Virtual Reality Therapy Versus Cognitive Behavior Therapy for Social Phobia: A Preliminary Controlled Study

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ABSTRACT

Social phobia is one of the most frequent mental disorders and is accessible to two forms of scientifically validated treatments: anti-depressant drugs and cognitive behavior therapies (CBT). In this last case, graded exposure to feared social situations is one of the fundamental therapeutic ingredients. Virtual reality technologies are an interesting alternative to the standard exposure in social phobia, especially since studies have shown its usefulness for the fear of public speaking. This paper reports a preliminary study in which a virtual reality therapy (VRT), based on exposure to virtual environments, was used to treat social phobia. The sample consisted of 36 participants diagnosed with social phobia assigned to either VRT or a group-CBT (control condition). The virtual environments used in the treatment recreate four situations dealing with social anxiety: performance, intimacy, scrutiny, and assertiveness. With the help of the therapist, the patient learns adapted cognitions and behaviors in order to reduce anxiety in the corresponding real situations. Both treatments lasted 12 weeks, and sessions were delivered according to a treatment manual. Results showed statistically and clinically significant improvement in both conditions. The effect-sizes comparing the efficacy of VRT to the control traditional group-CBT revealed that the differences between the two treatments are trivial.

INTRODUCTION

ACCORDING TO THE DSM-IV[1] and the CIM 10,[2] 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.[3,4] Put another way, social phobia is the marked, and persistent fear, and anxiety of being judged and evaluated negatively by other people, leading to feelings of inadequacy, embar-

rassment and humiliation. There are at least two broad subtypes of social phobia, *specific* social phobia (e.g., limited to the fear of a small number of situations such as speaking in public, or playing a musical instrument in a concert), and *generalized* social phobia (e.g., fear in almost all social situations). It is much more common for people with social phobia to have a generalized type. When anticipatory anxiety, worry, indecision, depression, embarrassment, feelings of inferiority, and self-blame are involved across most life situations, a generalized

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form of social phobia is usually at work.[5] A hierarchical classification of social anxiety has been proposed,[6] with four domains of fear: performance anxiety (speaking in public), intimacy anxiety (establishing contacts, small talk), assertiveness anxiety (protecting one's interests, view points, being respected), and observation anxiety (acting while being under scrutiny).

Some epidemiological studies estimated the lifetime prevalence of social phobia among the adult population to be between 2% and 4%.[7,8] According to the National Comorbidity Survey (NCS)[9] the 12-month and life-time prevalence of social phobia could be as high as 8% and 13%, respectively. This disease, which is one of the most frequent mental disorders, generally appears between the ages of fifteen and twenty and is about equally distributed in women and men (11% among males, and 15% among females according to the NCS).

People with social phobia usually experience significant emotional distress accompanied by physiological manifestations that may include intense fear, racing heart, blushing, excessive sweating, dry throat and mouth, trembling, difficulty swallowing, and muscle twitches, particularly about the face and the neck. This disorder is often accompanied by significant social disabilities and exposes the subject to severe complications such as depression, suicide, and alcoholism.[10]

Cognitive behavior therapy (CBT) is among the treatments of choice for social phobia.[11,12] CBT is believed to act in three different ways[13]: (a) through a regular and prolonged confrontation of the subject to anxiety-producing social situations (exposure therapy), (b) through a modification of the subjects thoughts and of his/her assessments of social situations (cognitive therapy), and (c) through the learning of more efficient relational behaviors (assertiveness therapy). Researchers have not yet been able to determine which of these three components is the most efficient to reduce social anxiety. However, it seems that exposure to the feared social situations, especially if the subject learns how to modify his/her thoughts and certain of his/her behaviors, is fundamental to obtain improvement of the anxious symptoms.[4] Traditionally, exposure therapies are done either *in vivo* (the subject is confronted to real social situations) or by imagining them. This latter procedure is often carried out when a confrontation to real situations is difficult to achieve, with the major drawback of reproducing situations imperfectly.

Virtual reality (VR) is a human–computer interaction paradigm, in which users are 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 close to their natural counterpart.[14] This technique attempts to mock *in vivo* exposure. Eliminating many constraints of the real world, VR seems to bring significant advantages by allowing exposures to numerous situations through the creation of a strong feeling of presence in the situation.[15]

One significant asset of virtual reality is the possibility for the therapist to control 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 participant. It is not always the case during *in vivo* exposure for social phobia, where it can be difficult to obtain adequate and controlled social interactions. Virtual exposure can be a useful intermediate step for social phobics. Moreover, the therapy is being carried out in the therapist's office, which preserves confidentiality.[16]

Several controlled studies already confirmed the efficiency of virtual exposure for phobic disorders such as acrophobia,[17] flying phobia,[18] arachnophobia,[19] or agoraphobia.[20] Two studies have investigated the efficacy of virtual reality therapy in the treatment of the specific anxiety subtype of social phobia, more precisely the fear of public speaking.[21,22] North et al. compared virtual reality therapy (VRT) ($n = 8$) to a control condition ($n = 8$). Participants were all diagnosed with the specific phobia of public speaking. The VRT condition was exposed to a virtual reality public scene, a virtual lecture theatre with a large audience, and guided to manage their phobias. Participants in the control condition were exposed to a trivial virtual reality scene and were advised by the experimenters to manage their fear and expose themselves on their own, without any systematic treatment program. The treatment was carried out through five weekly sessions, each lasting 10–20 min. A variety of outcome measures were used, from questionnaires (e.g., Attitude Towards Public Speaking Questionnaire and Subjective Units of Disturbance) to gain objective measures such as heart rate. A series of paired *t*-tests indicated that the six participants who completed the VRT treatment condition showed significant improvement after 5 weeks of treatment, while no meaningful changes were noticed in the control condition. Based on these analyses, the authors concluded that VRT was successful to reduce fear of public speaking.

From the same research team, Harris et al. selected fourteen university students and assigned them to two conditions: VRT individual treatment ($n = 8$) and waiting list (WL) ($n = 6$). The VRT

condition was exposed to a virtual auditorium scene. The treatment was delivered by a therapist in four weekly sessions, each lasting 12–15 min. Assessment measures included four self-report inventories, Subjective Units of Discomfort during exposure to VRT, and physiological measures of heart rate during speaking tasks. Results of the VRT condition indicated that the treatment sessions were effective in reducing public speaking anxiety in university students on most measures, but not only on the measure addressing social phobia (Liebowitz Social Anxiety Scale [LSAS]).[23] In addition, when compared to the waiting list, the only significant improvement was on the Personal Report of Confidence as a Speaker.

These two interesting and valuable studies dealt with the fear of public speaking, which represents a less severe subtype of social phobia. These studies did not pretend to aim at social phobia, as suggested by the facts that their participants were not diagnosed as social phobics, the treatment did not target general social phobia issues, and the outcomes did not extend to social phobia symptoms measured with the LSAS. However, there is one published single-case study where VR was used with social phobics.[24,25] In this article, a virtual environment designed for the fear of public speaking was integrated into a CBT treatment delivered to two females suffering from social phobia. Clinical and self-report data were gathered prior to, during, and after the treatments. Based on clinical observations and comparisons with other published outcome studies, the treatment was considered effective. Other research teams are also working on VR treatment designed specifically for social phobias,[26,27] but outcome data have not been reported yet.

The originality of the present study is to take into account the diversity of social situations that could potentially induce anxiety and to assess the efficacy of virtual reality exposure for social phobics. This paper and its statistical analyses represent a new step in the use of our collected data.[28,29] The objective of this study is to assess the efficacy of VRT compared to validated psychological treatment (CBT).

MATERIALS AND METHODS

This comparison between VRT and CBT was conducted in the Unité de Thérapie Comportementale et Cognitive (Behavior and Cognitive Therapy Unit) of the Sainte-Anne University Hospital (Professors Loo and Olié) in Paris and received ethics approval from the French authority (Comité Consultatif de Protection des Personnes dans la Recherche Biomédicale, CCPPRB Paris-Cochin).

The study is based on a pre-post design where the control condition is a standard treatment. Given that effective treatment is already available for social phobia, a traditional control condition such as a placebo was deemed not ethically acceptable. In such circumstance, a reasonable compromise is to compare the new treatment with a gold standard treatment. This approach has already been used successfully in VR research.[17] Given the already high success rate of traditional group–CBT, the strategy favoured in the present study is to use effect size to predict the magnitude of the differences between the two treatment approaches, and then to estimate the importance of these differences, if any.

Sample

Participants were the first 36 consecutive outpatients referred to our clinic, meeting the inclusion and exclusion criteria. Participants in the two conditions were matched based on the following variables: gender, age, duration, severity of social phobia (estimated by the LSAS), ability to use computers or virtual reality software, and time availability for some groups that were already prescheduled. After matching, the sample consisted of 18 participants in the VRT group (10 females and 8 males; mean age, 30.5 ± 5.06) and 18 in the CBT group (9 females and 9 males; mean age, 32 ± 10.76). On average, the participants have been suffering from social phobia for 15.7 years (mean CBT: 16.4; mean VRT: 14.5).

During a psychiatric interview, all participants received a principal diagnosis of social phobia according to DSM-IV's[1] diagnostic criteria. Participants were selected only if they met the following *inclusion criteria*: ambulatory men and women, at least 18 years old and at most 65 years old, satisfying the diagnostic criteria of social phobia, during a psychiatric interview, suffering from social phobia for at least 2 years and at most 25 years. In addition, participants had also to comply with all the following *exclusion criteria,* set *a priori*. They were excluded if (a) they were pregnant women, (b) currently suffering from a severe organic disease (e.g., dementia, mental retardation, schizophrenia, amnesia, psychosis, bipolar disorder, or borderline personality), (c) they were unable to move and to participate actively to the study, (d) their social phobia was secondary to any DSM-IV Axis-III diagnosis, (e) they have suffered at any time in the last 6 months from a concomitant panic disorder

with or without agoraphobia, or agoraphobia, (f) they were currently suffering from a major depressive episode (according to DSM-IV criteria), rated 10 or more on a brief 13-item version of the Beck depression scale, or were highly suicidal, (g) were currently taking medication for their social phobia, except if this treatment has been stabilized for at least 2 months and the social phobia remained stable and uncured, (h) they have been non-responding to a previous CBT, and (i) they were attending in parallel any other kind of psychotherapy.

In terms of comorbidity, specific phobia was diagnosed in one person in each group, as it was the case also for obsessive-compulsive disorder. Symptoms of major depression were found in nine participants in the VR condition and in 11 participants in the group-CBT condition, but not severe enough to reach the exclusion criteria.

Measures

Selection of participants. The Short Beck Depression Inventory (BDI-13)[30] estimates depressive symptoms with thirteen 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 it allows to establish four degrees of severity of the depression (none, mild, moderate, severe). It was used essentially to exclude potentially depressed participants.

Primary outcome measure: social phobia. The Liebowitz Social Anxiety Scale (LSAS)[23] is a self-report measure consisting of 24 items that has been used in most of the recent studies on social phobias. Eleven of these situations correspond to social interactions fear or avoidance and thirteen to performance fear or avoidance. It is resorted to assess social phobia symptoms. Participant fear or anxiety is rated from 1 (none) to 4 (severe); their avoidance from 1 (never, or 0%) to 4 (currently, or 68–100%) in 24 different situations. A total score is obtained, as well as fear and avoidance subscores.

Secondary outcome measures: social functioning. The Rathus Assertiveness Schedule[31] is a self-report that measures social assertiveness. Thirty 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 or her and select one of the six possible answers ranging from +3 (really typical) to –3 (really not typical). The Questionnaire on Social Contexts Inducing

Anxiety[7] enables one 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 participant should evaluate the degree of her/his anxiety (none, light, strong, or extreme). A score is obtained for each subscale.

Tertiary outcome measures: general functioning. The Zigmond and Snaith Hospital Anxiety Depression Scale (HAD)[32] is made of fourteen items. For each of these items, the subject chooses amongst four proposed answers ranging from 0 to 3. Seven items explore the participant anxiety level and seven items the depression level. The Sheehan Incapacity Scale[33] is assessing participant's quality of life and is filled by the therapist. It rates disability according to three dimensions: work, social life/leisure, and family life/home responsibilities. Each of these elements is rated from 0 (no disability) to 10 (very severe disability). The Clinical Global Impressions Scale (CGI) of the pathology severity[34], filled by the therapist, is based on a scale developed by the Early Clinical Drug Evaluation Unit (ECDEU) and assesses the global severity of the social phobia, excluding any co-morbidity. Participants 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.

Treatment

Virtual reality therapy.

Each participant of the VRT condition attended 12 sessions of virtual therapy.[35] Each session was individual and directed by a cognitive behavior therapist. During these weekly sessions of 45 min, the participant was exposed to virtual environments either for assessment or therapy. The duration of the virtual exposures lasted less than 20 min.

Five virtual environments (VE) were designed by GREYC laboratory, Caen, France,[36] in close collaboration with the clinical team of Sainte-Anne Hospital in Paris.[37] Four situations have been selected and four virtual storyboards have been designed. Each one corresponds to a specific case of social anxiety: assertiveness anxiety (protecting one's interests, viewpoints, being respected), performance anxiety (speaking in public); intimacy anxiety (establishing contacts, next-door neighbor, friends, and small talk), and observation anxiety (acting while being observed, being under scrutiny).[38]

Their purpose is to reduce the participant's unease in the corresponding real situations. They are all exposure environments, based on the retained storyboards, with the corresponding virtual humans and sounds. The fifth VE is a neutral environment, without virtual humans, destined for training. The virtual humans in our environments are *3D Sprites*, for example, simple plain surfaces used to simulate single quad objects with textures that can be constrained on one axe to always face the camera. Real persons were filmed in daily life situations via a digital video camera. These 3D virtual environments were created using two main software tools for PC: a graphic tool (Discreet 3D Studio Max 4) for 3D object design, visual effects production, and complex 3D world creation, and a behavior-based interactive 3D development tool (Virtools) for rendering, management of behaviors, navigation, and interactivity. According to the VEPSY[39] project constraints (www.vepsy.com), the environments were designed to run on ordinary PCs, equipped with a high-quality graphic card. They can be viewed with the Virtools Web Player, which can be freely downloaded from the Virtools site www.virtools.com/downloads/playerie.asp. The user navigated in the environments and interacted with objects using a mouse, arrow keys of the keyboard or a Cyberpuck. The virtual environments were displayed on a large monitor screen.

Neutral environment: Training. The user learns to navigate in a virtual environment. Three rooms with objects such as tables, chairs, bed, and pictures on the walls were created on both sides of a corridor. The user learns how to move forward and backward, how to look up, down and around, how to open doors, and how to sit on a chair in front of a television set.

Environment 1: Performance Anxiety. The user learns to speak in front of a public audience (Fig. 1). The storyboard takes place in a meeting room where the user joins seven other participants who are already sitting and speaking around a big table. First the user should reach an available chair at the table, and after the arrival of the director, she or he should present himself or herself, then stand up and walk to a paperboard to expose a subject while everybody is looking on, attentively or not.

Environment 2: Intimacy Anxiety. The user learns to establish contacts with neighbors, friends, and to have small talk (Fig. 2). 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 user with four other people. The user should introduce him/herself, talk about the decorations, and answer questions when all the guests are around the table.

Environment 3: Scrutiny Anxiety. The user learns to move and have small talk while being under scrutiny of unknown people (Fig. 3). The user walks from a street lined with trees to a square, and to outside of a coffee shop. Many people are looking at him or her, sitting on benches, at the tables, or standing up. The user should enter the coffee shop, looking for a friend, then go out and reach for

FIG. 1.   Performance environment.

FIG. 2. Intimacy environment.

a chair left available next to his or her friend who has just arrived and engage in conversation with him. The waiter will come to take the order, then to collect the bill. There will be a mistake in the bill. In all the situations, the user will feel as though they are under scrutiny.

Environment 4: Assertiveness Anxiety. The user learns to protect his/her interests, viewpoints, and to be respected (Fig. 4). Three main places were created: upstairs, an elevator with two persons who can criticize the user, downstairs, a hall with three people who block the exit way, and a shoe store with a director and two assistants who will try, repeatedly, to sell shoes to the user. Between the hall and the shoe store, the user can also navigate in a

street where people are standing or sitting on benches.

Virtual Therapy unfolding. The 12 sessions of VRT unfold as follows:

Session 1: During this initial session, the therapist introduces and presents the virtual therapy to the participant. The participant familiarizes with the virtual world and the tools in a neutral environment.

Sessions 2–9: Two sessions are devoted to each of the four virtual environments, previously described, for a total of eight sessions. For each of the virtual environments, the first session begins with an "assessment" of the participant in

FIG. 3. Scrutiny environment.

FIG. 4. Assertiveness environment.

this world. Then it goes on with the "therapy," consisting of exposing the patient to the virtual environment. The second session unfolds with two phases of "therapy" exposure to the environment.

Sessions 10–12: These three sessions are devoted to deepening work with one or two previously explored virtual environments which are the closest to the participant's difficulties. The 12th session also gives a conclusion to the therapy, with the definition of a personal program to carry out beyond the therapy.

"Assessment" exposure. During the unfolding of the story board, the therapist explores the participant's reaction with questions related to the cognitive domain ("What thoughts do you have?": assessment concerning a threat in the environment and coping strategies), to the emotional domain ("What do you feel?": presence and intensity of emotions), and to the behavioral domain ("What do you do?": avoidance or confrontation, passive or aggressive behaviors).

"Therapy" exposure. This exposure may be "spontaneous," the therapist letting the participant act and move about on his/her own in the world and decide himself or herself which behavior to adopt, or it may be "guided" under the therapist's instructions. During guided exposure, the therapist instructs the participant which attitudes are relevant to the situation. The therapist helps the participant learn adapted reactions in relation with behaviors (confrontation to a situation, assertiveness), cognitions (cognitive restructuring), and emotions (simple relaxation techniques).

Cognitive-behavior therapy.

Each participant of the CBT condition attended 12 sessions of CBT in groups of approximately eight people. These weekly 2-h sessions were directed by a cognitive behavior therapist over 3–4 months. The group format allows to create multiple social situations, likely to be used during further exposure exercises (tasks between the sessions).

The 12 sessions of therapy unfold as follow:

Session 1: During this initial session, the participant makes acquaintance with the other members of the group. The principle of the therapy is presented, and the participants identify the social situations inducing anxiety.

Sessions 2–4: During these sessions, the participants are exposed to social situations inducing anxiety. This progressive, repeated and prolonged exposure is carried out thanks to exercises or play roles. The social situations are either "face-to-face with participants," or speaking in front of the members of the group.

Sessions 5 and 6: During these sessions, the participants are exposed to the social situations inducing anxiety, but they also learn to counter the "micro-avoidances" or safety-seeking behaviors they adopt in these situations to protect themselves.

Sessions 7–11: Through exercise and exposure play roles to social phobic situations, the components of the cognitive therapy are introduced: identification of current cognitions, underlining the role of cognitions in the apparition of anxious emotions, and cognitive restructuring.

Session 12: Conclusion of the therapy with, for each participant, the definition of a personal program to carry out beyond the therapy.

Description of the tasks to carry out between the sessions. After each session of virtual therapy or after each session of group CBT, the participants should carry out prescribed tasks in order to apply the principles developed and experimented during these sessions, namely: (a) progressive, repeated, and prolonged exposure to usually avoided social situations, (b) development of behaviors adapted to the faced social situations (asserted behaviors and fight against behavioral "micro-avoidance"), and (c) cognitive work (identification of inappropriate cognitions appearing in social situation and modification of these cognitions). These tasks are based on CBT principle and allow to practice *in vivo* what was experienced in sessions to facilitate cognitive behavior learning processes.

Statistical analyses

To prevent inflation of the Type I error, Bonferroni's adjustments were applied to families of hypotheses. Three families of hypotheses were tested with significance levels fixed *a priori*: (a) *primary variable,* social phobia (as measured with the total score of the LSAS and its subscales), with a significance level of 0.05/3, (b) *secondary variables,* social functioning, with a significance level of 0.05/5, and (c) *tertiary variables*, general functioning, with a significance level of 0.05/6. All three families of hypotheses were tested using repeated measures ANOVAs (2 Conditions $\times$ 2 Times). The Huynh-Feldt *F* ratio was used since it is corrected with the ϵ index of sphericity. On two occasions, the condition by time interaction was affected by a lack of variance and the ANOVA provided an exact statistic of zero. Raw data were re-examined to confirm the situation and the interactions were analysed with a non-parametric Mann-Whitney test conducted on pre-post difference scores.

Given our hypotheses and the use of a gold-standard control condition, the results will also include the effect-size of the Condition by Time interactions and estimates of the importance of these differences.[40] Power analyses were conducted by using the partial η^2 provided by SPSS for each effect and by interpreting these values with tables from Cohen for *f*, qualitative interpretation of effect-size, and expected number of participants required to test the hypothesis with a power of 0.80 and an α fixed at 0.05. This level of significance was selected

TABLE 1. MEANS AND STANDARD DEVIATIONS ON THE OUTCOME MEASURES FOR PARTICIPANTS RECEIVING VIRTUAL REALITY THERAPY (VRT) OR COGNITIVE BEHAVIOR THERAPY (CBT)

	VRT condition (n = 18)		CBT condition (n = 18)	
	Pre	*Post*	*Pre*	*Post*
Liewbowitz Social Anxiety Scale (LSAS)				
Anxiety	48.9 (8.3)	27.9 (9.7)	43.7 (13)	26.5 (13.1)
Avoidance	40.7 (12.9)	19.9 (11.2)	34.3(13)	17.1 (12.5)
Total	89.7 (20.6)	47.6 (20.4)	78 (25.2)	43.5 (24.6)
Assertiveness (Rathus)	−27.8 (25)	−15.7 (26.6)	−26.9 (21.4)	−5.9 (27)
Social Contexts Inducing Anxiety (SCIA)				
Performance	2.6 (0.4)	1.4 (0.5)	2.4 (0.5)	1.1 (0.6)
Intimacy	1.7 (0.4)	0.8 (0.3)	1.9 (0.6)	1 (0.5)
Assertiveness	2.1 (0.7)	1.5 (0.6)	1.8 (0.7)	1 (0.7)
Scrutiny	1.7 (0.4)	0.9 (0.2)	1.9 (0.4)	1 (0.5)
Total	8.3 (1.3)	4.7 (1.2)	8.1 (1.3)	4.2 (1.7)
Hospital Anxiety and Depression (HAD)				
Anxiety	8.9 (3.7)	7.6 (2.7)	11.8 (3.8)	9.3 (3.7)
Depression	5.1 (3.2)	3.3 (3.9)	6.2 (3.2)	3.9 (4.6)
Sheehan				
Family	4.4 (2.2)	3 (1)	4.9 (2.4)	2.7 (1.8)
Social	7.4 (0.9)	4 (0.9)	7 (1.9)	3.9 (1.8)
Work	5.9 (2.5)	2.8 (1.9)	6.2 (2.7)	3.2 (2.3)
Clinical Global Impression (CGI)	4.8 (0.7)	2.8 (0.6)	4.7 (0.8)	3.1 (1.2)

TABLE 2.   RESULTS OF REPEATED MEASURES ANOVA AND EFFECT SIZES FOR
THE TWO TREATMENT CONDITIONS ($n = 36$)

	ANOVA (df = 1,34)			Effect size of the interaction		
Variables	Time	Condition	Interaction	Interaction eta squared	Effect size	Estimated N to find a significant difference
LSAS						
Anxiety	146.71***	0.96	1.43	0.04	Small	>200
Avoidance	123.94***	1.50	1.12	0.03	Small	>300
Total	147.34***	1.30	1.41	0.04	Small	>300
Rathus	36.30***	0.46	2.66	0.07	Medium	120
SCIA						
Performance	178.36***	2.72	0.088	0.003	Very small	>3,000
Intimacy	174.08***	1.24	(0)[a] 161[b]	0[a]		
Assertiveness	65.77***	3.29	0.81	0.02	Small	>350
Scrutiny	77.27***	1.04	(0)[a] 155[c]	0[a]		
Total	437.32***	0.80	0.39	0.01	Small	>800
HAD						
Anxiety	11.94***	4.96*	1.11	0.03	Small	>300
Depression	6.46*	0.66	0.10	0.003	Very small	>3,000
Sheehan						
Family	34.43***	0.01	1.50	0.04	Small	>200
Social	145.36***	0.40	0.23	0.01	Small	>800
Work	97.29***	0.21	0.01	0.00	Very small	>3,000
CGI	97.46***	0.12	0.58	0.02	Small	>350

*$p < 0.05$.
***$p < 0.001$.
[a]Due to an extreme lack of variance between the two conditions, the ANOVA provided an exact statistic of 0.
[b]A non-parametric Mann-Whitney test was performed and was far from significant (exact p value of 0.99).
[c]A non-parametric Mann-Whitney test was performed and was far from significant (exact p value of 0.84).

to provide a fair estimate of the impact of the treatment for each variable as if it were the main outcome variable.

RESULTS

Descriptive data are reported in Table 1 for all instruments, and results of the statistical analyses are reported in Table 2. On the LSAS, the primary outcome measure, the participants showed at pretreatment a very high level of social phobia, both on the total score and on the subscales. The significant time effect revealed that both treatments were highly effective to reduce social anxiety and social avoidance. The differences in efficacy between VRT and group-CBT were not significant. Based on the

interactions' effect sizes, it is reasonable to consider the difference between both treatments as trivial. To illustrate the matter further, the sample necessary to allow such interactions to be significant would have to be larger than 200 participants. With such a sample, and if the results were the same as those obtained by the participants in the current study, the analyses would suggest that VRT would be more effective than group-CBT.

The secondary outcome measure consisted of more general social functioning such as assertiveness (Rathus) and four social contexts inducing anxiety (SCIA). Both measures revealed a strong and statistically significant improvement after both treatments. On the Rathus assertiveness scale, the difference between VRT and group-CBT was not significant, but the power analyses revealed a

medium effect size. A much larger sample would still be required to detect a significant difference, but a medium effect might be clinically significant in some cases.

Moreover, this effect would be in favor of group-CBT compared to VRT. The treatment had a significant impact on the SCIA total score and all subscales. The effect size analyses could not be reliably performed on two subscales (intimacy and assertiveness) since the treatment had an impact so similar in both conditions that the ANOVA almost revealed a total lack of difference. Alternative non-parametric analyses confirmed the extremely strong similarities between both conditions (an average change score of 0.89, with SD of 0.32 and 0.47, respectively, for the VRT and the group-CBT conditions).

Analyses of the tertiary measures revealed that general functioning improved significantly after treatment on all measures except on the depression subscale of the HAD. The reduction of depression scores on the HAD reached the traditional 0.05 significance level. This should not be regarded as significant in the light of the number of measures administered. The scores were already rather low (as expected given the exclusion criteria), and the power analysis showed that their reduction was very similar in both treatment conditions. Improvement on the anxiety subscale of the HAD, as well as on the subscales of the Sheehan and on the CGI were very similar in both conditions. Participants in the CBT condition scored higher on the anxiety subscale of the HAD. Given this difference, covariate analyses of variances were performed on the other outcome measures. These reanalyses did not affect the interpretation of the results.

CONCLUSION

The aim of this study was to assess the efficacy of virtual reality exposure for adults suffering from social phobia. Some of its interesting features were the selection of a sample composed of young adults showing clinically significant and lasting social phobia, the use of virtual environments that tackle diverse social situations, and the assessment of the full spectrum of social phobia, from key symptoms to global functioning. The results showed that both virtual reality and group-CBT were effective to reduce the key symptoms of social phobia (as measured with the Liebowitz Social Anxiety Scale) and to improve social as well as global functioning. No effects were detected on the depression measure, most probably due to a "ceiling effect" where the treatment could not relieve much of the depressive

symptoms since people with major depression were excluded from the study. To compare VRT to group-CBT, our approach focused on documenting the effect-size of the difference in efficacy between the two conditions. The analyses show that for all measures except assertiveness, the difference between both treatments were small to very small. This suggests that, when compared to a gold-standard form of treatment, virtual reality is very effective. For example, social phobia symptoms, a clinical sample of 200–300 participants would be required to statistically detect a difference between both forms of treatment. In such a case, virtual reality would likely be more effective than group-CBT. In other cases, such as performance anxiety, a sample of 3,000 participants or more would be required given the very faint difference between the treatments. Given the already well-documented success rate of group-CBT compared to placebo or no treatment, these results clearly show the efficacy of virtual reality in the treatment of social phobia.

Our results complement those already reported with virtual reality[21,22] for performance anxiety, a milder form of social phobia. With the help of a virtual environment developed for the fear of public speaking, others[23,24] have reported case studies of social phobics benefiting from virtual reality based treatments. The present study extends even further to show that using environments designed and used to tap various social situations such as talking to strangers or acting under scrutiny are useful to alleviate the full spectrum of social phobia symptoms.

Although the level of anxiety experienced when one has to be assertive improved similarly in the two treatments, the change in assertiveness behavior appeared less similar. It would seem that, although it did not reach significance, assertiveness behaviors might have improved slightly more following group-CBT than virtual reality treatment. The effect size analysis showed a moderate difference in improvement that could become significant with a sample of 120 participants. It is difficult to comment much given the absence of a significant difference, but this difference might become clinically significant in some cases.

In order to further confirm the efficacy of virtual reality for the treatment of social phobia, additional outcome studies could be conducted with the inclusion of a third control condition such as a placebo or a waiting list. The comparison with a pharmacological treatment might also provide interesting information. Compared to the analysis of effect sizes, these more traditional approaches would replicate our findings with a different

methodology. In addition, the inclusion of participants suffering from comorbid depression, substance abuse, and other anxiety disorders would also be useful.

Despite these results, the fact that 3D computer generated virtual humans can be effective might be surprising. It is even more disconcerting when acknowledging the fact that these virtual humans are not perfect human representations performing complex and accurate inter-personal behaviours. However, there is a growing body of experimental data allowing to interpret these results. For example, James et al.[27] have immersed 10 non-phobics in various virtual social environments and found an increase in anxiety when users had to interact with virtual humans who appeared disinterested to the presence of the participants. Later on, the same research team[41] compared the reaction of 16 phobics and 20 non-phobics when they gave a speech in one of two conditions: an empty seminar room, or to a group of virtual humans behaving neutrally. The level of anxiety was not very high in the non-phobics in both conditions, but it was significantly higher among the phobics in the empty room condition and even higher when the phobics delivered their speech to the neutral virtual humans. These findings were based on both self-report measures of anxiety and heart rate response. Going even further, these researchers[42] compared the reaction of 43 people suffering of fear of public speaking when they delivered a speech to an audience of virtual humans that were responding neutrally, positively or negatively to the speech. The speeches delivered to the negative audience were significantly more anxiety inducing and rated as less satisfying than the speeches delivered to the neutral audience. In a different type of study, Herbelin et al.[26] asked 10 non-phobics to deliver a speech in a room filled with only images of eyes starring at them. Even in this unrealistic condition, participants reported significant increases in anxiety and heart rate. All this data shows clearly that people can react emotionally to virtual humans and their behaviors, even if they are unrealistic representations of humans.

A promising explanation can be found in the interplay between believability of virtual reality and emotions felt by the user immersed in the virtual environment. Suspended disbelief, or the perceptual illusion of non-mediation, refers to the concept of presence (the illusion of being *there*).[43,44] This phenomenon may be facilitated by emotional arousal induced in the participants by the mere idea of being involved in a potentially social interaction. Even if virtual humans were not perfect human replicas, a minimal level of realism might be suffi-

cient to trigger some arousal and negative emotions. These reactions can reciprocally interact with presence and the impression that the virtual humans are credible. This is suggested by a strong correlation between anxiety, presence, and realism,[45] as well as two experimental studies by Bouchard and colleagues.[46,47] In a first study,[46] a group of 31 snake phobics were immersed in a virtual environment while anxiety was experimentally manipulated. In some immersions, the participants were falsely led to believe that the environment was filled with dangerous and hidden snakes; a situation that strongly induced anxiety. In the anxiety-induced immersions, the level of presence was significantly higher than in the non-anxiety immersions. In the second study,[47] the feeling of presence was experimentally manipulated in a sample of 33 height-phobics who had to take an elevator and perform tasks on a scaffold outside of a 15-story building. When the immersion in the virtual environment was conducted in a high-presence setting, the level of anxiety was significantly higher than when the immersion was conducted in a low-presence setting. Taken together, these results show the existence of a bi-directional relationship between presence and anxiety. They may also suggest that with some minimal level of presence or realism, virtual environment could induce anxiety, which in turn would further the sense of presence or realism, and so on in a circular feedback loop up to the point where imperfect virtual humans can be anxiety provoking enough to treat social phobia as efficiently as objective humans.

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