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Virtual Environments in Clinical Psychology and Neuroscience

VIRTUAL REALITY THERAPY: AN EFFECTIVE TREATMENT FOR PHOBIAS

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Abstract. Behavioral therapy techniques for treating phobias often includes graded exposure of the patient to anxiety-producing stimuli (Systematic Desensitization). However, in utilizing systematic desensitization, research reviews demonstrate that many patients appear to have difficulty in applying imaginative techniques.
This chapter describes the Virtual Reality Therapy (VRT), a new therapeutical approach that can be used to overcome some of the difficulties inherent in the traditional treatment of phobias. VRT, like current imaginal and in vivo modalities, can generate stimuli that could be utilized in desensitization therapy. Like systematic desensitization therapy, VRT can provide stimuli for patients who have difficulty in imagining scenes and/or are too phobic to experience real situations.
As far as we know, the idea of using virtual reality technology to combat psychological disorders was first conceived within the Human-Computer Interaction Group at Clark Atlanta University in November 1992. Since then, we have successfully conducted the first known pilot experiments in the use of virtual reality technologies in the treatment of specific phobias: fear of flying, fear of heights, fear of being in certain situations (such as a dark barn, an enclosed bridge over a river, and in the presence of an animal [a black cat] in a dark room), and fear of public speaking. The results of these experiments are described.

1. Introduction

Behavioral therapy techniques for treating phobias often include graded exposure of the patient to anxiety-producing stimuli (Systematic Desensitization). These stimuli are commonly generated either through the patient's imagination or *in vivo* (patient experiences real situations).

In utilizing systematic desensitization, research reviews demonstrate that many patients appear to have difficulty imagining the prescribed anxiety-evoking scene. They also express strong aversion to experiencing real situations. This avoidance is not surprising, since it is simply the behavioral component of a phobia, and may well be a learned behavior that lowers the anxiety of clients, thus reducing their public embarrassment.

Virtual Reality Therapy (VRT) may be utilized to overcome some of the difficulties inherent in the traditional treatment of phobias. VRT, like current imaginal and *in vivo* modalities, can generate stimuli that can be utilized in desensitization therapy. Unlike conventional systematic desensitization therapy, VRT can provide stimuli for patients who have difficulty in imagining scenes and/or are too phobic to experience real situations. Furthermore, unlike *in vivo* systematic desensitization, VRT can be performed within the privacy of a room, thus avoiding public embarrassment and violation of patient confidentiality. VRT can also generate stimuli of much greater perceived magnitude than standard *in vivo* techniques. Since VRT is under patient control, it appears safer than *in vivo* desensitization and at the same time more realistic than imaginal desensitization. Finally, VRT

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adds the advantage of greater efficiency and economy in delivering the equivalent of *in vivo* systematic desensitization within the therapist's office.

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2. Fear of Flying (aerophobia) Experiments

Two case studies were conducted to assess the effectiveness of VRT for treatment of the fear of flying. The first experiment was our first pilot study which was conducted in late November 1992. The subject was a 32-year-old married woman, a human-computer interaction group researcher, who was diagnosed and treated for fear of flying utilizing an existing virtual scene. The virtual scene was a simulated city running on a Silicon Graphics computer. This scene originally was created to conduct research on an innovative navigational technique for virtual environments. The subject participated in eight sessions, each lasting about 30 minutes. The subject reported a high level of anxiety at the beginning of each session, gradually reported lower anxiety levels after remaining in the situation for a few minutes and eventually reported an anxiety level of zero. To investigate the transfer effect of VRT to the real world, she was flown with the therapist accompanying her on a helicopter for approximately 10 minutes at low altitude over a beach on the Gulf of Mexico. As with the VRT sessions, she reported some anxiety at the beginning, but anxiety rapidly reduced to a reasonably comfortable level. Now the subject much more comfortably flies for long distances and experiences much less anxiety [1,2,3,4].

The second case study, in September of 1995, involved a 42-year-old married man who conducts research at Clark Atlanta University and who also sought treatment for the fear of flying. The subject's anxiety and avoidance behavior were interfering with his normal activities. For example, he was unable to travel to professional conferences, visit relatives or take a vacation by air. The subject, accompanied by a virtual therapist, was placed in the cockpit of a virtual environment helicopter and flown over a simulated city for five sessions. A modified 11-point (0 for complete calm and 10 for complete panic) Subjective Units of Discomfort (SUD) scale was used to measure the degree to which the subject was affected by VRT. In virtual reality therapy the subject's anxiety usually increased as he was exposed to more challenging situations and decreased as the time in those new situations was increased. The subject experienced a number of physical and emotional anxiety-related symptoms during the VRT sessions. These symptoms included sweaty palms, loss of balance, weakness in the knees, etc. The VRT resulted in both a significant reduction of anxiety symptoms and the ability to face the phobic situation in the real world. The subject at this time is able to fly to the different geographical locations in reasonable comfort [2,3,4].

3. Agoraphobia Experiment

This experiment, in which we conducted the first known scientific study on the effectiveness of the virtual environments technology in the treatment of psychological disorders, commenced on February 1, 1993. Specifically, we assessed the effectiveness of virtual environments in the treatment of agoraphobia, the fear of being in places or situations from which escape may be difficult or embarrassing. Sixty subjects were selected for this study. Thirty were placed in the experimental group and thirty subjects were placed in the control group. Only subjects in the experimental group were exposed to the VRT. VRT was effective in the treatment of subjects with agoraphobia. Negative attitudes toward agoraphobic situations decreased significantly for the VRT group but not for the control group. The average SUD scores decreased steadily across sessions, indicating habituation. This study has been reported in detail in several publications [1, 6, 7, 8].

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4. Fear of heights (acrophobia) Case Study and Experiment

A case study first demonstrated the effectiveness of VRT in the treatment of acrophobia. During eight sessions, which were between 15 and 28 minutes each, individual VRT treatment was conducted in a standard format. The first session began with the least threatening level which was at the ground level near a bridge crossing a river in the middle of a simulated town. The SUD was administered periodically every two to five minutes. The progress was totally under the control of the subject, with the exception that if the subject's SUD score was zero, the experimenter urged the subject to move up to the next level of the scene. At one month after treatment, the subject was asked to complete a ten-point rating scale (including degrees for worsening symptoms) rating the degree to which his acrophobia symptoms had changed since a pre-treatment test (SUD). The results indicated significant improvement with respect to both anxiety symptoms and the avoidance of anxiety-producing situations. Thus, we concluded that the virtual reality treatment was successful in reducing the fear of heights [2,5].

The first acrophobia study was conducted in collaboration with others [10,11]. Twenty college students with acrophobia were randomly assigned to virtual reality graded exposure treatment or to a waiting-list comparison group. Sessions were conducted individually over 8 weeks. Outcomes were assessed by using measures of anxiety, avoidance, attitudes, and distress associated with exposure to heights before and after treatment. Significant improvements on all measures were found in the subjects who completed the virtual reality treatment as compared to subjects on the waiting list.

5. Fear of Public Speaking Experiment

The fear of public speaking, often referred to as “social phobia”, is a common disorder which affects many people. Research into treatment of this widespread phobia was conducted with special technical assistance from the Speech Improvement Company, Inc. Subjects who participated in the research were recruited from CAU General Psychology classes. After an extensive two-stage screening process, sixteen subjects were selected from the pool. They were assigned to two treatment conditions: virtual reality therapy and a comparison group.

A virtual version of an auditorium located in the CAU Research Science Building was created. The virtual auditorium is 48 feet wide, 100 feet long and 55 feet high. The seating area has three sections of seats and can accommodate over 100 people. Specialized features created for the facility include a virtual wooden podium with a speaker's stand. An amplifier with direct connection to the virtual reality software and hardware were used in the therapy sessions. This enabled the subjects to hear the echo of their voices. The treatment schedule consisted of five weekly sessions, each lasting 10-15 minutes.

Two assessment measures were used in this study. The first measure used was the Attitude Towards Public Speaking (ATPS) questionnaire which contains six items. The second measure used was the eleven-point Subjective Units of Disturbance (SUD) scale.

The symptoms experienced by the subjects during virtual realty therapy included an increase in heart rate, a lump in the throat, dry mouth, sweaty palms, loss of balance, weakness in the knees, etc. These symptoms also appeared in the studies which dealt with the treatment given for acrophobia (height phobia), agoraphobia, and fear of flying.

Similar to our first known controlled studies of VRT, the study of the fear of public speaking indicated that VRT was very effective in reducing self-reported anxiety. The VRT treatment resulted in both a significant reduction of anxiety symptoms (SUD and ATPS measurements) and the ability to face the phobic situations in the real world. At this time several of the subjects can comfortably speak in front of a crowd with increased confidence.

6. Assertions Concerning VRT

Based on the data collected and subjects' verbal reports of the VRT experiments we make the following assertions concerning Virtual Reality Therapy.

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** A person's experience of a situation in a virtual environment may evoke the same reactions and emotions as the experience of a similar real-world situation.*

The results of all of our research studies of psychological treatment categories demonstrated that people who are phobic in the real world are also phobic in a virtual world. When subjected to virtual phobic-invoking situations, our subjects exhibited the same types of responses as would be exhibited in a real-world situation. These responses included anxiety, avoidance, and physical symptoms.

As a measure of anxiety, subjects were repeatedly asked to rate their current level of anxiety on a SUD scale. The relatively high SUD scores at the beginning of each treatment session indicated that the subjects' were experiencing significant anxiety, and that the SUD scores (and thus fear levels) gradually decreased as subjects remained in the virtual scene.

A second measure of anxiety was actual subject behavior and verbalization. Examples of common subject behavior included tightly gripping the rails and displaying reluctance to let go of the rails. Verbal expressions recorded included: "The higher I get, the more worried I get", "I am really there!", "It feels like being in a real helicopter", "I am afraid to fall down!", "I do not like this at all!", "I am scared!", and "I feel like I am actually on the fiftieth floor!". Physical symptoms reported by subjects included shakiness in the knees, heart palpitations, tenseness, sweaty palms, and dizziness.

** A person may experience a sense of virtual presence similar to the real world even when the virtual environment does not accurately or completely represent the real-world situation.*

Remarkably, subject reactions consistent with phobic stimuli were experienced in spite of the fact that their virtual experience did not correspond to the real-world experience in several ways. All environments were visually much less detailed than a real scene, and some environments also included much simpler auditory and tactile cues such as the very limited engine sound and vibration of the Apache AH64 helicopter in the fear of flying study.

As stated previously, the subjects reported a number of physical and emotional anxiety-related symptoms such as dizziness, sweaty palms, heart palpitations, etc. These feelings would not have been reported by subjects if they did not perceive that they were experiencing a realistic situation even though the virtual environments were not exact copies of real world scenes. Once again, these studies remind us of the tremendous power of the mind-that perception is often much more than mere sensation.

** Each person brings his/her own background into a virtual reality experience.*

It is important to recognize the fact that perception is in many ways just as much a product of our previous experiences as of current stimulation. Each subject is a unique, specific individual with an independent experience of reality which is unique and different from the objective world, or the so-called world of reality. The implication for virtual reality is that the sense of virtual presence is dependent not only on the physical qualities (resolution, realism, interactivity, lag time) of the experience provided by the virtual reality, but also upon what the participant psychologically brings to the environment. The very nature of the act of perception causes each person to react differently to the same real or virtual experience.

This was evidenced by both objective measures and the verbal comments of the subjects. Just as different individuals may react differently to a real world experience, our subjects exhibited different reactions to the same virtual world experience. This point was clearly demonstrated by the variety of responses among subjects to same phobic stimuli of the virtual scene. Several subjects went through several levels of the phobic situations without reporting any significant anxiety. On the other hand, many subjects reported differing amounts of anxiety in different levels of the virtual scene. There was major variation in the amount of time spent in each level of the virtual scenes by different subjects.

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* *Experience with a virtual environment increases the participant's sense of virtual presence.*

The idea that a sense of presence may increase with experience has been suggested by several researchers [13,14,15,16]. Our experiments verified this hypothesis, in that the longer subjects stayed in the virtual scene the deeper they were pulled into the virtual world and the greater their sense of virtual presence.

Based on subjects' objective scores and verbal comments during the experiments, subjects initially felt some level of virtual presence in the phobic situation and their sense of virtual presence generally increased over time or at worst was maintained during all the sessions.

* *The sense of presence in virtual and physical environments is constant and subjects have to give up the sense of presence in an environment (e.g., physical environment) to achieve a stronger sense of presence in another environment (e.g., virtual world).*

This assertion is drawn based on the data (SPSVP--Sense of Presence Scale in the Virtual and the Physical Environments questionnaire--and SUD) collected from subjects. Specifically, the SPSVP was designed to assess one's sense of presence of the virtual environment and physical environment, sense of interactivity with the virtual reality system, and one's perception of the real world in reflection to the virtual environment.

The subjective measures of sense of presence in the virtual environment increased gradually during each session. The subjective measures of sense of presence of the physical environment while attending the virtual reality decreased gradually within and between sessions. These results led to the conclusion that the longer subjects remained in the virtual environment the higher was the subject's sense of presence in the virtual world (even when using very minimal stimuli), while the sense of presence of the physical environment decreased. This supports a theory that the total sense of presence is constant, and subjects have to divide their overall sense of presence between the virtual and real worlds—a theory consistent with what we know about consciousness and its limitations.

* *Subject concentration increases significantly in the virtual world as compared to in the physical world, when the subject has enough interaction to develop a strong sense of virtual presence.*

Each subject's interest level and sense of control in a virtual learning study were determined by a ten-point scale instrument administered at the end of each experiment. The scores ranged from very weak to very strong. The interest level and sense of control level in the virtual world were always higher than the scores in the physical world.

Based on the data and observation, it was obvious that each subject was excited, enthusiastic, and eager to be in the virtual environment, rather than the physical environment. The main conclusion of this research was that memory span increased significantly in the virtual environment as compared to the span in the physical environment, and that the learner's motivation and interest levels may be maintained longer in the virtual environment. We hypothesize that at least a part of this effect may be due to the simplicity of the virtual environment, providing less distractions to the learner.

* *A person's perceptions of real-world situations and behavior in the real world may be modified based on his experiences within a virtual world.*

Most applications of virtual reality are intended to augment human intelligence by either increasing or modifying a person's *intellectual understanding* of the structure or nature of objects or tasks [12]. A virtual environment can also modify users' perceptions of real-world situations and thus behavior in those situations. This conclusion is based on the reports of many subjects who exposed themselves to real-world phobic situations after receiving VRT

treatment. What was learned and experienced in the virtual environment was transferred to real-world perception and behavior.

7. Safety Issues in VRT

There are some potential risks associated with virtual reality technology, as pointed out by Stanney [17], and definite steps must be taken in treatment to minimize these risks. According to Stanney, subjects at risk for psychological harm are primarily those who suffer from panic attacks, those with serious medical problems such as heart disease or epilepsy, and those who are (or have recently been) taking drugs with major physiological or psychological effects. Questions regarding these situations must be asked as a part of the screening process, and persons with these characteristics must be excluded from VRT experiences. Also, some people experience symptoms ranging from headache to epileptic seizure when exposed to visual stimuli which flicker at 8-12 Hz. In VRT, no frame update rates in this range must be used. Furthermore, patients have to be closely observed at all times, and if there is evidence of any significant physical or psychological distress, both the patient and the observer must have the ability to quickly terminate the virtual reality session.

We recommend that therapist have the patient sit on a chair rather stand; use a modified head-mounted display so the patient can see his/her physical body partially; and most importantly, keep the sessions brief (15-20 minutes). This configuration reduces the degree of immersion but increases the physical and psychological safety of the patients. There is still a great need for additional research in this area, and we strongly recommend that researchers take appropriate steps in minimizing patient risks.

It must also be noted that symptoms of anxiety while under VRT are distinctly different from simulation sickness. The anxiety symptoms evoked under VRT are the same as the real world experience of the patient and include shortness of breath, heart palpitations (irregular or rapid heartbeat), trembling or shaking, choking, numbness, sweating, dizziness or loss of balance, feeling of detachment, being out of touch with self, hot flashes or chills, loss of control, abdominal distress, and nausea.

8. Complexity of VRT

VRT is different from simple desensitization and exposure therapy as described by the behavioral schools of thought. VRT appears to be oriented more toward neurophysiological information processing theory and the accelerated integrative information processing paradigm presented by Frances Shapiro [18]. Thus far, research has proven that VRT works very well with subjects who suffer from various kinds of phobias. Intuitive observation has also led to the belief that more than desensitization was at work. When patients were immersed in the virtual worlds; they typically would not communicate with therapists who reside in the physical world. They appeared to be reliving their previous disturbing or anxiety-provoking experiences even though the virtual world did not accurately match their existential world. They would usually look repeatedly at the same simple object or objects within the virtual world. Advanced graphics, while providing stronger immersion, seem to be distracting and to overload the human perceptual processing system, not allowing the other cognitive processes which are essential to problem solving and information reprocessing to work efficiently. Based on our observation, the processes seem to be very similar to the treatment that Shapiro calls EMDR (Eye Movement Desensitization Reprocessing).

Disturbing memory is stored by a picture, cognition, affect, and physical sensations. VRT reveals that these factors are stored by association and linked together. VRT appears to activate the visual memory, in cases where only visual stimuli are presented, and this in turn activates other related memories and experiences such as cognition, affect, and physical sensation. Under VRT, many of the subjects report physical and emotional symptoms associated with these stored memories. They report having sweaty palms and shaking knees, feeling scared, and feeling uncomfortable.

In general, VRT appears to provide a link between the reality of the client and the objective world. However, at this time there is no concrete or empirically based evidence to explain

why and how VRT works. Thus there is a great need for researchers to investigate the psychological mechanics of VRT.

9. Ongoing Research: VRT Combating Other Psychological Disorders

Although the results of the research projects covered in this chapter are impressive, additional research is needed to more thoroughly explore the effectiveness of VRT and extend it to other psychological disorders. Additional studies must allow for both objective and subjective measurements of anxiety to ensure the validity of research outcomes. We also recommend investigating the influence of subject variables (demographic and personality characteristics) on the effectiveness of VRT. Such studies should include an imaginal systematic desensitization (ISD) conventional therapy group in addition to the no-treatment control group used in previous studies. Our current and ongoing research projects include using virtual reality therapy to combat obsessive-compulsive disorders (OCD), attention deficit disorders (ADD), and post-traumatic stress disorders (PTSD).

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