Virtual Reality in Cognitive Behavioral Therapy : a Study on Social Anxiety Disorder

Bruno Herbelin[1], Francoise Riquier[2], Frederic Vexo[1] and Daniel Thalmann[1]

(1) Virtual Reality Laboratory, Ecole Polytechnique Fédérale de Lausanne,
1015 Lausanne, Switzerland, Tel:+41-21-693-5216, Fax:+41-21-693-5328,
Bruno.Herbelin, Frederic.Vexo, Daniel.Thalmann@epfl.ch

(2) Section des Troubles Anxieux et de l'Humeur,
Departement Universitaire de Psychiatrie Adulte, *1008 Prilly, Switzerland,*
Francoise.Riquier@inst.hospvd.ch

Abstract: This paper presents a study about the use of virtual reality techniques Social Anxiety Disorder therapy. The final idea of this technique is to treat social phobic people only by short time exposition in a dedicated stress environment parameterized in real-time. The technique is applied to the problematic of speaking in public with a symbolic representation of an audience. Nevertheless, the same methodology can be used to treat different phobias.

Keywords: Virtual Reality Exposure, Mental Health/Rehabilitation, Social Anxiety Disorder, Phobia.

1 Introduction

This paper presents the first results of a project between the VRlab of EPFL in Lausanne and the DUPA (Département Universitaire de Psychiatrie Adulte) in Lausanne on the treatment of the social phobia by using immersive virtual reality techniques.

The main goal of this project is to provide a better mean to incorporate technology in medical applications and to improve the wellness of patients by the use of the developed technology. The project is a combination between accessible technology for everyone and state-of-the-art medical applications. Although the methodology is general, the project will mainly address social anxiety.

Social Anxiety Disorder (SAD) is one of the widest psychiatric disorder in the world today : in the nineties, it was concerning around 19% of the population of occidental countries.

SAD is characterized by intense and persistent fear of social performance situations in which embarrassment may occur (typically fear of public speaking and/or situations where interactions with others will occur). SAD can be divided in specific and general types : in the former case, the patient complains of a single specific performance fear with avoidance behavior, and in the second case he may complain of several fears and avoidance behaviors. This disease is often associated with other subtypes of anxiety disorders with an average of 50% of SAD patients reporting phobic or panic disorders, or generalized anxiety. A history of substance abuse or depressive disorders are also frequent for SAD patients [9].

Research data support that cognitive behavioral therapy could be the most effective psychological approach for the treatment of social anxiety disorder [4, 16, 6]. Cognitive behavioral therapies commonly include prolonged exposure to social stimuli (within the therapy session and as homework assignments), cognitive therapy which attempts to restructure maladjusted beliefs about social situations and other persons' opinions, and social skill training.

Virtual Reality (VR) entered the mental health field some years ago to determine if Virtual Reality Exposure (VRE) may be an alternative to standard in vivo exposure for wide phobias : agoraphobia, fear of spider or fear of flying. Our goal is to experiment this ideas in the particular domain of Social Anxiety Disorder (SAD).

The paper is organized according to the following structure: in the next section we present a short overview of the existing work in this area. The section 3 is a description of our approach in the specific case of building a Virtual Environment for SAD exposure. Finally, section 4 will give our results and discuss on the particularity of VR immersion in a psychological application.

2 Related works

2.1 Revue of VR usage in phobia treatment

The goal of studies like [14], [10] or [11] is to evaluate the effectiveness of low-cost virtual reality exposure (headphone, Head Mounted Display, etc) in patients suffering from phobias. VRE was found to be as effective as exposure in vivo on anxiety and behavioral avoidance. This section presents a panel of experiences for different phobias:

- *Virtual reality exposure therapy* [13]: A case study supported the efficacy of VR exposure therapy for the fear of flying because it is a typically difficult situation to reproduce in vivo.
- *From toy to tool: the development of immersive Virtual Reality environments for psychotherapy of specific phobias* [2]: Overview of the implementation of the technology in the mental health research facility in Basel, Switzerland. The development of two applications for use with claustrophobic and acrophobic patients serves just as an example within this context.
- *The use of Virtual Reality Exposure in the treatment of anxiety disorders* [15]: VRE therapy has been successful in reducing the fear of heights in this study of virtual reality therapy (assessed on measures of anxiety, avoidance, attitudes, and distress).
- *Virtual reality: using the virtual world to improve quality of life in the real world* [1]: Description of the immersive properties of virtual reality and its importance for clinical purposes, and reviews of current clinical applications of Virtual reality. Then VR has been used in the treatment of specific phobias, post-traumatic stress disorder, eating disorders, and pain management.
- *Redefining therapeutic success with Virtual Reality Exposure therapy* [5]: Large surveys assessed on 162 students high in fear of spiders to propose VRE in stead of in vivo exposure (whose success is high, but few phobic (less than 15-20%) ever seek treatment). This shows that more than 80% prefer VR in this case.

2.2 Social Anxiety Disorder

VRE has not been applied to the particular case of Social Anxiety Disorder until very recently. This may be due to the recent advances in computer graphics, and to the progression of this disease in our society:

- *An experiment on fear of public speaking in virtual reality* [12]: The authors aim to answer a critical question : if someone is extremely anxious with real people, will he also be anxious when faced with simulated people, despite knowing that the avatars are computer generated? This paper describes a follow up study conducted with 40 subjects and their results show that not only is social anxiety induced by the audience, but the degree of anxiety experienced is directly related to the type of virtual audience feedback the speaker receives.

- *The development of the virtual reality system for the treatment of the fears of public speaking* [8]: In this study, they develop a public speaking simulator for the treatment of the fear of public speaking. The imagery of the virtual environment consists of a seminar room and 8 virtual audiences. The main interesting point of this experience is that the therapist can control motions, facial expressions and voices of each virtual audience (chatting, yawning, agreement, disagreement, hand clapping). Best effort is done to build a low-cost solution (standard PC and I-Glasses game pack).

One can also find over Internet a few VR Companies which propose some ready-made software solutions for therapeutic uses. A few of them now have dedicated environments to treat the "fear of public-speaking". However all of them are focused on social skills training rather than medical therapy:

- Virtual audiences of Virtually Better Company [17]: "If you dread cell phones ringing, people falling asleep, getting up to leave and ignoring your talk, these Virtual Audiences can help you prepare."

- Public Speaking Simulator using Image Based Rendering and Chroma-Keying [7]: Integration of video-impostors into a 3D scene to have "real" persons inside (but they still have to improve the rendering) (same team as for [8]) .

3 Developments and experiments

In this section we describe our approach to create a dedicated Virtual Reality Exposure environment for Social Anxiety Disorder. Then we will present the experiments and the results obtained in cooperation with the psychological partners.

3.1 Creation of the Virtual Scene

It has been proved that exposure to a public speaking situation can be efficient and powerful in the treatment of Social Phobia because it is the widest feared social situation.This exposure is difficult to realize because it is difficult to reproduce in-vivo. This requires to create other exposures that simulate the original situation.

So, we first developed a virtual environment with virtual humans in an office to simulate a typical social situation where the subject has to speak. The scenario shown in figure 1 has two stages: in the first one, the subject has to ask the secretary where the boss is, and then he enters the office and presents himself to a man sitting behind his desk (as for an interview).

But we found that humanoids are not expressive enough to show natural attitudes expected from the listener, and we risk to get away from the therapeutic requirements.

Then we built another environment focused only on eyes because :

- horizontal elements of the face (mouth, eyes) are essential in human perception (like for new born),

- the look of others is an important parameter of SAD (usually, social phobic people tends to avoid the gaze of others),

Figure 1: Virtual Environment of the realistic “interview” scenario

- the work on eyes allows us to concentrate on their expressiveness.

“Phobia” virtual world must be constituted only of eyes, associated with a sound ambiance. This environment should allow us to select many faces, with many different expressions.

3.2 Technical Description

VR Devices

Among the available VR display techniques, we chose the Head Mounted Display (HMD) for its high power of immersion.

Another constraint is the immersion simplicity required common untrained people : the direct navigation paradigm was used since it is the most natural one (the vision follows your head movements). Technically, we use a six Degrees Of Freedom sensor (Ascension Technology Motion Star) placed on the Head Mounted Display (Kaiser ProView XL50) and connect the virtual camera to it’s movements (position and orientation).

The computer graphics rendering is done in real time and in stereoscopic vision by a normal PC with an accelerated graphics board (NVidia GForce2).

the “Phobia” exposure environment

The “Phobia” exposure environment is a generic and symbolic virtual environment that places the subject at the center of a virtual audience (figure 2).

To assure that the user can’t avoid the regards, the spectators are placed all over in concentric circles. All the organization of the scene is configurable by the user : number of circles, number of virtual eyes and their repartition (centered or far), altitude profile, and size of the room. This allows a progressive exposure process, from a friendly discussion to a presentation in an amphitheater (figure 3).

As explained in section 3.1, we chose to use only eyes to figure the presence of someone. We placed photographs of eyes taken from a the facial-expression dedicated work of Ekman and Friesen [3], and managed to keep the eyes fixed upon the user while in motion.

An ambient sound is also necessary to obtain good immersion. We use a sound track recorded in amphitheater for this experiment and the subjects can hear it directly with earphones in the HMD (the absence of 3D spacialisation at this early stage of development was not a serious lack for the system).

3.3 Experiments

Selection of the sample

Subjects are ten voluntary students in computer science of the EPFL, aged between 20 and 30, constituted of four females and six males.

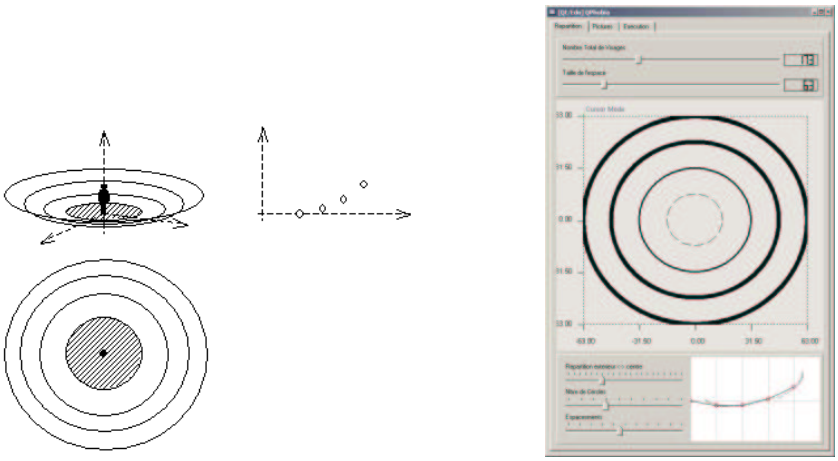

Figure 2: Simulation of an assembly by circular repartition of faces and creation GUI

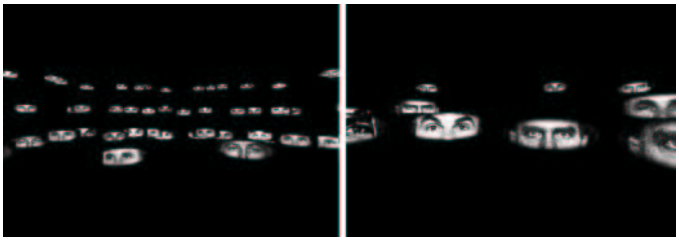

Figure 3: Snapshots of the symbolic Virtual Environment : a large and a normal space.

Measures

Different assessment tools were used to appreciate the social handicap of the subjects and the severity of their anxiety in situation :

- *Liebowitz scale* : this auto-assessment questionnaire gives a appreciation of the degree of anxiety of the subject in many usual social situations. According to his answers, the therapist can compute a score between 0 and 123.
- *Subjective stress evaluation* : this analogic scale from zero to ten is used by patients to appreciate the intensity of their anxiety (zero for feeling relax, and ten for high anxiety).
- *Objective physiological measures of anxiety* : the bio-feedback device (Physio-Recorder from Vienna Test System) gives the two main physiological parameters of anxiety : pulse and skin conductivity (in the hand) during all the experience.

Experimental procedure

The cognitive behavioral therapy experimented here is based on four main phases :

- Phase 1: present the devices to the subject and wear the equipment (HMD, sensor, earphones, bio-feedback), as shown in figure 4.
- Phase 2: relaxation with quiet music and a restful picture,
- Phase 3: immersion in the virtual assembly,
- Phase 4: and finally a speech in front of the virtual assembly.

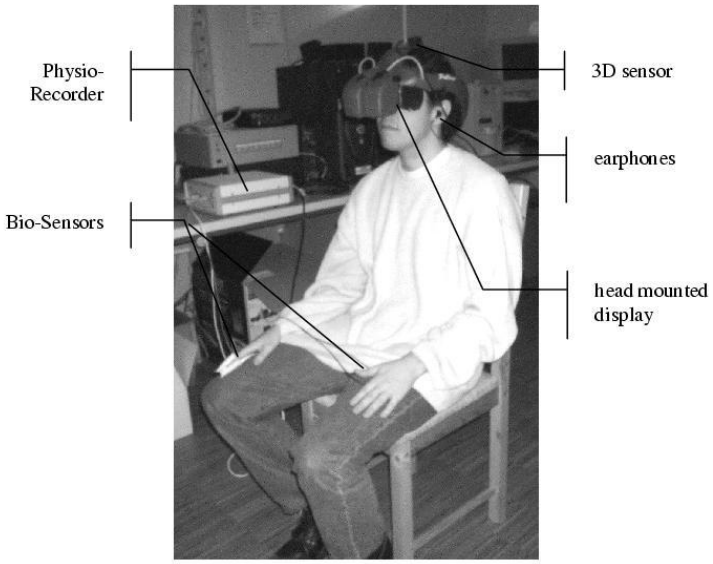

Figure 4: A subject during the VR exposure

At the end of each stage (at times T1, T2, T3 and T4), the subjective stress was evaluated. The goal of the relaxation phase is to recover from the additional stress generated by the first phase, and to come back to a “normal” anxiety level.

The supervisor has a control station on which he can elaborate the virtual scene content (see section 3.2) on a dedicated Graphical User Interface (figure 2), overview the evolution of bio-feedback values, and control other parameters like sound volume, relaxation pictures, etc...

4 Results and Discussion

4.1 Data analysis

Liebowitz scale

The analysis of the questionnaires manifest a separation of the sample into two groups :

- group A : score more than 40 : SAD-inclined subjects.
- group B : score less than 40 : non anxious subjects in social situation.

Subjective anxiety

At T2, we can notice a different evaluation for each groups : for the group A, we observe a persistence of the level of anxiety at T1 after the relaxation, and in group B this level of anxiety decreases. This corroborate the fact that the anxious subject can’t calm down as they know they will be confronted to speech.

Between T2 and T3, and between T3 and T4, we can observe for each group a significant increase of anxiety (x 2, x 2.5); however the group A has greater values than the group B (they are more stressed).

Measures	0<Anxiety <10				Pulse (in bpm)			
Time	T1	T2	T3	T4	T1	T2	T3	T4
Group A : SAD-inclined subjects								
subject 1	2.5	2.5	6	6.5	58	52	74	85
subject 2	3.5	3.5	3.5	6.5	98	77	98	114
subject 3	7	6	7	7.5	111	98	120	117
subject 4	4	6	7	7	74	70	75	78
subject 5	5	3	6	7	94	89	121	132
Group B : non anxious subjets								
subject 6	1	0.5	0.5	2.5	74	74	81	86
subject 7	5	3	3	5.5	74	68	82	89
subject 8	2	1	1.5	1.5	71	61	73	75
subject 9	1	0.5	2	2.5	74	78	86	91
subject 10	1	0.5	1	3.5	81	77	87	86

Table 1: Subjective Anxiety evaluation and cardiac frequency

Physiologic measures

For the two groups, the physiological anxiety parameters increase between T2 and T3, and between T3 and T4, but less significantly than for subjective anxiety. Nevertheless, the cardiac frequency variations seem close to the subjective anxiety variations as shown in table 1.

The sample should to be much bigger to allow a correct interpretation of pulse and skin conductivity measures.

4.2 Subjective appreciation

As this application is dedicated to the well-being of the subjects, it was necessary to spend some time with them afterward. We noticed some judicious remarks from the dozen of persons interviewed:

- the situation by itself is stressful ; wearing a HMD and being plugged to the bio-feedback sensors is not natural. They globally appreciated the relaxing phase as it takes time to get used to this equipment. Some subjects even proposed to do it a second time as they felt more self confident with the equipment,
- we shall not speak to them directly while they are inside the HMD, but use a micro-phone and speak throw the earphones so they are not called back to reality during the immersion,
- the sound ambiance was essential to get the immersive sensation,
- some accepted very naturally the visual symbolism used to represent the assembly, but for all of them the environment was too much static; it misses some real human behavior for the people.

We can notice the apparent contradiction of the last observations. In fact, the solution with eyes photographs is certainly too reductive. Even if people accept very well a simplified representation of human-beings (like for cartoons), it has to be expressive and lifeful (one solution could be to isolate eyes from videos instead of photographs).

4.3 Discussions

Building a Virtual Exposure environment

Even if the actual computer graphic techniques tend to realism, real time simulation does not allow the rendering of complex scenes with several realistic virtual humans. In fact, the animation of humanoids is generally done at the expense of some "details" (level of details, poor facial expression, simplified hairs and dress,..). But for humans, details make the difference and for the treatment of social phobia, it is necessary in the psychological point of view to integrate some expressive faces and some natural (precisely chosen) gestures. Moreover, the interaction with realistic virtual humans has to be accordingly realistic : a multi-modal (at least vocal) interaction must be provided in a such simulation. This is one of the main challenge of Virtual Reality, and we are still working on this solution, trying to satisfy the necessity of expressive humanoids (face and gesture).

But our experience shows that it is possible to take a different way : based on the psychological minimal requirements, we could isolate some essential multimedia stressful elements and build a symbolic environment dedicated to social exposure stimuli.

The main advantage of a symbolic virtual environment is that is does not require the elaboration of a complex technical virtual reality engine. But on the other hand, the choice of the content must be very judicious and his impact is limited to a specific target. As symbolism was an interesting experience, we now plan to make a comparison with a realistic Virtual Exposure, in order to obtain more informations on required exposure elements for Social Anxiety Disorder.

Stress in VRE

One of the main problem when using VR devices is that they are not very "natural" (fear to be ridiculous, claustrophobia...) and this may corrupt the expected effects of the exposure. In this preliminary study, the subjects were used to this technology as the groups were made of computer workers, but in the general case, we shall develop a complete therapy session program with comparison with a frontal screen-based immersion (large screen and stereoscopic glasses). As the results of virtual reality exposure are best explained in terms of habituation (anxiety, heart rate and negative self-statements decline both within session and across sessions[18]), it is also important to follow this therapy on several exposures.

To evaluate the stress generated by the VR equipment, we plan to improve the therapeutic procedure (define more phases, test on different environments,...) and to compare with a parallel program with classical in-vivo exposures.

Specific advantages of computer based simulation

As Virtual Exposure has some important constraints due to the usage of computers and devices, we must keep in mind that it will be really used by psychologists only if this solution provides some specific and important advantages :

- Generic disease environment : a single system that allows several simulations gives many possibilities for the therapy: follow step by step a progressive immersion, adapt the situation to the degree of illness, or use it for a similar disease.
- Control of the simulation : as medical users may have different feelings with technology, the system must include simple automatic functionalities and full access to data and scenarios.
- More attractive : as the therapy require to expose the subject to a situation he doesn't like, the usage of technology may be a way to make the experience more attractive, especially for young subjects (throw amusement and curiosity).

5 Conclusion

The preliminary experiments carried on using this first version of the Virtual Reality Exposure environment show that the developed system has great potential. We have a promising technology which could constitute a valuable tool in the treatment of Social Anxiety Disorder.

Results confirm that our VRE can provoke some anxiety. The generated stress during the experiments is sufficient to substitute the in-vivo exposure by VRE. It is conceivable to use this support in a treatment of social phobia, but we have to confirm that the main anxiety is generated by the virtual environment, more than by the unusual technical context. We should now compare them with classical in vivo exposures to distinguish the effects due to the VR equipment and to the simulation itself.

Another important issue subject to further discussions and experimentations is the simulation approach: which kind of virtual environment will be the more effective in the treatment? A realistic image rendering, using human models and scenarios of high visual quality, or a rather symbolic representation of appropriate stimuli using specific multimedia effects (corresponding to a particular phobia). In either case, a close collaboration between the medical specialists and computer scientists is essential to continue the development and the enhancement of this technology.

In order to create virtual interactive content that will simulate the cause of a phobia, we should create an authoring simulation platform able to reproduce the stressing environment including sound, visual and even tactile stimuli, but also able to interface the bio-feedback material to determine the level of stress of the patient in order to adapt the virtual environment.

We will continue on this project with the development of a generic software based on virtual reality in order to treat for other specific phobias i.e. acrophobia, claustrophobia.

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