going weekly sessions are usually needed for the therapy to be successful. This does not eradicate the phobia but simply places strategies and alternatives to cope with anxiety. The study illustrates how VRT has almost eradicated all anxieties caused by aerophobia in fewer sessions than CBT would necessitate. Using VRT for aerophobia also has realism over other exposure therapy methods. Traditional exposure would involve a fake plane being used for the phobic to become familiar with the surroundings; adding a VR to this induces realism immensely. These two examples show the success VRT has over traditional methods for treating aerophobia.

2.1.3 Claustrophobia
An individual is classified as having claustrophobia if they irrationally fear that they have no escape when being in small spaces or rooms [14]. When VRT is applied to claustrophobia it immerses the sufferer into a restricted environment. This environment causes the phobic to feel the same emotions and anxieties as they would in a real life situation where they feel confined [15].

Bruce and Regenbrecht created their own virtual environment aimed at helping claustrophobics overcome their fear. They made use of a PC with high-end graphics to create the environment. The software was produced as a Windows.NET application, using C# as the programming language.

The researchers decided to produce two affordable versions of the therapy so the successes of them could be compared. They produced one on form of therapy using a 32 inch monitor and another as a Head-Mounted Display (HMD). To manœuvre
around the virtual world, an x-box controller was attached to the technology. This gave the participants the ability to experience different rooms; each room becoming more enclosed as the therapy progressed (figure 2-1). 18 participants were gathered to test the two technological approaches to this therapy. However, two participants could not partake in the whole exercise because their claustrophobia was so severe; as deemed by the psychologist who was present throughout the study [16].

Figure 2-1: View from the third room into the fourth [16]

After the studies were conducted it became evident that the HMD was more successful than the 32 inch monitor. This is thought to be because it immerses the participant into the VR in a more effective way. The researchers would like to develop their technology further to try and make it accessible to everyone. They would like to do this by creating a video game for the MS Xbox 360 which can be cost-effective for everyone. The researchers would like this technology to make use of a HMD because they have established that it produces high success rates to treat phobias.

This study illustrates how successful VRT can be at eradicating claustrophobics irrational anxieties. It would not be ethical to apply traditional exposure therapies to claustrophobia as it would mean that the psychologist would have to place the phobic in a confined space. The application of VRT overcomes this issue as it is a virtual world which can be stopped at any moment in time.

2.1.4 VRT over traditional methods of treating phobias

It is evident that using VRT to overcome phobias has advantages over the traditional methods of treating phobias in terms of time-scales, cost and reducing the amount of ethical confusions. All studies have shown an immense difference in the amount of fear the phobic has after VRT has been carried out. None of the VRT studies were carried out over a long period of time; whereas, traditional talking mechanisms need weekly sessions over a few months.

A lot of phobias cannot be treated through traditional exposure therapies because of the ethical issues which would be brought about. Section 2.1 illustrated these issues. Through using VRT no issues arise surrounding not being able to calm the phobic down by getting them out of the situation. To discontinue the anxiety inducing situation the VR can simply be switched off.

2.2 Treatment to overcome physical defects

Currently a combination of physiotherapy and occupational therapy are applied to help a patient overcome physical defects. These methods are widely used throughout many different forms of physical defects [17, 18]. Physiotherapy involves restoring movement and physical abilities through evaluating the patients physical functioning and preventing further injury [19]. Whereas, in occupational therapy, the therapist focuses on enabling the individual to carry out every day activities by devising strategies to improve functional abilities [19].

The following sections will explore how VRT has been applied to aid patients with different types of physical defects. Case studies where VRT has been applied to patients suffering from cerebral palsy, stroke deficits and those who require prosthetic limbs will be illustrated and evaluated.

2.2.1 Cerebral Palsy

Cerebral Palsy defines a group of disorders which restrain the development of an individual to be able to co-ordinate properly. It is caused by having injury to the brain or abnormal brain development; which occurs in children during pregnancy, birth or early childhood. It causes the child to find it challenging to control how they move their muscles [20]. Children with cerebral palsy typically undergo therapy with a physiotherapist and an occupational therapist. Both therapists work on improving the individual’s movement and co-ordination to aid the child to cope with the condition [21].

A study was carried out into the improvement of functional performance in children with cerebral palsy when VRT is used assesses the appropriateness of the therapy [22]. It used a control group of abled children and a study group of children suffering with cerebral palsy to compare the impacts VRT has. The researchers produced a virtual environment called the Meal-Maker which would be used as their VRT. They compared Meal Maker to other virtual environments which were not specifically developed to aid children with cerebral palsy. Each participant was immersed into the different virtual environments and the appropriateness of the therapy was evaluated using The Short Feedback Questionnaire for Children. The results showed that the MM, which is tailored to aid children with cerebral palsy, was perceived to be the most appropriate and engaging for co-ordination and motor skills. This is because the children were more involved with this VR than the other ones which were tested.

This study does not assess the improvement in motor skills by using VRT for cerebral palsy. It states that the Meal Maker is appropriate and engaging for children with cerebral palsy, but not how effective it is. A second study [23] concludes that currently VRT is too stressful for children with cerebral palsy; making it an ineffective form of therapy. Conversely, both studies highlight how more research needs to be carried out into this area before VRT can be applied to cerebral palsy. After this occurs the studies conclude that this form of therapy could be successful because further research would highlight specific requirements which need to be included in the VR. However, this form of treatment ignores the benefits physiotherapy may have on cerebral palsy sufferers.

2.2.2 Stroke Rehabilitation

Strokes are the leading cause of disabilities in the United Kingdom. Strokes occur when an artery has a blood clot or a blood vessel breaks, causing an area of the brain to receive an insufficient amount of blood. The brain cells of that area die and the functionality controlled by that part of the brain is disturbed [24]. Most stroke sufferers are left with a number of motor and functional deficits in their upper body; only one side of the body is affected [25].

Handroos et al looked into the creation of a “virtual reality mirror robotic therapy system” [26]. They apprehend how this type of VRT will need different stages specifically designed to help stroke patients with mobility issues. The first stage will capture the current motor ability of the healthy limb and the unhealthy limb; for example, comparison of a healthy left arm and unhealthy right
arm. These abilities will then be compared, using a programmed algorithm, to attain an indication of what the rate of recovery should be. Next the system will ensure there is an appropriate manipulator for the limb to interact with the virtual world. Simultaneously, the patient’s movement is visualised within the virtual world. Real-time feedback needs to then occur; this will use audio-visual feedback of the patient’s movement. The virtual environment has to have the ability to provide feedback on the overall progress over the time-period the therapy has occurred. A prototype was created from this study which is shown to have positive effects; however, it is not conclusive that this therapy works.

An evaluation into the existing technologies which make use of VRT for stroke rehabilitation was carried out. The paper identifies how many experiments into this area were extremely successful. The most popular approach was seen to use a cyber-glove as well as a virtual environment so that the mobility of an arm or hand could be tracked more accurately; figure 2-2 [27].

Both papers look at VRT which try to improve the victim’s ability to function as normal; this would aid occupational therapists. Yet, psychotherapists would still need to be involved in the patient’s treatment to ensure that their physical functioning is adequate and there is no risk of further injury.

![Figure 2-2: Example of a cyber-glove](image)

2.2.3 Prosthetic Limbs

Prosthetic limbs are used to replace an amputated limb so that the individual can function as if they had their original limb. Each prosthetic device is tailored to the individual’s specific case. After being fitted, the individual needs therapy to become confident at using their new limb [28].

Davoodi et al designed a virtual environment for patients so that they can get an insight as to how a simulated arm will interact with objects [29]. Within the virtual environment, the patient will try and perform day-to-day activities using their virtual prosthetic limb. To achieve realism, real-time algorithms were used. The software was developed to work with a 3D HMD which could provide visual feedback to the patient. The prosthetic limb will be tracked using magnetic motion tracking. This is then processed and output as a driver for the virtual limb to move; which is displayed on the 3D HMD. However, there are currently limitations of magnetic motion tracking which need to be researched into further to be addressed [30].

The researchers produced a prototype which was tested with actual limb movement, rather than prosthetic limbs. This brought about the need for the participant to wear an array of sensors to provide input to the software; as they could not use magnetic motion tracking on a real limb. The prototype was produced to attain an indication of how appropriate the therapy would be before exposing it to individuals who need prosthetic devices. It was tested this way because it was deemed unethical to carry out such early testing on vulnerable patients who are distressed by losing a limb.

Two participants used the software to pick up objects within the virtual world using a virtual arm. They then had to move it to a virtual box and drop it into the box successfully. The time it took to drop the object into the box and the participant’s accuracy of placing the object into the box was recorded. The VR was deemed successful; therefore in further studies it could be used as a therapy for patients who need prosthetic limbs. However, there was a delay between the participant’s movement and the virtual movement; this lag must be addressed before the software can be developed further.

This study illustrates how manipulating the patient to move objects virtually will improve their perceived ability to use a prosthetic limb. This will make them more confident at using it. However, it ignores aspects of occupational therapy such as being able to cope with carrying out every-day activities. This is essential to include during therapy as the individual must be able to cope with their everyday lives.

2.2.4 VRT over traditional methods of treating medical defects

Using VRT to treat medial defects has not been researched or established enough to be a successful treatment. The meal maker, to aid children with cerebral palsy, has taken into consideration occupational factors to help those with cerebral palsy carry out day-to-day activities. However, other VRT to aid those with physical defects have ignored occupational factors, such as coping mechanisms. This may be one reason as to why the studies into using VRT to treat those with physical defects are not seen to be as effective as traditional methods.

It is apparent that there is not enough solid research into using VRT for physical defects. Future studies must take occupational factors into consideration as well as physical factors to ensure that this method of treatment can be prosperous.

3. PHOBIAS THERAPY VS. THERAPY FOR PHYSICAL DEFECTS

An evaluative comparison into the effectiveness of the different VRT fields will be undertaken to assess which type of therapy is more triumphant. The two approaches will be evaluated by looking at the current successes, problems encountered and if the field has an established method in which they carry out their therapy.

Using VRT brings up a number of ethical issues. When applying VRT to treat phobias it causes the participant distress because they are being confronted with their fear. During the study into VRT for claustrophobia, two of the participants had to pull out because they became so petrified [16]. This raises questions surrounding if it is morally right to put someone in such a situation. During the studies into using VRT to aid individuals with physical defects, there were ethical considerations as to whether it was appropriate to test the prototype systems with non-disabled bodied individuals [30]. When a person has lost their limb, or suffered a stroke, they will be in a lot of distress. To then ask them to partake in an experimental study is unfitting. To ensure that these studies were not unethical a psychologist is required to be present. The psychologist can then assess whether the situation is becoming too distressing for the participant, and if necessary, stop the study [31].
Every study evaluated, for overcoming both phobias and physical defects, had a very small amount of participants. This means that the studies may have only been applicable in that case. More studies need to be carried out to ensure a conclusive decision about the validity VRT plays in each field. By looking into existing research into VRT it is apparent that there are many convincing studies displaying the success of using it for phobia therapy [32]. On the other hand, the studies into using VRT for helping those with physical defects do not show any clear accomplishment [22, 26, 29]. These studies conclude that more research needs to be carried out as this is a complicated area to apply VRT to.

Technology is becoming progressively more advanced [30]. This can be seen as a benefit to VRT as well as a problem. When applying VRT to areas involving physical defects, a range of high-quality technologies must be used for the therapy to be successful. This type of VRT requires complex software and hardware; such as magnetic motion tracking. Magnetic motion tracking currently experiences a number of issues when used for VRT [26]. If the technology advanced it may enable VRT to be successful when it is applied to aid individuals when learning to use their prosthetic limb. Advances in technology will facilitate the improvement of ecological validity in VRT. This is because the VR will become more realistic. This could be detrimental when treating phobias because it could mean the therapy becomes too distressing for the participant; causing them to be unable to proceed with their therapy [16].

It is evident that for VRT to treat phobias effectively, an immersive technology should be used. All of the VR’s within the treatment of phobias made use of HMD’s; showing the success of the technology in this field [10, 13, 16]. All of the software was designed and implemented for the same purpose. Each study incorporated audio technology into their VR to add ecological validity. Conversely, all of the studies concerning the use of VRT to aid physical defects deliberated using a number of different technologies [22, 26, 29]. None of the technology combinations evaluated by these studies were deemed victorious.

In summary, the VR’s produced to overcome phobias were immensely successful. Each study resulted in the participants conquering their fear. This type of VRT has established that through using a fully immersive technology, participants are able to face up to their fears. The use of a HMD to completely submerge the participant into their VR has been recognised as the most appropriate technology. Less success has been documented by studies into using VRT to overcome problems due to physical defects. This is primarily due to the lack of research, established methods and technology constraints. It is predicted that with further research, and the increasing advancements in technology, this type of VRT will progress into an auspicious way of helping those who have physical defects.

4. FUTURE USES

The concept of including senses other than sight and hearing in VR’s has been around for a number of years. However, the technology is still lacking to formulate concrete ways of implementing this idea. Future developments in the technologies used to create a VR will see fully immersive systems which utilise most of the senses. Touch will be incorporated more efficiently to provide the VR user with a sense that the objects are real [34]. Research has also been carried out into integrating the sense of smell (olfactory information) into VR’s. Woodrow and Eric foresaw the benefits of including olfactory information and defined how it would have to make use of “a collection of hardware, software and chemicals” to be successful [35].

Currently, research into incorporating the sense of smell into VR’s has been scarce. Chen points out how having olfactory information will increase the validity of the virtual environment for the participant immensely. Using a VR which integrates the sense of smell can be utilised during VRT because the scents can be developed as a stimulus for the treatment [36]. This area is now being focused upon more; meaning in the near future VRT will make use of olfactory information to make the VR more realistic.

All of the studies evaluated in this paper have shown that researchers are trying to do two things to improve VRT. Firstly, to perfect the technological method VRT uses within their research area. Secondly, they are striving to create cheaper methods of implementing VRT so that it is more readily available. With technology increasingly advancing, and hardware and software decreasing in price, these two goals are achievable in the near future. This will mean that VRT will be more realistic as well as being widely available. As a consequence, future VRT’s will be exceptionally realistic, affordable and able to treat many different things effectively; such as depression and attention deficit disorder [37]. On the other hand, having a VR which is more lifelike may cause further ethical issues to arise.

5. CONCLUSION

This paper has established that using a VR as a way of treating various physical and psychological problems is an applicable concept. It is evident that at this moment in time VRT is more appropriate and victorious at treating phobias than physical difficulties. VRT is successful at treating phobias because a superior method has been established through extensive research. This method makes use of a HMD, 3D technologies and audio to immerse the individual into their virtual environment. To ensure that VRT can be prosperously applied to aid individuals with physical defects, it is obvious that more research must be carried out. An effective use of technology must be established; along with an appropriate approach to overcome the physical problem. The studies explored have indicated that the use of a tracking sensor could be advantageous; such as a cyber-glove.

Further advances in technology will increase the validity of the virtual environments used within VRT. This realism could be seen as a negative. We have seen how VRT can be used to bring about an anxiety when treating phobias, if this anxiety could be too distressing for the individual undergoing therapy if the VR is exceptionally vivid. Nevertheless, the increased realism caused by technological advances is primarily considered a positive. This is because it will mean that individuals become entirely absorbed in the virtual world so that it can be more effective.

Overall, VRT has been shown to be successful when the area it is being applied to is explored efficiently. VRT has an established method at treating phobias; however more research needs to be carried out into other areas. With advancements in technology, and decreasing prices of equipment, VRT will be able to be used efficiently in many different ways in the future.

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