6   Virtual Reality Exposure in the Treatment of Social Phobia

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Abstract. Social phobia is one of the most frequent psychiatric disorders and is accessible to two forms of scientifically validated treatments: anti-depressant drugs and cognitive-behavioral therapies. Graded exposure to feared social situations (either *in vivo* or by imagining the situations) is fundamental to obtain an improvement of the anxious symptoms. Virtual reality (VR) may be an alternative to these standard exposure techniques and seems to bring significant advantages by allowing exposures to numerous and varied situations. Moreover studies have shown that human subjects are appropriately sensitive to virtual environments.

This chapter reports the definition of a VR-based clinical protocol and a study to treat social phobia using virtual reality techniques. The virtual environments used in the treatment reproduce four situations that social phobics feel the most threatening: performance, intimacy, scrutiny and assertiveness. With the help of the therapist, the patient learns adapted cognitions and behaviors when coping with social situations, with the aim of reducing her or his anxiety in the corresponding real life situations.

Some studies have been carried out using virtual reality in the treatment of fear of public speaking, which is only a small part of the symptomatology of most of social phobic patients. The novelty of our work is to address a larger group of situations that the phobic patients experience with high anxiety. In our protocol, the efficacy of the virtual reality treatment is compared to well established and well validated group cognitive-behavioral treatment.

1. Introduction

Virtual Reality (VR) is a human-computer interaction paradigm, in which users are no longer mere external observers of images on a computer screen, but the active participants in a three-dimensional (3D) virtual world. Virtual reality allows the presentation of virtual objects to all of the human senses in a way identical to their natural counterpart [1]. Virtual reality also offers a variety of tools and approaches that can be used to understand human emotional responses and the psyche [2].

For all these capabilities therapists take now interest in virtual environments and do not hesitate to envisage their use in Psychotherapy. "Three important aspects of VR systems offer new possibilities for assessment and treatment" [3]: Monitoring of movements or actions from any body part or many body parts at the same time and process

of these actions and signals; Translation of feedback and prompts into alternate senses for users with sensory impairments; Location of patients in environments that would otherwise be dangerous or inaccessible or would generate too much stress for effective therapy. The idea of using VR technology to treat psychological disorders was first conceived at Clark Atlanta University in 1992. Since then, experiments have been successfully conducted, especially in the treatment of specific phobias [4].

Cognitive and behavioral therapy techniques for treating phobias include graded exposure of the patient to anxiety-producing stimuli (Systematic desensitization).

Traditionally exposure therapies are carried out either *in vivo*, the patient experiences real situations, either through the patient's imagination. But patients may experience difficulties to imagine or aversion for the real situation.

Virtual Reality Therapy (VRT) brings advantages allowing exposure therapy and overcoming some of the difficulties inherent in the traditional treatment. VRT is an innovative alternative or support treatment for patients. It gives the therapist greater control over multiple stimulus parameters. It also provides the ability to isolate the specific parameters that determine the dysfunctional response. Like *in vivo* therapy, VRT can provide stimuli for patients who have problem with guided imagery. It can be used as an intermediate step in preparing patient for maintenance therapy involving self-directed *in vivo* exposure. Finally, safer and less threatening than *in vivo* desensitization, preserving privacy, VRT is well accepted by the patients.

Based on data collected and subjects' verbal reports, North and al. [4] made a few assertions, very useful for the therapy definition but also for the description and the design of the virtual environments:

- 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.
- 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.
- Each person brings his/her own background into a virtual reality experience.
- Experience with a virtual environment increases the participant's sense of virtual presence.
- 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) to achieve a stronger sense of presence in the other one (e.g. virtual).
- 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.
- A person's perceptions of real-world situations and behavior in the real-world may be modified based on his/her experiences within a virtual world.

Nevertheless, the potential risks associated with VR technology should not be neglected and some precautions should be taken [5]. Subjects at risk for psychological harm are those with serious medical problems such as heart disease or epilepsy, those who are taking drugs with major effects. Experience of symptoms ranging from headache to epileptic seizure may occur after exposure to visual stimuli. Some precautions in the installation of the patient should also be taken to increase his/her safety, such as to sit on a chair rather standing up or to keep the sessions brief [4].

As studies showed that Virtual Reality exposure can be effective with relatively cheap hardware and software on stand-alone computers currently on the market [6], we can

reasonably assert that virtual reality exposure will come within reach of the ordinary practitioner within the next few years.

2. Description of Social Phobia

According to the DSM IV [7] and CIM 10 [8], social phobia is the unreasonable or excessive fear of social situations and the interaction with other people that can automatically bring on feelings of self-consciousness, judgment, evaluation, and inferiority.

Put another way, social phobia is the fear and anxiety of being judged and evaluated negatively by other people, leading to feelings of inadequacy, embarrassment, humiliation, and depression [9].

It has been estimated that 3 to13 percent of people suffer from a social phobia during some period of their lives [10]. The percentage suffering from a social phobia at any one time is 1 to 2,5 %. Shyness is much more common. Studies have shown that 80-90% of people say they have felt shy at some time in their lives. And 30-40 % consider themselves shy at the present time. Social phobia generally appears between the ages of fifteen and twenty and is about equally in women and men [11].

It is distinguished the *specific* social phobia (e.g. fear of speaking in front of groups), and the *generalized* social phobia where people are anxious, nervous, and uncomfortable in almost all social situations. It is much more common for people with social phobia to have a generalized type of this disorder. When anticipatory anxiety, worry, indecision, depression, embarrassment, feelings of inferiority, and self-blame are involved across most life situations, a generalized form of social phobia is at work [12].

People with social phobia usually experience significant emotional distress in the following situations: being introduced to other people, being teased or criticized, being the centre of attention, meeting people in authority ("important people"), most social encounters, especially with strangers and so on.

The physiological manifestations that accompany social phobia may include intense fear, racing heart, turning red or blushing, excessive sweating, dry throat and mouth, trembling, swallowing with difficulty, and muscle twitches, particularly about the face and neck. Constant, intense anxiety that does not go away is the most common feature sense.

This pathology is often accompanied by significant social disabilities and exposes the subject to severe complications (depression, suicide, alcoholic behaviors, etc) [12].

The development of social phobia has not yet been fully explained. It is unlikely that a social phobia arises suddenly as a result of a particular negative experience (trauma).

Various possible factors have been suggested: social learning, defective social skills, biological and genetic factors.

3. Traditional approaches

If this disorder has long been ignored, it is now – and this for 15 years or so – the object of an intensive research. It has been shown that two forms of treatment may well be of value in social phobia [13]: drugs [14] and cognitive-behavioral therapy [15].

3.1 Drugs treatment

Drugs exist that are helpful in depression (antidepressants). A certain class of antidepressants (reversible inhibitors of monoamine oxidase-A or RIMAs) is also effective in social phobia. Physical symptoms of tension can be redacted with drugs known as beta-

blockers. These are often prescribed for occasional use in situations it is feared that physical symptoms may occur (e.g. fear of trembling when giving a speech or musical recital). The chances of achieving lasting positive effects by the use of antidepressant drugs are increased by supplementary behavior therapy.

3.2 Cognitive-behavioral therapy

Cognitive-behavioral therapy is a form of treatment that is strongly oriented towards reducing symptoms [16]. A careful investigation is always made to determine how the symptoms have arisen and what keeps them going. Treatment is then given according to a structured plan. The behavior therapist chooses methods and techniques that studies have shown to be effective in combating such symptoms. Patients are given assignments that must be completed at home. Between sessions the patient records all kinds of information and does practical exercises. Step by step, increasingly more difficult situations are practiced.

Three aspects must be distinguished in the cognitive-behavioral therapy of social phobia [17]:

- Dealing with anxiety-provoking thoughts

Dealing with anxiety-provoking thoughts is also known as cognitive therapy. The first step is to track down negative thoughts that are then examined to see whether they are justified. If possible, they are replaced by more realistic, and often more positive thoughts.

- Acquiring social skills

It has been shown that some people with a social phobia become anxious because they have defective social skills. The risk of rejection is greater if someone does not know how to initiate a conversation or turn down a request. Acquisition of social skills is usually carried out in groups. Social behavioral options are discussed, demonstrated and practiced by role-playing.

- Overcoming avoidance

Behavioral therapy cannot be successful unless avoidance is overcome. A highly effective approach is the use of "exposure exercises" [18], [19]. In this case, the patient is exposed to situations that arouse anxiety. Usually the patient starts with something easy. This exercise is then followed by increasingly difficult situations. Someone with social phobia will practice, for example, by going to a party, or drinking something in a café.

Another key element in virtually all anxiety and phobia treatments based on behavioral therapy is the use of relaxation exercises [20]. This reduces physical tension, making other exercises less difficult.

Cognitive behavioral therapies (CBT) act in three different ways [17]:

- Through a regular and prolonged confrontation of the subject to anxiety-producing social situations (exposure therapy)
- Through a modification of the subject thoughts and of her/his assessments of social situations (cognitive therapy)
- Through the learning of more efficient relational behaviors (assertiveness therapy).

Studies cannot exactly determine which of these three components is the most efficient to reduce the social anxiety of phobic subjects. However, it seems that the exposure to feared social situations – especially if the subject learns how to modify his/her thoughts and

certain of his/her behaviors) is fundamental to obtain an improvement of the anxious symptoms [21].

4. The new VR-based treatment

Cognitive and behavioral therapy techniques include exposure to anxiety-producing situations. So most of the therapies treating phobias and using virtual reality are drawn on the principle of exposure consisting in confronting and accustoming the patient to the stress situations [22, 23]. This technique attempts to mock the *in vivo* exposure that is normally executed in the real world.

Case studies demonstrated the effectiveness of exposure carried out through Virtual Reality. Only few studies reported VR applied to social phobia [23-26]. More exactly, these studies dealt with the fear of public speaking, which is one of the situations frequently met by social phobics. The aim was to expose people to negative, positive, and neutral audience. The results showed a positive correlation between the kind of audience, the self-rating and the public speaking anxiety. But social phobics can meet difficulties in other social situations than the fear of public speaking.

Using artificial settings, virtual reality eliminates many constraints of the real world and therefore seems to be a tool that brings significant advantages. One of the principal assets of virtual reality is the possibility for the therapist of controlling the intensity of the stimuli (e.g. variations of the stress situations, addition of new sources of stimuli: tactile, visual...) in order to make progress in a continuous and soft way for the patient. In addition, the patient as well as the therapist has the possibility to stop immediately the simulation in the event of faintness. It is not the case in the *in vivo* exposure where it can be difficult or take some time to stop the therapy. VR exposure, which we call *in virtuo* exposure here, can be a useful intermediate step for social phobics who feel aversion to face real world situations. Moreover all the therapy is carried out in the therapist's office, and the indispensable confidentiality is preserved [27].

In imaging exposure, the patient has to imagine the anxious stimuli. However, it is proved that several of them cannot or are too phobic to imagine the situation prescribed by the therapist. Moreover, one does not know what the patient imagines really.

According to the knowledge of potential risks related to either major organic health problems such as heart disease, or either other mental disorders such as depression, or either side effects of VR use such as headaches, definite steps must be taken in treatment to minimize these risks [4]. Special attention must be paid to the elimination of some treatments which could distort the action of the Virtual Reality Therapy.

We took all these advantages and potential risks into consideration in the definition and the design of a new VR-Based treatment of social phobia [28], in which the presence of the therapist is fundamental to assure the safety of the patient. It may appear as a first step in a new way of therapy and the conclusions of the large scale clinical trial should give issues for its improvement.

5. The VR-based clinical protocol

The objective of this study is to assess the efficiency of a virtual reality therapy (VRT), compared to a validated psychological treatment (CBT: cognitive behavioral therapy) [29].

5.1 Studied population

The studied population is formed of patients showing a social phobia according to the diagnostic criteria of the DSM IV and complying with inclusion and non-inclusion criteria, such as those defined here:

- *Inclusion criteria :* Men and women, at least 18 years old and at most 65 years old, ambulatory, social phobics since least two years and at most 25 years.
- *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 an active medicinal treatment against social phobia that is not stabilized, other kind of psychotherapy).

5.2 Architecture of the study

In an open study we compared two types of treatment – virtual reality therapy and cognitive-behavioral therapy – for ambulatory patients showing a social phobia. Two groups of patients are formed and compared: a "VRT" group and a "CBT" group.

The allocation of patients to one of these two groups was done according to some constraints (more specifically the ability to use computers and virtual reality software) while ensuring of the homogeneity of the two groups in terms of significant criteria (sex and age of the patient, duration and severity of the social phobia estimated by the Liebowitz's scale). We did not retain the principle of randomization because of organization's constraints: the calendar of cognitive-behavioral therapies, the limited number of social phobics, and the calendar of the study.

We worked on the basis of the following hypotheses: The virtual therapy group will improve at least as much as the cognitive and behavioral therapy group.

The study was conducted in the Unité de Thérapie Comportementale et Cognitive (Behavioral cognitive therapy unit) of the Sainte-Anne University Hospital (Professors LOO and OLIE), Paris, and extended over 9 months from September 1, 2002 (first inclusions) to May 31, 2003 (end of treatments).

5.3 Assessments

After the diagnostic assessment (DSM IV criteria of social phobia, co-morbidities, associated medicinal treatment), all the patients fill the self-report scales described below before the first session (pre-treatment assessment) and after the last session (post-treatment assessment).

- Liebowitz Social Anxiety Scale (LSAS) [30]

It is a self-report questionnaire consisting of 24 items that has been used in different studies on social phobias. It is resorted to assess social phobia symptoms. Patient fear or anxiety is rated from 1 (none) to 4 (severe) their avoidance from 1 (never or 0%) to 4 (currently or 68 to 100%) in 24 different situations. Eleven of these situations correspond to social fear or anxiety and 13 to performance fear or anxiety.

- Zigmond and Snaith Hospital Anxiety Depression Scale (HAD) [31]

It is a self-report questionnaire consisting of 14 items. For each of these items, the subject chooses amongst 4 proposed answers ranging from 0 to 3. 7 items explore the patient anxiety level and 7 items the depression level.

- <u>Short Beck Depression Inventory (BDI -13)</u> [32]

This self-report questionnaire estimates the depressive semiology with 13 items. Each item is constituted by four statements corresponding to four degrees of increasing intensity of a symptom. The global score is obtained by adding each item's score and allows to establish four degrees of gravity of the depression (none, mild, moderate, severe).

- <u>Rathus Assertiveness Schedule</u> [33]

It is a self-report questionnaire enabling to measure the degree of assertiveness. 30 items, under the form of assertions concerning the way of behaving in different social situations are proposed. The subject must indicate to which degree these assertions are typical of him/her and selecting one of the 6 possible answers ranging from +3 (really typical) to –3 (really not typical).

- <u>Social Interaction Self Statement Test (French adaptation TAPIS by Cottraux)</u> [34]

This self-report questionnaire estimates the frequency of positive thoughts or negative thoughts arising in the context of social relationships. Each of 30 items is rated from 1 (I almost never have this thought) to 5 (I have this thought very often).

- <u>Questionnaire on social contexts inducing anxiety</u> [10]

This questionnaire enables to establish the typology of the social phobia (focused or generalized phobia, and type of subgroup: performance, assertiveness, intimacy or scrutiny anxiety). For each of these four types of social phobia, the patient should evaluate the degree of her/his anxiety (none, light, strong or extreme).

- <u>Sheehan Incapacity Scale</u> [35]

It consists of a scale assessing the quality of life of the patient and filled by the therapist. It rates the disability according to three dimensions, that is: job, social life/leisure, and family life/home responsibilities. Each of these elements is rated from 0 (no disability) to 10 (very severe disability).

- <u>Clinical Global Impressions (CGI) of the pathology severity</u> [36]

This scale filled by the therapist is based on scales developed by the Early Clinical Drug Evaluation Unit (ECDEU) and assesses the global severity of the social phobia, excluding any co-morbidity. Patients are rated from 1 (normal, not ill) to 7 (amongst the most severely hit). The reference point being the experience the therapist has of this population.

- <u>Clinical Global Impressions of change</u> [36]

This scale is based on scales developed by the ECDEU. It assesses the significance of the patient change relatively to the initial situation. The primary dimension is social phobia excluding any other co-morbidity. Patients are rated from 1 (very clear improvement) to 7 (very clear aggravation). This scale is not used in "pre" but only in "post" and in "follow-up". Two versions of this scale are used. One concerns the assessment of the patient by him/herself and the other by the therapist.

The score obtained on the Liebowitz Social Anxiety Scale is retained as the main criteria for the statistical analysis of the results. The rates on the other scales are considered as secondary criteria.

5.4 Therapeutic group definition

36 patients were included in our study: 18 patients were allocated in the "virtual reality therapy" group (VRT) and 18 patients in the "cognitive behavioral therapy" group (CBT). All the patients were submitted to clinical and psychometric "pre" and "post" assessments.

Each patient of the VRT group attended 12 sessions of virtual therapy. Each session was individual and directed by a cognitive behavioral psychotherapist. During these weekly sessions of 45 min, the patient was exposed to virtual worlds in a purpose of assessment or therapy. The duration of exposure was less than 20 min.

Each patient of the CBT group attended 12 sessions of cognitive behavioral therapy in a group of approximately 8 persons. These weekly sessions of 2 hours were directed by a cognitive behavioral psychotherapist.

5.5 Presentation of the Virtual Therapy

- **Virtual exposure situations**

We selected four exposure situations and we designed four virtual environment story boards. 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:

Story board #1 deals with Assertiveness anxiety, and its objective is "Protecting one's interests, viewpoints, being respected".

Story board #2 deals with Intimacy anxiety, and its objective is "Establishing contacts, next-door neighbor, friends, and small talk".

Story board #3 deals with Observation anxiety, and its objective is "Acting while being observed, being under scrutiny".

Story board #4 deals with Performance anxiety, and its objective is "Speaking in public".

- **Structure of the virtual therapy sessions**

During the first session, the therapist introduces and presents the therapy to the patient. She/he familiarizes with the virtual world and the tools in a neutral environment. The eleven remaining sessions constitute the core of the therapy. They repeat a same structure and use the virtual environments and social situations in the same way. The same virtual environment is used during two consecutive sessions: sessions 2 and 3 with performance, session 4 and 5 with intimacy, session 6 and 7 with scrutiny, and session 8 and 9 with assertiveness. Even sessions consist of an introduction, a clinical interview, a virtual exposure to the environment to assess the patient, a prescription of tasks to carry out between the sessions, and a conclusion of the session. Odd sessions consist of an introduction and the results of the tasks, two virtual exposures to the environment for therapy, a prescription of tasks to carry out between the sessions, and a conclusion of the session.

At the end of each session, the therapist prescribes the patient tasks to carry out in order to apply what was learned during the VR session.

During sessions 10, 11 and 12, after the introduction and the results of the tasks, the patient is exposed to an environment chosen by her/himself, and a conclusion is given.

- **Content of the virtual therapy sessions**

Virtual therapy sessions were conducted according to three modes: "assessment", "spontaneous", and "instructed". The two latter modes correspond to the therapeutic parts.

"Assessment" sessions: During the navigation in the virtual world, the therapist explores the patient's reactions with questions related to:

- The cognitive domain – *What thoughts do you have?* - Assessment concerning a "menace" of the environment; Assessment concerning "resources" to face them.
- The emotional domain – *What do you feel?* - Presence of an emotion; Intensity of the emotion
- The behavioral domain – *What do you do?* - Avoidance or confrontation; Passive or aggressive behaviors

"Spontaneous" sessions: While the story board unfolds, the therapist lets the patient act and move about on his/her own in the world and decides himself/herself which behaviour to adopt.

"Instructed" sessions: During the navigation, the therapist instructs the patient which attitudes are relevant to the situation. The therapist helps the patient learn adapted reactions in relation with Behaviors (Confrontation to a situation, assertiveness), Cognitions (Cognitive therapy), and Emotions (Relaxation).

- **Description of the tasks to carry out between the sessions**

After each session of virtual therapy, the patient should carry out prescribed tasks in order to apply the principles developed and experimented during these sessions, namely Progressive, repeated and prolonged exposure to usually avoided social situations; Development of behaviors adapted to the faced social situations (asserted behaviors and fight against behavioral "micro-avoidance") ; Cognitive work (identification of inappropriate cognitions appearing in social situation and modification of these cognitions).

These tasks are based on the principle of the cognitive and behavioral therapies and allow to practice in vivo what was experienced in a dummy situation (in the virtual world); to facilitate the cognitive behavioral learning process. They are, in their general outline, completely comparable to those prescribed to the patients of the cognitive and behavioral therapeutic group.

5.6 Presentation of the Cognitive Behavioral Therapy

The CBT was carried out with groups of approximately 8 patients. This group format enables to create multiple social situations that may be used during the exposure exercises.

- **Structure of the cognitive behavioral therapy sessions**

During the first session, the therapist introduces and presents the therapy to the patient, then identifies the social situations creating anxiety. All the sessions begin with an introduction and the results of the tasks carried out between the sessions, and end with a prescription of tasks. Sessions 2 to 4 consist of exposure exercises to social situations. In sessions 5 and 6, work on avoidances is added. Sessions 7, 10 and 11 are full situations with exposure exercises, work on avoidances and work on cognitions. During sessions 8 and 9, the patient works only on cognitions. Session 1é, the last one, allows, for each patient, the definition of the medium-term objectives and the elaboration of a personal program. A conclusion is given.

Table 1 presents the comparison between the structure of VRT and that of CBT.

- **Description of the tasks to carry out between the sessions**

These tasks are, in their general outline, completely comparable to those prescribed to the patients of the virtual reality therapeutic group.

Table 1. Structure comparison between VRT and CBT

VRT	CBT
Session 1 Introduction and presentation of the therapy The patient gets familiar with a neutral VE	**Session 1** Introduction and presentation of the therapy Identification of social situations creating anxiety
Session 2 Introduction Virtual exposure to story board 1 for ASSESSMENT Virtual exposure to story board 1 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 2** Introduction Exposure exercises to social situations Prescription of tasks to carry out and session conclusion
Session 3 Introduction and results of the tasks Virtual exposure to story board 1 for THERAPY Virtual exposure to story board 1 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 3** Introduction and results of the tasks Exposure exercises to social situations Prescription of tasks to carry out and session conclusion
Session 4 Introduction and results of the tasks Virtual exposure to story board 2 for ASSESSMENT Virtual exposure to story board 2 for THERAPY Prescription of tasks to carry out and conclusion	**Session 4** Introduction and results of the tasks Exposure exercises to social situations Prescription of tasks to carry out and session conclusion
Session 5 Introduction and results of the tasks Virtual exposure to story board 2 for THERAPY Virtual exposure to story board 2 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 5** Introduction and results of the tasks Exposure exercises to social situations and work on avoidances Prescription of tasks to carry out and session conclusion
Session 6 Introduction and results of the tasks Virtual exposure to story board 3 for ASSESSMENT Virtual exposure to story board 3 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 6** Introduction and results of the tasks Exposure exercises to social situations and work on avoidances Prescription of tasks to carry out and session conclusion
Session 7 Introduction and results of the tasks Virtual exposure to story board 3 for THERAPY Virtual exposure to story board 3 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 7** Introduction and results of the tasks Exposure exercises to social situations and work on avoidances Work on cognitions: identification of one's cognitions Prescription of tasks to carry out and session conclusion
Session 8 Introduction and results of the tasks Virtual exposure to story board 4 for ASSESSMENT Virtual exposure to story board 4 for THERAPY Prescription of tasks to carry out and session conclusion	**Session 8** Introduction and results of the tasks Work on cognitions: modification of one's cognitions Prescription of tasks to carry out and session conclusion
Session 9 Introduction and results of the tasks Virtual exposure to story board 4 for THERAPY Virtual exposure to story board 4 for THERAPY Prescription of tasks to carry out and conclusion	**Session 9** Introduction and results of the tasks Work on cognitions: modification of one's cognitions Prescription of tasks to carry out and session conclusion
Sessions 10 and 11 Introduction and results of the tasks Virtual exposure to one of the story board selected by the patient (deepening) Virtual exposure to one of the story board selected by the patient (deepening) Prescription of tasks to carry out and session conclusion	**Sessions 10 and 11** Introduction and results of the tasks Exposures to social situations and work on avoidances Work on cognitions: modification of one's cognitions Prescription of tasks to carry out and session conclusion
Session 12 Introduction and results of the tasks Virtual exposure to one of the story board selected by the patient Virtual exposure to one of the story board selected by the patient. Conclusion	**Session 12** Introduction and results of the tasks Definition of the medium-term objectives for each patient Elaboration of a personal program for each patient Conclusion

5.7 Forms and recording tools

Each patient who decides to enter the clinical trial receives an information notice which describes and explains the study. Then she/he fills up an agreement form which specifies all the ethical guarantees. The patient is free to leave the study whenever she/he wants.

For each patient of each of the two groups, all the data, the results of the assessments and the events occurring along the therapy are recorded in an Observation Book specially designed for this study and for the therapist.

5.8 Legal disclaimer

This protocol has been submitted to an ethical committee and has been approved in conformity with the French law.

6. The use of Virtual Environments in the clinical protocol

GREYC-ENSICAEN, Caen, France, designed Virtual Environments (VE) to treat Social Phobia, in close collaboration with the clinical team of Sainte-Anne University Hospital, Paris. According to a precise clinical protocol, the purpose of these VE is to expose patients to social situations inducing anxiety [37].

6.1 Technical characteristics of the platforms

6.1.1 The software

The creation of the 3D virtual environments used in the treatment of social phobia required two main software tools for PC:

- A graphic tool, Discreet 3D Studio Max 4, which is a high-performance graphic application for object design, visual effects production, complex 3D worlds creation. Character Studio 3, an extension of 3DS Max offers the possibility of advanced characters creation and animation.

- A behavior-based interactive 3D development tool, Virtools Dev 2.0 Education, which is an authoring application that allows to create interactive, 3D content; that brings to life imported media; that allows the creation of simple media such as cameras, lights, curves, interface elements, and 3D frames. It is a behavioral engine that 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. They can be reusable. Virtools Dev is also a rendering engine that draws the image seen on-screen. Based on information supplied by the behavioral engine, the render engine decides what should be drawn. It is finally a software development kit (SDK) that provides access to the behavioral engine and the rendering engine, which allows, for example, to create and modify behaviors.

6.1.2 The equipment

The environments are running on PC. The files (.vmo) can be viewed with the Virtools Web Player, which can be freely downloaded from the Virtools site (www.virtools.com/downloads/playerie.asp). The system configuration is a PC DELL Dimension 8250, Pentium IV, 2.4 GHz, Windows 2000, Chipset Intel with 533 MHz, 256

MB of DDR RAM with 333MHz, Internet Explorer 5.0, DirectX 7, Monitor color display 17". It is equipped with a sound card, a graphic card nVidia GeForce 4MX AGP 4x, 64MB, and with a 17" monitor.

The patient navigates in the environments using the mouse and the cursor movement keys (up, down, left, right) or a Cyberpuck pad. Resembling a hockey puck, the Cyberpuck is a hand controller which allows the user to navigate the virtual environment with ease as an independent virtual reality controller device, and to interact with the environment.

The virtual worlds are displayed on a large screen monitor. Experiments with a complete immersion can also be conducted. The patient wears a head mounted display (HMD) VFX3D and moves forward or backward with the Cyberpuck pad. The VFX3D is a Virtual Reality System complete with a three degree of freedom tracker for roll, pitch and yaw positioning, standard VGA interface, audio inputs and 360,000 pixel color.

6.1.3 The environments

Four situations have been selected in the protocol and four virtual story boards have been designed. Each one corresponds to a special case of social anxiety and the purpose is to reduce the patient's anxiety in the real situations. Consequently, four virtual environments have been created with the corresponding characters and sounds. A fifth virtual environment was designed, a neutral one, without characters, in which the patient learns how to use the tools, how to navigate. All the instructions are invisible to the patient. The therapist can refer to them in a separate manual.

These virtual environments were born from a close cooperation between the clinical team and the technical team, from a good comprehension of the needs for the ones and possibilities for the others.

- **Environment #0: Training**

Objective: To train the patient to a virtual environment (Figure 1. **Training environment**)

Three rooms with objects such as tables, chairs, bed, pictures on the walls, plant, were created on both sides of a corridor. The patient learns how to move forward, and backward; how to look up, dn, and around; how to open doors; how to sit on a chair in front of a television set.

- **Environment #1: Assertiveness Anxiety**

Objective: the patient learns to protect her/his interests, viewpoints, to be respected (Figure 2. **Assertiveness environment**)

Three main places 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.

- **Environment #2: Intimacy Anxiety**

Objective: the patient learns to establish contacts with neighbors, friends, to have small talk (Figure 3. **Intimacy environment**)

Figure 1. Training environment
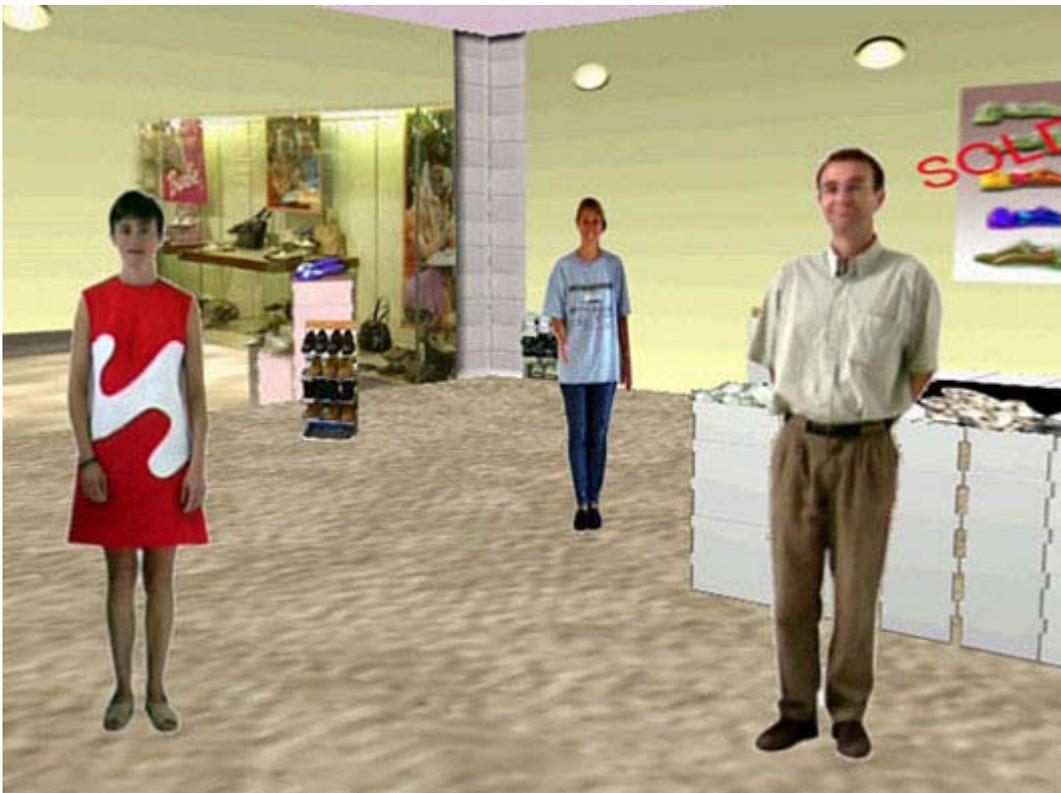
Figure 2. Assertiveness environment

Figure 3. Intimacy environment

The story board 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.

- **Environment #3: Observation Anxiety**

Objective: the patient learns to move, to speak while being under scrutiny (Figure 4. **Scrutiny environment**)

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 should enter the coffee shop, looking 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.

- **Environment #4: Performance Anxiety**

Objective: the patient learns to speak in public (Figure 5. **Performance environment**)

The story board 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 present her/himself, then stand up and walk to a paperboard to expose a subject while everybody is looking on attentively or not.

6.1.4 The media

The Virtools rendering tool imposes constraints on the object models to synthesize images in real time and to allow an interactive navigation.

Figure 4. Scrutiny environment

Figure 5. Performance environment

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.

- **3D Objects models**

The virtual environments are full of *3D Objects models*, which were created in 3DS MAX and exported to a Virtools readable format (.nmo). In 3DS MAX, objects are designed from a mesh, constituted of polygons. More these polygons are small and numerous, better is the sensation of realism, but bigger are the files.

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.

- **3D Sprites**

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.

- **Textures**

The textures are images used to give an element a certain appearance. Realistic textures increase the quality aspect of the environments. However, a trade-off was constantly looked for between the degree of realism and the size of the textures. Attention was paid to their dimensions that should be an integer power of 2 (.tga, .jpg, .png). Although, they are not necessary square.

- **Sounds**

The *sounds* designed in the story boards were recorded in real situations. Attention was paid to the tone of the voices, which had to be gentle, without aggressiveness. We decided to use wav files in order to preserve the quality of the sounds.

We optimized the file size and we stored of all the sounds and some of the 3D Sprites externally to the files. So, for the user, all the files concerning the environment (.vmo, .wav, and some .nmo) have to be in the same folder.

6.1.5 The 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.

- **Patient's representation**

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.

- **Navigation**

The patient navigates in the environments using the mouse and the cursor movement keys (up, down, left, right) or a Cyberpuck pad. The mouse allows the patient to look around, up and down. The cursor movement keys and the pad allow the patient to move forward (up) or backward (down) or to look around (left and right).

Although the Consortium decided that we will propose a non-immersive therapy, 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. A driver allowing the use of the Head Mounted Display VFX3D has been developed.

- **Interaction**

Some of the objects of the virtual environments are interactive, such as doors. The patient can open the doors by click on the mouse or the pad when s/he is close to them, thanks to a test of proximity.

We introduced tests of collisions with walls, objects, characters of the environments. In environment#3 (Scrutiny), the patient does not enter in collision with some tables because these tests would have complicated the navigation of the patient between the tables.

We developed some effects such as the "sitting down effect". When the patient has to sit down on an indicated chair, she/he moves towards the chair and, in the proximity of it, the computer takes charge of the installation of the patient (Intimacy, Scrutiny and Performance).

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, according to the story board. All the navigation and interaction details are provided to the therapist through the manual of Social Phobia.

6.2 Use of the VE in the clinical protocol

6.2.1 Virtual exposure

Exposure to feared social situations is fundamental to obtain an improvement of the anxious symptoms [21]. Traditionally, exposure is carrying out *in* vivo or through imagination of situations. Virtual exposure is based on the same rationale as *in vivo* exposure for its application:

- **Exposure to all phobic situations**

The patient is exposed to all the scenarios which are dealing with assertiveness, scrutiny, intimacy or performance anxiety and at last to those that he/she considers the

most threatening. The therapist can decide to repeat, to prolong or to stop the exposure according to the behavior of the patient.

- ### Work on cognitions and behaviors
In a first step all cognitions and behaviors of the patient during her/his progress in the virtual environment are analyzed with the therapist. Then later, with the help of the therapist the patient will learn new ones more adapted to face the feared situations. This work of the patient on her/himself is prolonged during the tasks she/he has to carry out between the sessions.

- ### Presence and help of the therapist
Patients exposed to social phobic situations are always accompanied by a cognitive and behavioral therapist.

It has been shown that human subjects respond appropriately to negative or positive audiences even when they are completely virtual [24]. So we can assume that social phobic patients will feel anxiety and physiological disorders when they will be confronted to virtual environments related to their illness.

6.2.2 Virtual reality treatment

After the clinical assessment (diagnosis of Social Phobia and check of all the inclusion and non-inclusion criteria), the psychiatrist can propose the Virtual Reality Therapy (VRT) to the patient. A psychologist takes then charge of the patient who is subjected to a battery of psychometric assessments before the treatment begins ("pre" assessment), after the treatment ("post" assessment) and if possible, six months later ("follow-up" assessment).

The patient attends twelve sessions of virtual therapy, spread over three to four months. 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. At the end of each session the therapist prescribes the patient tasks to carry out in order to apply what was learned.

6.2.3 Virtual reality sessions

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 eight next virtual sessions constitute the core of the therapy. After an introduction and a discussion about the tasks carried out, the patient is exposed twice to the same virtual environment in a purpose either of assessment then therapy, either of therapy then therapy. Finally the therapist prescribes the patient tasks and gives a conclusion to the session. During the therapy the patient is exposed to all the environments.

During the last sessions the patient chooses the exposure environment according to her/his specific social phobia for deepening. During session twelve, the last one, a final conclusion is given to the patient.

The virtual reality sessions are conducted according to three phases described in the protocol that are the Assessment phase, and the two therapeutic phases, "Spontaneous" and "Instructed"..

The role of the cognitive behavioral therapist is fundamental in this VR-Based Therapy. The therapist guides the patient through the virtual environments, prescribes

her/him tasks, and receives the patient feedback. It seems that VR reinforces the therapeutic relation between patient and therapist on a collaborative mode.

7. The large-scale clinical trial

7.1 Inclusions evaluation

7.1.1 Inclusion difficulties

The recruitment of the social phobic patients to include in this study was difficult because of several reasons:

- The beginning of the inclusions was related to the approval of the French authority, *Comité Consultatif de Protection des Personnes dans la Recherche Biomédicale* (CCPPRB Paris-Cochin) and to the time schedule of the outpatients' department of Saint-Anne University Hospital, where the Unit of Cognitive and Behavioral Therapy takes place. So we included the first patients in September 2002 and the last one in February 2003 in order to be sure to end the treatments in May 2003. The average duration of treatment is three months. So we had only six months to include the patients.

- Social Phobia is a pathology which is "shamefully" lived by the patients who seldom look for a therapeutic help. Our centre, which is one of the most active in the field of social phobia in France, receives on average two to three new social phobics per week.

- Inclusion and non-inclusion criteria (in particular absence of associated depression, no co-morbidities with other anxious disorders, stabilization of medicinal treatment) forced us to retain only a small percentage of these social phobic patients. The 36 patients, verifying inclusion and non-inclusion criteria, were included in six months, which is about six patients per month.

7.1.2 Inclusion results

In order to preserve the number of patients included in the two therapeutic groups (CBT and VRT), we decided not to place patients in a waiting list and so to carry out a study whose objective is to compare VRT to the validated CBT.
        36 patients were included in the study, 18 patients in the CBT group, and 18 patients in the VRT group.

7.2 Subjects

Subjects were consecutive outpatients seeking treatment at the Unit of Cognitive and Behavioral Therapy of the Sainte-Anne Hospital, Paris, France. The patients constituted a young adult population of 19 females and 17 males (Mean age: 31,6 ±8,3) between the ages of 18 and 65 years. According to the protocol, non inclusion criteria were defined in term of population, pathology and treatment to select the participants.
        The sample was divided in two groups: the virtual reality therapy group (10 females and 8 males; mean age: 30,5 ±5,06) and the cognitive-behavioral therapy group (9 females and 9 males; mean age: 32 ±10,76).

The study received an ethical approval in conformity with the French law. Before starting the trial, the nature of the treatment was explained to the patients who gave a written informed consent.

7.3 Assessments

According to our clinical protocol, pre and post assessments were carried out for all these 36 subjects, first, by a psychiatrist for the diagnostic assessment and the inclusion of the patient, second by a psychologist, for the psychometric assessments.

Once the patient fit the criteria to enter the study, he/she was asked to fill out the following self-report questionnaires:

- Liebowitz Social Anxiety Scale (SAS)
- Zigmond and Snaith Hospital Anxiety Depression Scale (HAD)
- Short Beck Depression Inventory (BDI-13)
- Rathus Assertiveness Schedule (Rathus)
- Social Interaction Self Statement Test (SISST)
- Questionnaire on Social Contexts inducing Anxiety
- Sheehan Incapacity Scale
- Clinical Global Impressions of the pathology severity (CGI)
- Clinical Global Impressions of change

We remind that the score obtained on the Liebowitz Social Anxiety Scale is retained as the main criteria for the analysis of the results. The rates on the other scales are considered as secondary criteria.

7.3.1 Duration of Social Anxiety

On average, the patients show a 15,7 years old disorder (mean (CBT): 16,4 and mean (VRT): 14,5).

7.3.2 Level of Social Anxiety

Liebowitz mean score is 83,9 (mean (CBT): 78 and mean (VRT): 89,7). Our patients show very high level of social anxiety and consequently an established social phobia, which is severe for some of them. This score is higher for the patients of the VRT group.

The two sub-scores of the Liebowitz scales in the VRT group are also higher than those of the CBT group: anxiety sub-score (mean (CBT): 43,7 and mean (VRT): 48,9); avoidance sub-score (mean (CBT): 34,3 and mean (VRT): 40,7).

The two populations are concerned in the same way with regard to the total mean score for the Questionnaire of Social Contexts Inducing Anxiety (mean (CBT): 8,1 and mean (VRT): 8,3) but also for the various sub-scores: Performance sub-score (mean (CBT): 2,4 and mean (VRT): 2,6), Intimacy sub-score (mean (CBT): 1,9 and mean (VRT): 1,7), Assertiveness sub-score (mean (CBT): 1,8 and mean (VRT): 2,1), and Scrutiny sub-score (mean (CBT): 1,9 and mean (VRT): 1,7).

7.3.3 Level of Anxiety

HAD mean score is 10,3 (mean (CBT): 11,8 and mean (VRT): 8,9). This score is higher for the patients of the CBT group.

7.3.4 Level of Depression

BDI-13 mean score (5,5) is relatively low (mean (CBT): 6,3 and mean (VRT): 4,7). It confirms that we do not have a population of depressed patients.

We find again this difference in the HAD depression sub-score (5,7) (mean (CBT):6,2 and mean (VRT): 5,1).

7.3.5 Level of Assertiveness

Rathus Assertiveness mean score (-27,3) is relatively low. The two populations are quite similar (mean (CBT): -26,9 and mean (VRT): -27,8).

7.3.6 Severity of the disease

According to Clinical Global Impressions questionnaire, the two populations appear equally affected (mean (CBT): 4,7 and mean (VRT): 4,8). It shows again that our patients are suffering from an important social phobia.

7.3.7 Handicap

The two populations seem to show same levels of handicap in Sheehan Scale. The handicap in the social field is the higher for the two populations (mean (CBT): 7 and mean (VRT): 7,4), followed by the handicap in the professional field (mean (CBT): 6,2 and mean (VRT): 5,9). The handicap in the family field seems to be lower (mean (CBT): 4,9 and mean (VRT): 4,4).

7.3.8 Conclusion

The studied population is composed of young adults showing an important social phobia, being developed since many years. According to the Liebowitz Scale, the VRT group patients are appreciably more socially anxious than the CBT group patients. However there are fewer differences between the two groups in the other anxiety evaluation criteria.

7.4 Treatment

The patients were allocated to Virtual Reality Therapy group (VRT) or to Cognitive Behavioral Therapy group (CBT) and experienced their therapy as described in *paragraph X.5*. They attended twelve sessions of therapy, spread over three to four months, and directed by a cognitive and behavioral therapist.

The patients of the VRT group attended individual sessions of 45 minutes, which includes 20 minutes of exposure to the virtual environment. As described in *paragraph 5.5*, through the duration of the therapy, the patients were exposed to all the four scenarios, dealing with assertiveness, intimacy, performance or scrutiny anxiety, in a purpose either of assessment, or either of therapy. The assessment phase contains questions to explore the cognitions, the emotions and the behaviors of the patient. The therapeutic phases mix "spontaneous phase" during which the patient moves about freely in the world and decides himself/herself which attitudes to adopt, and "instructed phase" during which 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.

The patients of the CBT group attended sessions of two hours, in a group of eight to ten social phobics. This group format enables to create multiple social situations that may be used during the exposure exercises.

After each session, the patients of the two groups carried out tasks in order to apply the principles developed and experimented during the VRT or CBT sessions. The purpose of these tasks is to practice *in vivo* what was experienced in dummy situations (in the virtual world, or in the therapeutic group), and to facilitate the cognitive behavioral learning process.

7.5 Outcome

We present here results, comparing 18 patients of CBT group to 18 patients of VRT group, after treatment and complete evaluation. All the means and standard deviations for the assessments scores, respectively for the global population and comparing the two therapeutic groups are presented in two tables (Table 2 and Table 3).

Table 2. Mean, standard deviation and evolution LSAS, HAD, BECK-13, Rathus, TAPIS, Sheehan, CGI and Social Contexts inducing Anxiety scores before and after treatment (general population)

	N=36 17 males / 19 females Age = 31,6 (8,3)		
Duration of the disorders	**15,7 years (9,8)**		
	Pre	Post	Delta
LSAS • Anxiety • Avoidance • Total	46,3 (11,12) 37,5 (13,2) 83,9 (23,5)	27,2 (11,4) 18,5 (11,8) 45,5 (22,4)	-19,1 -19 -38,4
HAD • Anxiety • Depression	10,3 (3,9) 5,7 (3,2)	8,4 (3,3) 3,7 (4,2)	-1,9 -2
Beck – 13	5,5 (2,9)	3,5 (2,6)	-2
Rathus	-27,3 (22,9)	-10,8 (26,9)	16,5
Tapis (SISST) • Thoughts + • Thoughts – • Total	36 (6,7) 52,9 (8,3) -16,8 (9,8)	43,1 (6,4) 41,3 (10,1) 3,6 (19,5)	7,1 -11,6 20,4
Sheehan • Family • Social • Professional	4,6 (2,3) 7,2 (1,5) 6,1 (2,6)	2,8 (1,5) 3,9 (1,4) 3 (2,1)	-1,8 -3,3 -3,1
CGI • Gravity • Improvement	4,8 (0,7) 0	3 (1) 2 (0,7)	-1,8 2
CGI • Improvement by the patient	0	2,2 (0,6)	2,2
Social Contexts inducing Anxiety • Performance • Intimacy • Assertiveness • Scrutiny • Total	2,5 (0,5) 1,8 (0,5) 2 (0,7) 1,8 (0,4) 8,2 (1,3)	1,3 (0,5) 0,9 (0,4) 1,2 (0,7) 1 (0,4) 4,5 (1,4)	-1,2 -0,9 -0,8 -0,8 -3,7

Table 3. Mean, standard deviation and evolution LSAS, HAD, BECK-13, Rathus, TAPIS, Sheehan, CGI and Social Contexts inducing Anxiety scores before and after treatment (CBT and VRT groups)

	CBT group (n=18) 9 males / 9 females Age = 32			VRT group (n=18) 8 males / 10 females Age = 30,5		
Duration of the disorders	16,4 years (12,2)			14,5 years (6,8)		
	Pre	**Post**	**Delta**	**Pre**	**Post**	**Delta**
LSAS • Anxiety • Avoidance • Total	43,7 (13) 34,3(13) 78 (25,2)	26,5 (13,1) 17,1 (12,5) 43,5 (24,6)	-17,2 -17,2 -34,5	48,9 (8,3) 40,7 (12,9) 89,7 (20,6)	27,9 (9,7) 19,9 (11,2) 47,6 (20,4)	-21 -20,8 -42,1
HAD • Anxiety • Depression	11,8(3,8) 6,2 (3,2)	9,3 (3,7) 3,9 (4,6)	-2,5 -2,3	8,9 (3,7) 5,1 (3,2)	7,6 (2,7) 3,3 (3,9)	-1,3 -1,8
Beck – 13	6,3 (2,9)	3,7 (2,9)	-2,6	4,7 (2,8)	3,3 (2,3)	-1,4
Rathus	-26,9 (21,4)	-5,9 (27)	21	-27,8 (25)	-15,7 (26,6)	12,1
Tapis (SISST) • Thoughts + • Thoughts – • Total	34,7 (7,2) 54,1 (9,9) -19,3 (11,4)	42,6 (7,3) 41,1 (11,8) 5,2 (25,4)	7,9 -13 24,5	37,3 (6) 51,7 (6,3) -14,3 (7,3)	43,6 (5,6) 41,5 (8,2) 2,1 (11,4)	6,3 -10,2 14,8
Sheehan • Family • Social • Professional	4,9 (2,4) 7 (1,9) 6,2 (2,7)	2,7 (1,8) 3,9 (1,8) 3,2 (2,3)	-2,2 -3,1 -3	4,4 (2,2) 7,4 (0,9) 5,9 (2,5)	3 (1) 4 (0,9) 2,8 (1,9)	-1,4 -3,4 -3,1
CGI • Gravity • Improvement	4,7 (0,8) 0	3,1 (1,2) 2 (0,9)	-1,6 2	4,8 (0,7) 0	2,8 (0,6) 2 (0,5)	-2 2
CGI • Improvement by the patient	0	2,3 (0,7)	2,3	0	2,1 (0 ,4)	2,1
Social Contexts inducing Anxiety • Performance • Intimacy • Assertiveness • scrutiny • Total	2,4 (0,5) 1,9 (0,6) 1,8 (0,7) 1,9 (0,4) 8,1 (1,3)	1,1 (0,6) 1 (0,5) 1 (0,7) 1 (0,5) 4,2 (1,7)	-1,3 -0,9 -0,8 -0,9 -3,9	2,6 (0,4) 1,7 (0,4) 2,1 (0,7) 1,7 (0,4) 8,3 (1,3)	1,4 (0,5) 0,8 (0,3) 1,5 (0,6) 0,9 (0,2) 4,7 (1,2)	-1,2 -0,9 -0,6 -0,8 -3,6

7.5.1 Principal criterion

The level of social phobia of our population, evaluated by the Liebowitz's scale, is considerably reduced, passing from 83,9 to 45,5 (-38,4 points). The two groups know this same improvement. The CBT group passes from 78 to 43,5 (-34,5 points) and the VRT group from 89,7 to 47,6 (-42,1 points).

The two subscores of the Liebowitz's scale know the same positive evolution.

Anxiety subscore in our population varies from 46,3 to 27,3 (-19,1 points) points while avoidance subscore varies from 37,5 to 18,5 (-19). For VRT group, anxiety subscore varies from 48,9 to 27,9 (-21 points) points while avoidance subscore varies from 40,7 to

19,9 (-20,8). For CBT group, anxiety subscore varies from 43,7 to 26,5 (-17,2 points) points while avoidance subscore varies from 34,3 to 17,1 (-17,2).

7.5.2 Secondary criteria

- **Social Anxiety Components**

The progress of the assertiveness level, evaluated with the Rathus scale, is favorable for the whole population (evolution of +16,5 from -27,3 to -10,8): improvement of the CBT group patients (evolution of +21, from -26,9 to 5,9) is a little better than improvement of the VRT group patients (evolution of +11,9, from -27,8 to -15,6).
The evaluation of the social contexts inducing anxiety shows a clear and identical improvement for the two groups: the total score passes from 8,1 to 4,2 for the CBT group patients (-3,9) and from 8,3 to 4,7 for the VRT group patients (-3,6). The improvement of the two groups is very similar in the sub-scores of performance (CBT: -1,2 and VRT: -1,3), intimacy (VRT and CBT : -0,9), assertiveness (CBT: -0,8 and VRT : -0,6) and scrutiny (CBT: -0,9 and VRT: -0,8).

- **Anxiety level**

Anxiety level evaluated by the sub-score of HAD scale shows a slightly higher improvement for the CBT group patients, varying from 11,8 to 9,3 (-2,5) compared to the VRT group patients, varying from 8,9 to 7,6 (-1,3).

- **Depression level**

The general level of depression of our population, measured with the BDI-13 scale, evolves a little, passing from 5,5 to 3,5 (-2). This evolution is of -2,6 for CBT group (from 6,3 to 3,7) and of -1,4 for VRT group (from 4,7 to 3,3).
The depression subscore of the HAD for the whole population varies from 5,7 to 3,7 (-2 points). This evolution is of -2,3 for CBT group (from 6,2 to 3,9) and of -1,8 for VRT group (from 5,1 to 3,3).

- **Handicap**

Improvement of the handicap, evaluated by the Sheehan's scale, is similar for the two groups. We notice: a social handicap decrease of 3,3 points for the global population (from 7,2 to 3,9), of 3,1 points for the CBT group patients (from 7 to 3,9) and of 3,4 points for the VRT group patients (from 7,4 to 4); a professional handicap decrease of 3,1 points for the global population (from 6,1 to 3), of 3 points for the CBT group patients (from 6,2 to 3,2) and of 3,1 points for the VRT group patients (from 5,9 to 2,8); and finally a family handicap decrease of 1,8 points for the global population (from 4,6 to 2,8), of 2,2 points for the CBT group patients (from 4,9 to 2,7) and of 1,4 points for the VRT group patients (from 4,4 to 3).

- **CGI**

According to the evaluation clinically carried out with the two CGI scales, we notice a regression of the gravity of the illness of 1,8 points for the global population (from 4,8 to 3), of 1,6 points for the CBT group patients (from 4,7 to 3,1) and of 2 points for the VRT group patients (from 4,8 to 2,8). Clinical therapist evaluation of the improvement for the whole population is rated to 2, this score being identical for the patients of CBT group and the patients of VRT group.
Patient evaluation of her/his disease improvement is rated to 2,2 for the general population, to 2,3 for the CBT group patients and to 2,1 for the VRT group patients.

7.5.3 Discussion

According to the methodology retained for this study, a statistical analysis of the results was not available, and this, for several reasons:

- No randomization of the patients has been realized. A randomization was impossible within the framework of this study for several practical reasons related to the characteristics of the two types of therapy. The organization of CBT groups is done according to an established calendar scheduled in advance and the patients are included in these groups at the beginning of each program, in other words, two times per year. In the VRT group, we only included patients having some abilities to use a computer or the interfaces.

- Patients number (18 in each therapeutic group) was not enough to give a statistical significativity to the obtained results. By retaining the score obtained on the Liebowitz Social Anxiety Scale (LSAS) as the main criteria for the statistical analysis of the results, and according to the evolution of this scale during the therapy, we should have included 90 patients in each group to statistically exploit the collected data.
In addition, evaluations have only been carried out "before" and "after" treatment. Follow-up evaluations (6 months after the end of the treatment)) are in progress and are not presented in this study.

However a clinical analysis of the results can be clearly made. It reveals several significant points:

- We included in the study patients showing high levels of social phobia, and not having a simple light or average social anxiety.

- According to the principal criterion, that is LSAS total score, but also anxiety and avoidance LSAS sub-scores, patient's improvement is approximately the same in the two groups, VRT and CBT. At first the two populations did not seem perfectly homogeneous in term of inclusion. Patients of the VRT group seemed to be more socially anxious than those of the CBT group. However, the positive results observed for VRT group, slightly higher than those of the CBT group, are very interesting, insofar as patients of VRT group were more severely social phobics than those of CBT group.

- For the secondary criteria, all in all, VRT patients show the same improvement as CBT patients. It is thus the case for the SISST, the Rathus scale or the Questionnaire of Social Contexts inducing Anxiety, even if the improvement seems a little better for the patients of CBT group.

- The weak variations of depression assessment, observed before and after treatment, does not have much value, insofar as these evolutions are weak and that, at the beginning, the depression levels were very weak.

- Patients handicap evaluation in the three fields (family, social and professional) shows a favorable evolution that is completely clinically comparable for the two groups.

- The same observation can be made with CGI measurements (improvement, gravity) where, all in all the two groups positively evolve in a very similar way.

Regarding the therapeutic care of the VRT group patients, we found a good observance of the treatment. The patients came to all the sessions. According to our clinical experience with social phobics, we usually notice that patients often miss some sessions, which was not the case here with the VRT group. The patients underlined the "playful" aspect of the therapy, which may probably and partially explain this good observance. The patients reacted to the virtual environments in a way similar to that of their *in vivo* experiments.

When they were facing the feared virtual situations, they felt discomfort, anxiety or shame. Physiological manifestations appeared, such as blushing. We can suppose that an improvement of the quality of the virtual worlds could increase this impression of realism and presence during the virtual exposure sessions. VRT allowed the therapist to control the exposure to stimuli inducing anxiety (e.g. variations of the stress situations, addition of new sources of stimuli, etc.) better than in the *in vivo* exposure sessions.

Despite these good results among patients having followed the virtual reality treatment, we must be very careful in the results interpretation (but it's also the case for the patients having followed the traditional CBT). Many therapeutic components go along with the used treatment process. There is certainly the regular and repeated exposure to the virtual environments, but there is also the presence of the therapist who guides the patient and works with him/her in order to modify her/his behavioral and cognitive reactions.

Moreover, the patients of the two groups have carried out some tasks between their therapeutic sessions, in order to apply the principles developed and experimented during the sessions. For these reasons, it is difficult to conclude which of all these ingredients explains the improvement of the patients.

8. Conclusion

The main goal of Vepsy Updated was to prove the technical and clinical viability of using portable and shared Virtual Reality systems in clinical psychology. One of the selected disorders was Social Phobia, an anxiety disorder that has long been ignored and that is, since fifteen years, the object of an intensive research.

We defined a very precise clinical protocol and 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.

We sketched four scenarios fitting the cognitive behavioral 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.

We observed from the results of our small-scale clinical trial and previous studies that the patients reacted to the virtual environments in a way similar to that of their *in vivo* experiments in most cases. They 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 other physical feelings may appear.

In the large-scale clinical trial, we carried out a pilot study comparing a virtual reality therapy with a cognitive-behavioral therapy for social phobics patient. To our knowledge, it is the first study including patients suffering from a severe social phobia (and not a simple isolated fear to speak in public) and based on varied social environments,

corresponding to the various forms of social anxiety (and not only on the public environment). Even if the format of this study has not allowed a statistical analysis of the results, we noted in the two groups of treatment a significant clinical improvement.

According to the principal criterion, the patients of VRT group, initially the most anxious, showed a more significant reduction of their social anxiety than the patients of CBT group. Clinically improvement is similar for the two groups with regard to the other psychometrics criteria.

These encouraging results agree entirely with the published studies related to the treatment of phobic disorders by virtual reality. However it will be necessary to lead other studies to conclude about the efficacy of VRT in social phobia, by carrying out a randomization of the patients, by including a sufficient number of patients to allow a statistical analysis and by carrying out follow-up evaluations of the treatments.

The Social Phobia Module could be improved and expanded. Here are some development directions we suggest:

- Improve the designed worlds and extend the virtual worlds to other social situations;
- Introduce richer avatar behaviors
- Introduce some other techniques, like video
- Improve the management of the patient's database and follow-up, and its user-interface.
- The trials have been done with a virtual protocol only. A further investigation could consider its integration in the traditional cognitive behavioral treatment.

As a summary of our achievements so far, the design of the protocol to address social phobia troubles involved the contribution of psychologists/psychiatrists, computer scientists, and graphic artists. We implemented it in close collaboration and with a constant feedback between the members of the teams. We tested it and reported our preliminary results through conference communications. Our provisional conclusion is that virtual environments are likely to be efficient in the treatment of social phobia.

Following our demonstrations and communications, we received demands from medical teams to replicate our approach and to build specific environments for other diseases. These teams would like to use the methods we designed or to adapt the virtual worlds to Parkinson disease, multiple sclerosis, or aging. We take it as a very rewarding appreciation that opens significant perspectives to Vepsy.

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