Issues in the Design of Virtual Environments for the Treatment of Social Phobia

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Abstract
Social phobia is an anxious disorder that is now the object of an intensive research. It has been shown that social phobia was accessible to two forms of treatment yielding scientifically validated results: drugs and cognitive-behavioral psychotherapies. Exposure to feared social situations is fundamental to obtain an improvement of the anxious symptoms. Traditionally, exposure therapies are done either *in vivo* or by imagining them.

Virtual reality (VR) seems to bring significant advantages. It allows exposures to numerous situations and this through the creation of a strong feeling of presence in the situation. Studies have shown that human subjects are appropriately sensitive to virtual environments.

This paper reports a protocol, which specifies patients' assessment and allocation, therapy's structure and a study to treat social phobia using virtual reality techniques. It describes the virtual environment consisting of four three-dimensional worlds reproducing four situations that social phobics feel the most threatening. It presents the

relation scientists-technicians, explains the steps of the worlds' design, the hardware requirements, and the software tools. It also describes some specific constraints we add to take into account in the world model and to improve the therapeutic usability. It finally assesses the efficiency of the virtual reality therapy, the comfort and handiness of the designed technology, and presents results of a clinical trial.

The patients reacted to the virtual environments in a way similar to that of their *in vivo* experiments. We noticed an improvement of their symptomatology and a good observance of the treatment. The patients showed an average adhesion to the virtual environments in which they navigated at ease.

Keywords
Virtual Reality; Social phobia; Virtual reality therapy; Virtual reality exposure; Cognitive-behavioral therapy; 3D-Worlds; Interactivity

1 Introduction

According to the *Diagnostic and Statistical Manual of Mental Disorders* (DSM IV)[i], social phobia, like other phobias, is defined by "a persistent and irrational fear, anxiety and avoidance." Social phobics experience significant emotional distress facing situations like: being introduced to other people, being teased or criticized, being the center of attention, meeting people with some sort of authority, and so on[ii]. Several physiological symptoms may occur together with social phobia: intense fear, racing heart, blushing, excessive sweating, dry throat and mouth, or trembling[iii].

Social phobia affects between two and four percent of the adult population. This disease is one of the most frequent mental diseases and generally appears between the ages of fifteen and twenty[ivv]. If this disorder has long been neglected, its most common example, the fear of public speaking, is now the object of an intensive research[vi,vii,viii].

Social phobia is accessible to two forms of treatment: drugs such as certain anti-depressants (inhibitors of serotonin recapture) and Cognitive Behavioral Therapies (CBT)[ix]. CB therapies combine three different components[x]:

- Exposure therapy: A regular and prolonged confrontation of the subject to anxiety-producing social situations.
- Cognitive therapy: A modification of the subject thoughts and assessments of social situations.
- Assertiveness therapy: The learning of more efficient relational behaviors.

The exposure to feared social situations is essential to obtain an improvement of the anxiety symptoms[xi]. Traditionally, exposure therapies are done either *in vivo*, the subject is confronted to real social situations, or by imagining them. However, *in vivo* exposure has is sometimes difficult to control.

Virtual reality seems to bring significant advantages by allowing exposures to numerous, varied and well-mastered situations[xii,xiii]. Moreover, it has been shown that human subjects respond appropriately to negative or positive audiences even when they are completely virtual[xiv].

We used virtual reality techniques in a CB therapy to treat social phobia. We describe here the virtual worlds, the scenarios, and the techniques we designed for the therapy. This work is part of the VEPSY Updated project whose goal is to understand and to exploit the potential of virtual reality for psychological disorders[xv].

The social phobia module consists of four virtual environments where the patients are exposed and where they learn new behaviors. These environments are used according to a clinical protocol that is defined in Nugues et al. (2001)[xvi]. We summarize here the clinical protocol, which specifies the patients' assessment and allocation and the

therapy's structure. We describe the required equipment, the virtual worlds, the scenarios, and the techniques we designed for the therapy. We assessed the efficiency of the virtual reality therapy, the comfort and handiness of the designed technology within the framework of a small-scale clinical trial and we report the results we obtained.

The final purpose of this project is to assess the efficiency of a Virtual Reality Therapy compared to a validated Cognitive Behavioral Therapy and to the absence of treatment for social phobia patients[xvii].

2 The Clinical Protocol

The target population is constituted of patients showing a social phobia according to the diagnostic criteria of the DSM IV. They must comply with

- Inclusion criteria: men and women, at least 18 years old and at most 65 years old, ambulatory social phobics, and
- Non-inclusion criteria: in terms of population (pregnant women), of pathology (severe organic disease, mental disorder of an organic origin, depression), and of treatment (with active medicinal treatment against social phobia that is not stabilized, other kind of psychotherapy).

After the clinical assessment, the patients are subjected to psychometric assessments. They have to fill in self-report questionnaires that include the Hospital Anxiety Depression Scale(HAD)[xviii], the Social Anxiety Scale (SAS)[xix], the short Beck Depression Inventory (BDI-13)[xx], and the Rathus Assertiveness Schedule (RAS)[xxi].

We have selected four exposure situations dealing with anxiety tied to assertiveness, performance, intimacy, and scrutiny. Each one corresponds to a special recognized case of social anxiety and its purpose is to reduce the patient's unease in the corresponding real situations. The objective is to teach the patient new behaviors: protecting one's interests, being respected; speaking in public, facing "important" people; having informal contacts, small talks with friends; moving or speaking with people around, being observed.

We defined the structure of the Virtual Reality Therapy (VRT), which includes patients' assessment and the contents of the VR sessions. Each patient attends twelve sessions of virtual therapy. Each session is individual and directed by a cognitive behavioral psychotherapist. During these weekly sessions of forty-five minutes, the patient is exposed to virtual worlds in a purpose of assessment or therapy. The duration of each exposure should be less than twenty minutes.

During the first session the therapist introduces and presents the therapy to the patient. Then the patient familiarizes with the virtual training world and the tools. The ten next virtual sessions constitute the core of the therapy. During session twelve, the last one, a conclusion is given to the patient. At the end of each session the therapist prescribes the patient tasks to carry out in order to apply what was learned.

Virtual reality sessions are conducted according to four phases. The assessment phase contains questions to explore: Cognitions – *What thoughts do you have?* Emotions – *What do you feel?* Behaviors – *What do you do?* Therapeutic phases mix Spontaneous phase: The patient moves about freely in the world and decides himself/herself which attitudes to adopt; Instructed phase: The therapist instructs the patient which attitudes are relevant to the situation. The therapist helps the patient to learn adapted reactions in relation with cognitions, emotions, and behaviors; Model phase: The therapist shows the patient a model of behavior and attitude to face the situation encountered in the world.

3 Equipment and Software

The use of low-cost PCs in virtual reality is one of the requirements of the Vepsy Updated project. The system minimum configuration is a Pentium III or IV PC with 64 MB of RAM, an Internet browser (Explorer and Navigator), and a plug-in to visualize the virtual worlds. Some features are recommended. They include a Direct3D or OpenGL compatible 3D accelerator graphics card with at least 8 MB of RAM, DirectX, a monitor color display set to 16/32 bits, and a sound card.

The virtual world images are displayed on a large screen monitor. The patient navigates in the world and interacts with the artifacts either with a mouse and a keyboard or with a Cyberpuck pad. We also conducted experiments with a VFX3D head-mounted display (HMD) that ensures a complete immersion. The VFX3D consists of a three degree of freedom tracker for roll, pitch and yaw positioning, a standard VGA interface, audio inputs and 360,000 pixel color displays.

We used two main software tools to create the 3D virtual exposure environments in the treatment of social phobia. We designed the objects, the visual effects, and the virtual worlds with Discreet 3D Studio Max 4. We also created animated characters with Character Studio 3, an extension of 3DS Max. The 3D design was then integrated in a behavior-based interactive 3D development tool, Virtools Dev.

Virtools Dev is an authoring application that enables to create interactive 3D content using cameras, lights, curves, interface elements, and 3D frames. A behavioral engine processes behaviors, which are descriptions of interactions of elements in an environment. These behaviors are realized by building blocks, which can be combined to create complex interactive behaviors. A rendering engine draws the image seen on-screen, according to the information supplied by the behavioral engine. The environment is running on PC and can be viewed with the Virtools Web Player (www.virtools.com).

4 The Virtual Environments

4.1 The Scenarios

We sketched four scenarios fitting the CB therapy and then we created four virtual environments with the corresponding characters and sounds. A fifth virtual environment was designed without characters, in which the patient learns how to use the tools and how to navigate in a virtual world.

In the *Assertiveness* environment (Figure 1), the patient learns to protect her/his interests, viewpoints, and to be respected. Three main rooms were created: upstairs, an elevator with two persons who can criticize the patient, downstairs, a hall with three persons who block the exit way and a shoe store with a director and two assistants who will try, repeatedly, to sell shoes to the patient. Between the hall and the shoe store, the patient can also navigate in a street where persons are standing or sitting on benches.

In the *Intimacy* environment (Figure 1), the patient learns to establish contact with neighbors, friends, and to have small talks. The storyboard takes place in an apartment, showing a table set for dinner, a lounge, a kitchen, and decorative objects such as lamps, shelves, and pictures. A friend invites the patient with four other people. The patient should introduce her/himself, speak about the decoration and answer questions when all the guests will be around the table.

In the *Scrutiny* environment (Figure 1), the patient learns to move and to speak while being under scrutiny. The patient walks from a street lined with trees to a square and the outside of a coffee shop. Many people are looking at her/him, sitting on benches, at the tables, or standing up. The patient must enter the coffee shop, look for a friend, then go out and reach a free chair next to her/his friend who has just arrived and engage a conversation with him. The waiter will come to take the order, then to collect the bill. There will be a mistake in the sum. In all the situations, the patient will feel being under scrutiny.

In the *Performance* environment (Figure 1), the patient learns to speak in public. The storyboard takes place in a meeting room where the patient joins seven other participants who are already sitting and speaking around a big table. First s/he should reach a free chair at the table, and after the arrival of the director s/he should introduce her/himself, then stand up and walk to a paperboard to expose a subject while everybody is looking on attentively or not.

assertiveness intimacy

scrutiny performance

Figure 1 Snapshots of the virtual environments.

4.2 A Dialogue between Psychiatrists, Psychologists, Computer Scientists and Graphic Artists

Long discussions between scientists and artists have been necessary to design the worlds, which fit with the technical constraints and the clinical needs. For example in the

café, one psychologist wanted that people eat olives and spit out the stones. The dialogue between the members of the team enabled to determine the details to include in a scene that were both clinically relevant and technically possible.

We discovered also that words are not always informative enough to describe a situation. With "Café" for example, the psychologists were thinking of a representation of a city café different to what the artist designed: a holiday café from the south of France.

A very important issue in social phobia is the permanent feeling of scrutiny. This means that for each world, the designer had to think not only in terms of architecture but also consider the people living and moving in the scene.

Finally, through our permanent dialogue we hope we obtained effective scenarios that reduce as far as possible each world to one single phobic situation. From our initial prototypes, we also simplified the dialogue until we obtained precise and instrumental sentences although during the recording, actors felt that sometimes sentences were more written than spoken…

5 Object and Media Types in the Virtual Worlds

The Virtools rendering tool imposes constraints on the object models to synthesize images in real time and to allow an interactive navigation. These constraints include the axis orientation, the texture size, the number of vertices and facets, etc. We describe here the design process and the decisions we made to comply with these constraints.

We designed the *3D Objects models* from polygon meshes using 3DS Max and then we exported them to a Virtools readable format. Attention was paid to the orientation, the size and the scale of all the designed objects in order to respect the Virtools constraints. We optimized the design to render the virtual world faster. Most of the objects have a simple shape, with a limited number of vertices and faces. Non-visible faces were eliminated. Repeated objects were duplicated in Virtools. In this case, there are two object entities but only one mesh. The new objects always refer to the original mesh so the rendering is faster and it spares disk space. We used invisible objects to detect collisions. When it was not necessary to design 3D objects, we used texture-mapping techniques.

The characters in our environment are *3D Sprites*, which are simple plain surfaces used to simulate single quad objects with textures. Real persons were filmed in daily life situations via a digital video camera. The pictures were edited in Photoshop and exported to a Virtools readable format. A 3D Sprite can be constrained on one or more axes to always face the camera. This choice was a good trade-off between realism and the number of avatars. The design and the implementation of such a number of biped characters with Character Studio would have been time-consuming.

The textures are images used to give an element a certain appearance. Realistic textures increase the quality aspect of the environments. Some textures come from

photos taken with a digital camcorder but most of the time a better result is obtained with textures created with Photoshop, although this process is time-consuming. In addition, we constantly took care to balance the degree of realism and the size of the textures.

The sounds written in the storyboards were recorded in real situations. We decided to use wav files in order to preserve the quality of the sounds. Sounds play an important role in the realism of a scene. It helps the patient's immersion in the world and the scenario. The human voice coming from the sprites tend to establish a more realistic dialogue.

6 Interactivity

Virtools Dev was used to integrate the objects and media – textures, sounds – and to add interactivity to the environments. This has been created using behaviors that can be applied to almost any element in Virtools. Each behavior, when executed, can activate other behaviors through links, characterized by a link delay measured in frames. The propagation of the activation depends on this link delay.

We let the patient experience the environments from a *first person perspective* without the intermediary of an avatar, which would hinder the identification and the involvement of the patient. The patient is represented by a 3D Frame (a reference point) bound to a camera. Both of them move together because of a hierarchy link, the camera being a child of the frame. The collision tests between the patient and the objects of the environments are managed by the 3D Frame, which is also bound to be on floor.

The patient navigates in the environments using the mouse and the cursor movement keys or a Cyberpuck pad. The mouse and pad allow rotation movements, while the cursor movement keys and the pad allow translation movements.

We also conducted experiments with a complete immersion. The patient wears a VFX3D head-mounted display (HMD) that determines the patient's head position and moves forward or backward with the Cyberpuck pad. The images that the patient sees in the HMD also appear on the screen of the computer for the therapist. (Figure 2)

The interaction with some objects of the virtual environments, such as doors, is allowed using the mouse or the pad. Tests of collisions with walls, objects, characters of the environments were introduced. We developed some effects such as the "sitting down effect". When the patient has to sit down on an indicated chair, he moves towards the chair and, in the proximity of it, the computer takes charge of the installation of the patient.

The virtual session always unfolds under the *control of the therapist* who can introduce virtual characters or ambient sounds and manage the progress of the session.

Figure 2 The head-mounted display.

7 Results and Discussion

We carried out a small-scale clinical trial in the Unité de Thérapie Comportementale et Cognitive (Behavioral cognitive therapy unit, Doctor Patrick Légeron) of the Sainte Anne University Hospital (Professors Henri Loo and Jean-Pierre Olié), Paris. Ten social phobic patients were included and followed a virtual therapy treatment, a complete one for two of them, and a partial one of two virtual sessions for the eight others. A complete case report is described in Roy et al. (2002)[xxii].

We report here some results of this trial. Using the interfaces we described and assisted by the therapist, the patients navigated with ease in the virtual environments. We experimented navigation with the VFX3D Head Mounted Display. If the HMD definitely brings a better sense of immersion, it is not without drawbacks due to its weight, the small size of the image seen on the screen, and shortcomings in the rendering of the stereoscopic vision. These shortcomings are certainly due to the VFX3D equipment, which is a very sensitive device. Its calibration or adjustment is a relatively difficult task and it needs a refreshment rate of 60Hz for stereoscopy. We think of a new approach to solve these vision and immersion issues by using a large screen and a videoprojector.

If an exact replication of the reality is not necessary to generate a reaction from the patients, it is essential to bring all the possible accuracy in the stimuli design. The work of adapting the technical possibilities to the clinical requirements was the fruit of a narrow collaboration between all the members of our team.

The patients react to the virtual environments in a way similar to that of the corresponding *in vivo* experiments. There are sensitive to the environments and react consistently with their problem. When they are facing the feared situation, they feel discomfort, or anxiety, or shame. Blushing and physical feelings may appear. These results are consistent with those of Rothbaum et al. (1996) and North et al. (1998) showing the effectiveness of VR exposure.

An improvement in the symptoms has been noticed among the patients who followed a complete virtual therapy treatment. This improvement was confirmed at the same time by the psychometric evaluation, the clinical observation, and by the statements of the patients.

We found a good observance of the treatment. The ten included patients came to all the prescribed sessions. Our clinical experience shows that when participating in regular sessions of therapy, patients often miss some sessions, which was not the case here. The patients underlined the "playful" aspect of the therapy, which may probably explain this good observance.

During this trial, we were able to notice that the reactions of the patients facing the environments differed according to their problem (assertiveness, scrutiny, intimacy, or performance). As far as we know, we consider that we have described the first study of social phobia in which a complete VRT was carried out.

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