THE DEVELOPMENT OF A VIRTUAL REALITY THERAPY SYSTEM FOR THE TREATMENT OF ACROPHOBIA AND THERAPEUTIC

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ABSTRACT

Virtual Reality (VR) is a new technology that enables humans to communicate with a computer. It allows the user to see, hear, feel and interact in a three-dimensional virtual world created graphically. Virtual Reality Therapy (VRT), based on this sophisticated technology, has been recently used in the treatment of subjects diagnosed with acrophobia. Acrophobia is a disorder that is characterized by marked anxiety upon exposure to heights, avoidance of heights, and a resulting impairment in functioning. Conventional virtual reality systems for the treatment of acrophobia have limitations, such as overly expensive devices or somewhat unrealistic graphic scenes. The goal of this study is to develop an inexpensive and more realistic virtual environment in which to perform an exposure therapy for acrophobia. It runs on a personal computer, and a virtual scene of a bunge-jump tower in the middle of a large city. The virtual scenario includes an open lift surrounded by props beside a tower, which allows the patient to feel a sense of heights. The effectiveness of the VR environment was evaluated through the clinical treatment of a subject who was suffering from the fear of heights. Based on pre- and post- questionnaires and subjective comments from the subject, This virtual reality environment proved to be an effective and realistic tool for the treatment of acrophobia.

1 INTRODUCTION

Acrophobia is classified as a specific phobia in the Diagnostic and Statistical Manual of Mental Disorders. People who have this disorder are characterized by marked anxiety upon exposure to heights, avoidance of heights, and a resulting interference in functioning. Behavioral dysfunction involves interference with normal routine or interpersonal relationships (American Psychiatric Association, 1994).

Currently, the advancement of computer and display technology allows the creation of virtual reality environments which can evoke stimuli similar to the real phobic situation (North, M. M., North, S. M., & Coble, J. R., 1996). Virtual reality therapy(VRT) has recently been suggested by a few studies for the treatment of specific phobia including acrophobia. VRT is based on systematic desensitization, a type of behavior therapy. VRT provides stimuli for the patient who cannot imagine well. VRT adds the advantage of greater control over graded exposure stimulus parameters as well as greater efficiency and economy in delivering the equivalent of in-vivo exposure within the therapist's office (Rothbaum et at., 1995; North & North, 1994; Rothbaum et al., 1995).

Traditionally, virtual environments for acrophobia treatment have been based on over-costly devices and consist of a low quality, unrealistic image (Kooper, 1994; North et al., 1997; Slator et al., 1999). The goal of this study was to develop inexpensive and more realistic virtual environments for use in exposure therapy for the treatment

of an individual with acrophobia. It is based on an inexpensive personal computer and its virtual scene consists of the bunge-jump tower in the middle of a large city. It includes an open lift surrounded by props beside a tower which allows the patient to feel a more realistic sense of heights. The effectiveness of the VR environment was evaluated through the clinical treatment of a subject who was suffering from the fear of heights.

2 VIRTUAL ENVIRONMENT

As illustrated in Figure 1, the VRT environment consists of patient monitoring with a video camera, bio-signal acquisition system (operator or therapist), and the virtual reality environment.

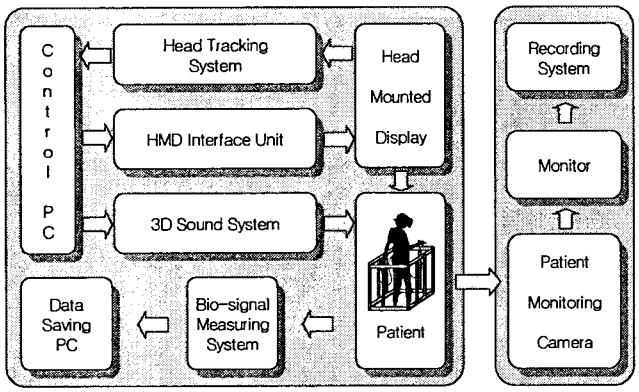

Figure 1. Block diagram of virtual reality therapy (VRT) system

2.1 Software

Real-time virtual reality scenes were designed with 3D modeling tools, Rhinoceros (Robert McNeel & Assoc.) and 3D Studio MAX (Kinetix). It is important to make models with small polygon data for the real-time visualization, therefore all models were constructed at a minimum polygon data, the visual quality of the scene was enhanced by texture mapping with high quality texture. Also a simulation program was made with Visual C++ and DirectX 7.0 SDK(Software Development Kit) for real-time processing. 3D wind sound and Lift sound was added to the simulation for more immersiveness. The height of the lift was designed so it could be easily adjusted by the therapist..

2.2 Hardware

The virtual environment system for this study consists of a stereoscopic head-mounted display (HMD) (ProView (tm) XL50, Kaiser Elector-Optics, Inc., 1204H X 768V, 50 degree diagonal), an electro-magnetic head tracker (FASTRAK, Polhemus, Inc.), 3D sound system and an aluminum lift frame which was made to be matched to a lift in virtual imagery. Real-time imagery was generated using DirectX 3D accelerator (Elsa Inc., ErasorX graphic card), and executed on a Pentium-III 450MHz personal computer (128MB RAM). Bio-signal acquisition system (BIOPAC) was used for checking the physiological symptoms of the subject.

2.3 Virtual environment scene

One of the advantages of virtual reality is that it is possible to make situations that are impossible or nonexistent in the real world. For instance, fearful situations can be designed without subjecting the participant to real-life dangers. As illustrated in Figure 2, the steel-frame building was constructed in the middle of the city, modeled after a bunge jump site. The platform can go up and down between the 1st and 50th floor. A steel-frame enclosure was used to simulate the lift. This augments the fear of heights by allowing participant to feel like as he/she is in a real lift. In order to increase a sense of realism, moving cars and trees were added to the virtual environment.

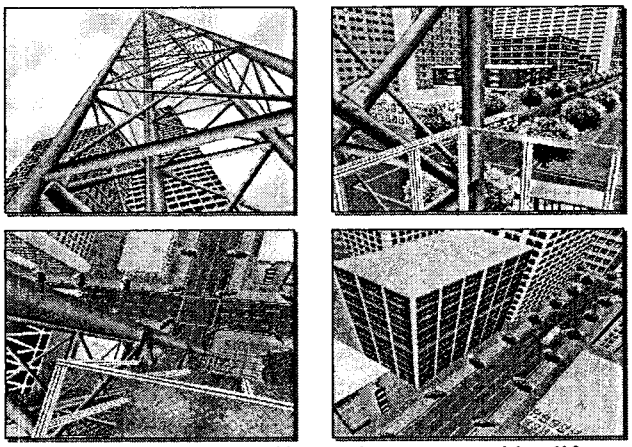
Figure 2. Virtual scenes of bunge-jump tower with a lift

2.4 Immersive environment

It is a critical point in virtual reality psychotherapy for the subject to immerse himself in the virtual world. Therapy depends on the immersion. In virtual reality

psychotherapy, the subject shows similar physiological symptoms and fear to those they experience in the real world. In previous work, following 3 factors were found to impede the immersion process (Jang et al., 2000);

1. The HMD is a primary source of interference on immersion process. Wearing the HMD appeared to be a burden for the subjects, and 20 minutes of wearing it apparently made the subjects uncomfortable. The HMD was hence softened by the support of a smooth sponge.

2. It was problematic that the therapist and systems operator stood next to the subject. The subject had a habit of constantly making sure of the therapist's presence, especially during periods of high anxiety and stress. As a result, the therapy room was divided into two parts: therapist and operator room, and subject room. This allowed the subject to be observed through a video camera and to communicate with therapist by microphone (Figure 3).

3. Light was another source that attenuated full immersion. Because of the bright light, the subjects could always see their feet through the crevice of the HMD. The room was hence made darker in order for the subject to concentrate on the virtual scene inside the HMD (Figure 3).

Figure 3. Experimental Room

3 CLINICAL EXPERIMENT

3.1 Case History

The participant was a 60-year-old male who indicated fear and avoidance of heights. He had a bad experience that he went up a 10-story building when he was 34-year old. The subject's anxiety and avoidance behavior were interfering with his normal activities. For example, he wasn't able to visit relatives who lived in an apartment on the 10^{th} floor.

3.2 Treatment procedure

In this study, eight sessions, three times a week, were scheduled. Each session was 25 to 30 minutes long. All sessions were video recorded. First, the subject became acquainted with the virtual reality system through both explanation and demonstration. Before the VRT therapy, the subject was asked to complete the Anxiety Sensitivity Index (ASI), the Agoraphobic Cognition Questionnaire (ACQ), the Body Sensation Questionnaire (BSQ), the Acrophobia Questionnaire (AQ), the Fear Questionnaire (FQ) and the Attitude Towards Heights Questionnaire (ATHQ) as showed in Table I. To begin the VRT procedure, the subjects were asked to sit still for 5 minutes during which baseline physiological measures were obtained. Next, the subjects undergoing VRT completed the Subjective Units of Discomfort Scale (SUDS) every 2-5 minutes during the exposure. To examine whether or not the subject actually experienced anxiety and fear, physiological data (i.e., blood pressure, pulse, and respiration) were measured simultaneously with the SUDS. A psychiatrist was present during the VRT sessions and induced relaxation when the subject experienced extreme anxiety or fear. The psychiatrist closely observed the subject through the video monitoring system and encouraged the subject to attempt to immerse himself in the virtual situation by communicating via a microphone. After an exposure session, the participants were asked to fill out the Simulation Sickness Questionnaire (SSQ), an instrument that was developed to evaluate if experiencing the VRT system had caused and adverse physical effects such as nausea or double vision (Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lilienthal, M.G., 1993).

Table 1. Questionnaires using for assessment

Questionnaire	Point	Reference
Anxiety Sensitivity Index	0 = Not at all 4 = Extremely	Peterson et al. 1987
Agoraphobic Cognition Questionnaire	1 = Not at all 5 = Extremely	Chambless et al. 1984
Body Sensation Questionnaire	1 = Not at all fearful 5 = Extremely fearful	Chambless et al. 1984
Fear Questionnaire	0 = Not at all fearful 8 = Extremely fearful	Mark & Mathews 1979
Acrophobia Anxiety Questionnaire	0 = Not at all anxious 6 = Extremely anxious	Cohen 1977
Attitude Towards Heights Questionnaire	0 = Not at all anxious 10 = Extremely anxious	Abelson & Curtis 1989

4 RESULT

The results of the pre- and post- assessments on all measures are presented in Table 2. The pretreatment Attitude Towards Heights Questionnaire (ATHQ) and Acrophobia Questionnaire (AQ) scores for the subject were 3.20 and 7.27, respectively. ATHQ and AQ scores decreased to 1.85 and 1.00 respectively after treatment with the virtual environment system. Figure 4 illustrate how SUD ratings varied with lift height and time during the six sessions.

Table 2. Comparison result of a variety of questionnaire of before and after experiment

Questionnaire	Pre-treatment (Mean)	Post-treatment (Mean)
Anxiety Sensitivity Index	0.56	0.13
Agoraphobic Cognition Questionnaire	1.64	1.29
Body Sensation Questionnaire	1.59	1.53
Fear Questionnaire	2.87	1.47
Acrophobia Questionnaire	3.20	1.85
Attituede Towards Heights Questionnaire	7.17	1.00

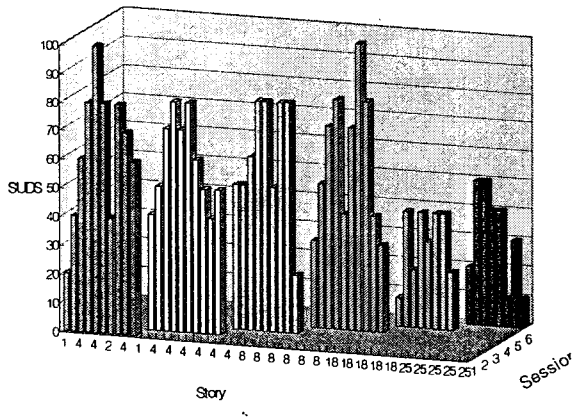

Figure 4. SUDS scores of a subject for the six sessions

These results appear to indicate a decrease of anxiety as the session progress. The most encouraging thing is that the therapy was completed in only 6 sessions instead of the planned 8-session protocol. In addition, the subject was able to expose himself to height situations in-vivo between treatment sessions, even though he was not specifically instructed to do so. After the session, the subject accompanied by the therapist, went to a 63-story building in Seoul, Korea for confirmation of treatment success. The subject experienced minimal anxiety during exposure to the 63rd floor in the tower.

5 CONCLUSION

The virtual environment was developed for the treatment of acrophobia. Based on pre- and post- questionnaires and subjective comments from the subject, this virtual environment proved to be an effective and realistic tool for the treatment of acrophobia. According to the subject's comments, the virtual environment seemed to evoke more fearful feelings than the real situation. Although this study has the limitation of being a case study, it does support future research on the effectiveness of the VR environment on the subject's longstanding fear. Specific remarks and therapeutic results given for this subject include:

1. As illustrated in Figure 4, the anxiety and fear of heights decreased as the subject was exposed to the phobic situation in the virtual environment and as the therapy sessions progressed.

2. In the first session, the subject said that the virtual steel-frame enclosure situated evoked more fearful feelings than the real situation. This indicates that virtual reality can provoke reactions similar to real-life through the use of sophisticated scenarios.

3. Based on subject's remark that he could concentrate on the HMD screen owing to the darkness of the room. It was concluded that light detracts from immersion within the virtual environments.

4. Judging from the results of the pre- and post-assessments, the virtual environment has a lot of possibilities to apply to the treatment of fear of heights.

The weaknesses of this study center on the case report format with its limited generalizability and the absence of follow-up data. Future research should focus on exploring the VR environmet's efficacy by doing a large scale study and follow-up.

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