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ORIGINAL ARTICLE

Virtual reality exposure using three-dimensional images for the treatment of social phobia

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Objective: To test a potential treatment for social phobia, which provides exposure to phobia-inducing situations via computer-generated, three-dimensional images, using an open clinical trial design.
Methods: Twenty-one patients with a DSM-IV diagnosis of social phobia took part in the trial. Treatment consisted of up to 12 sessions of exposure to relevant images, each session lasting 50 minutes.
Results: Improvements in social anxiety were seen in all scales and instruments used, including at follow-up 6 months after the end of treatment. The average number of sessions was seven, as the participants habituated rapidly to the process. Only one participant dropped out.
Conclusion: This study provides evidence that exposure to computer-generated three-dimensional images is relatively inexpensive, leads to greater treatment adherence, and can reduce social anxiety. Further studies are needed to corroborate these findings.

Keywords: Social phobia; cognitive behavioral therapy; virtual reality exposure; anxiety

Introduction

Cognitive behavioral therapy (CBT) is used in the treatment of social phobia, challenging dysfunctional thoughts and beliefs and stimulating more adaptive behavioral responses. Techniques such as exposure, social skills training, and cognitive restructuring are used.[1-4]

One of the most efficient methods for treating phobias is exposure,[5-7] which can be in vivo or imagined (in vitro). In vivo exposure is superior to imagination, but it is costly and time-consuming, and situational elements are difficult to control. An additional problem with in vivo exposure is the possibility of encountering people the patient knows, thus revealing that she or he is in therapy. Conversely, in vitro exposure can be difficult for people who are unable to imagine vividly, who avoid imagining their phobia-inducing situations, or who tend to overwhelm themselves with images.[8]

Studies of virtual reality exposure (VRE) have demonstrated efficacy in the treatment of anxiety disorders, such as social phobia,[9-13] fear of flying,[14,15] acrophobia,[16,17] arachnophobia,[18,19] and panic disorder with or without agoraphobia.[20,21] VRE has advantages over imagined or in vivo exposures.[9-11,13,22] It can provide standardized and controlled environments, and scenes can be repeated to achieve therapeutic goals.[23,24]

Moreover, exposure to virtual environments bridges the gap between an imagined situation and a real one; it allows the patient to be exposed to anxiety-generating stimuli as if he or she were in a real situation.[25,26] When treating those with social phobia, live exposure is a more difficult procedure to perform, as social situations are variable and unpredictable, which makes building hierarchies for gradual and repeated exposure more difficult.[27] VRE also has the advantages of costing less than in vivo exposure, because it shortens the treatment time, and being associated with fewer dropouts than live exposure.[10,28]

Numerous studies have tried to create and evaluate the use of virtual environments that reproduce anxiety-generating situations.[8-13] However, few controlled studies have demonstrated efficacy in the treatment of social phobias. All relevant studies have shown improvements, but with limitations such as the use of participants with circumscribed social phobia[8,10-13]; the use of more complex VRE systems, such as virtual reality headsets[9-13]; the use of patients on a waiting list for therapy as a control group[11]; and collection of limited measurements of the phobic experience.[8,10,12]

DSM-5 did not modify the diagnostic criteria for social phobia. The relevant changes in this new edition are fourfold. First, a specifier has been added for performance-related social anxiety; in the DSM-IV-TR, this specifier was for generalized social phobia. Second, fear of offending others has been included. Third, the minimum duration has been defined as 6 months for adults. Fourth, social anxiety in children can now be manifested by attention-seeking behavior.

The aim of this study was to develop and refine a software program to treat patients with social phobia through VRE using three-dimensional images. Our hypothesis was that VRE would reduce anxiety in social situations.

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Methods

Participants

A convenience sample of 25 subjects meeting DSM-IV criteria for social phobia responded to a newspaper advertisement. Three were excluded: one because of major depression with risk of suicide, one was addicted to psychoactive substances, and one was undergoing psychotherapy. An additional participant left the study before completion because of external time pressures. Therefore, the final sample consisted of 21 participants, 11 males and 10 females (mean age, 39 years); 61.9% had completed undergraduate education. On average, participants had been suffering from social phobia for 24.9 years. Comorbid depression was found in 38% of the group. Although no participant had received a diagnosis of psychoactive substance abuse or dependence, five were using alcohol to cope with social situations. Furthermore, 62% had social phobia of the generalized subtype. The severity of social phobia symptoms was estimated using the Liebowitz Social Anxiety Scale (LSAS), with a mean score of 73.95% (Table 1).

Instruments

The following instruments were used: The Social Phobia section of the Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition (SCID I/P DSM-IV-TR)[29]; LSAS[30] (Portuguese version, validated for use in Brazil[31]); Clinical Global Impression Scale (CGI)[32]; The Medical Outcome Studies 36-Item Short-Form Health Survey (SF-36)[33] (Portuguese version, translated and validated for use in Brazil[34]); Subjective Units of Discomfort (SUDs)[35]; Scale for Measuring Therapy Sessions (created for this study, this scale allows participants to assess how much the virtual scene resembles real situations; each item is scored on a six-point Likert-type scale, where 0 = none, 1 = very little similar, 2 = a little similar, 3 = moderately similar, 4 = very similar, and 5 = extremely similar); Beck Depression Inventory (BDI)[36]; Sheehan Disability Scale[37]; Social Adjustment Scale (SAS)[38] (validated Portuguese translation[39]); Automatic Thoughts Questionnaire (ATQ 30)[40] (translated into Portuguese[41]); Dysfunctional Attitude Scale (DAS)[42] (Brazilian adaptation of the English DAS).[43]

A virtual reality program to treat social phobia using the exposure method was created and planned by the first author, and developed by Outra Vista studio. The scenes created anxiety-generating social situations in three dimensions (3D), merging motion capture of real actors with interactive characters to simulate reality. The scenes involving actors were recorded using a 3D camera over an infinite background. Actors ranged in age from teenagers to older adults, and included both genders. Individuals as well as small groups were captured, taking into consideration the particular difficulties of patients with social phobia.

Two virtual scenarios were created: one on a street and one at a party. The scenes consisted of walking down the street, approaching people on the street, entering the party, engaging in conversation at the party, welcoming guests at the party, and talking and giving a speech at the party.

Procedure

In their first session, participants were interviewed by a trained psychiatrist who applied a structured clinical interview for social phobia according to DSM-IV criteria (SCID) and administered the CGI. Participants who fulfilled the criteria for a primary diagnosis of social phobia according to the DSM-IV were included in the study. After signing a consent form, the participants completed the instruments and scales described above.

The inclusion criteria were primary diagnosis of social phobia via the SCID and age between 18 and 65 years.

The exclusion criteria were major depression with risk of suicide, substance dependence, psychotic disorders, and not currently undergoing psychotherapy treatment.

The Assessment Scale for Therapy Sessions was created for this study and was applied at the end of each session. SUDs were checked throughout each session.

At the end of treatment, all scales and instruments were sent to the participants for completion online, via the Google Drive platform. Six months after the end of the

Table 1 Demographic data, number of sessions, and duration of virtual reality exposure

Panel A - Demographic profile of the sample

	Gender		Educational attainment				Phobia	
	Female	Male	Graduate (completed)	Undergraduate (completed)	Undergraduate (ongoing)	High school (completed)	Social phobia	Performance anxiety
n (%)	10 (47.6)	11 (52.4)	2 (9.5)	13 (61.9)	1 (4.8)	5 (23.8)	13 (61.9)	8 (38.1)

Panel B - Age, number of sessions, and duration of exposure

	Mean ± SD	Median (range)
Age (years)	39.62±11.14	38.00 (19.00-63.00)
Number of sessions	5.00±1.60	5.00 (2.00-7.00)
Duration of exposure (minutes)	21.29±8.72	20.00 (5.00-45.00)

SD = standard deviation.

treatment, participants were contacted by phone and the scales were sent to them for completion once again.

Treatment

The virtual reality program requires a PC platform running the Microsoft Windows 7 operating system and capacity to display 3D video. Hardware requirements consist of an Intel i7 processor (or higher); 4 GB RAM; an NVIDIA GT 540M graphics adapter (or better); and a DVD optical disc drive, as well as a row-interleaved micro-polarized LCD screen with a display resolution of at least 1,366 $\times$ 768 pixels or a 3D TV or 3D monitor connected via HDMI (to display the 3D images). The sole software requirement, in addition to the Windows 7 operating system, is a program capable of displaying 3D motion pictures side-by-side in full-screen format, such as CyberLink DVD 10 or higher, or a similar alternative.

Application and devices

To activate the optical illusion that generates the 3D image for the user, polarized passive 3D glasses should be used, as well as in-ear headphones for sound immersion in the environment. The therapist should help the patient position correctly before the screen, always striving to achieve a straight angle relative to the patient's eyes. The program presents images at 30 frames per second with a focal distance equivalent to 50 mm (50-degree field of vision).

The commands for activation of the interaction and scene change are given by the therapist through a wired or wireless USB keyboard, using standard shortcuts to change chapter (R in the CyberLink DVD suite) and angle (ENTER in CyberLink).

The program was administered by two research psychologists, who were both M.Sc. graduates and trained in CBT. One of the researchers was trained on how to operate the software program, which was used for up to 12 sessions, each lasting 50 minutes. Situations that elicited anxiety were presented via the virtual reality system. The hierarchies of these situations were set according to the symptoms of each patient. The participant was exposed gradually and repeatedly. Scenes were of a short duration and were played on a loop, allowing for repeated exposure until habituation was achieved. To minimize interference with the patients, the program allowed the therapist to use an auxiliary keyboard to type in the characters' answers in scenes involving dialog (i.e., approaching people on the street and engaging in conversation at a party). The session ended if there was a decrease of at least 50% in anxiety level, as measured by SUDs. If the participant did not experience any anxiety in a given scene, the next scene was presented. Participants could have the treatment terminated before the expected 12 sessions if the scenes no longer elicited anxiety. Table 2 provides details on each session of the program.

Statistical analysis

Responses to the scales were compared at three time points: before treatment, after treatment, and at a follow-up assessment 6 months after the end of treatment.

A multivariate analysis of variance (MANOVA) (GLM procedure) was used to analyze the data. According to Fávero et al.,[44] this technique differs from analysis of variance (ANOVA) in that it enables researchers to investigate the existence of significant differences between groups, considering multiple dependent variables simultaneously. The IBM SPSS version 21 statistical package was used for this analysis.

Initially, the Kolmogorov-Smirnov test of normality was performed, in which the variables Sheehan 3 family life/home responsibilities, SF-36 functional capacity, SF-36 physical aspects, and SF-36 emotional aspects rejected

Table 2 Description of the 12 program sessions

Technique presentation session	Psychoeducation with the necessary explanations of the nature of the procedures: exposure and virtual reality exposure. Anxiety hierarchy (from low- to high-anxiety scenes).
Sessions 1 and 2	Scene 1: Go for a walk on the street. The therapist asks the participant to walk down a street, where he/she will be observed by passersby.
Sessions 3 and 4	Scene 2: Approached on the street. The therapist asks the participant to walk down a street and asks a stranger for information, e.g., where the nearest pharmacy is. He or she thanks the stranger and repeats the same question to another. The therapist pushes the button on the auxiliary keyboard, and each character replies the same way: "Go straight ahead and turn right." The characters are a teenager, a man, a woman, and, finally, a small group.
Sessions 5 and 6	Scene 3: Entering a party. The therapist asks the participant to enter a house where a party is taking place and be observed by the guests.
Sessions 7 and 8	Scene 4: Dialog at the party. The therapist tells the participant he/she is at a friend's party. He/she is then introduced by one of the characters to a stranger at the party, who initiates a conversation. The questions regard the subject's acquaintance with a supposed friend of the party's host/hostess, previously set before the start of virtual exposure. The therapist pushes the button on the auxiliary keyboard to insert the character's questions, e.g., "how long have you guys known each other?".
Sessions 9 and 10	Scene 5: Guest reception. The therapist says the participant is the host/hostess and must welcome the guests.
Sessions 11 and 12	Scene 6: Speech at the party. The therapist says the participant is the host/hostess and has to give a speech thanking the guests. Depending on the feared situation, the participant may eat, drink, or write in front of the guests. One of the characters takes a cell phone call, another coughs, and another whispers to the person next to him/her and laughs out loud.

the null hypothesis ($p > 0.05$). We used a repeated measures model considering covariates of gender, phobia, age group, and educational attainment. As no significant effect of these covariates was observed, the model was adjusted to include only the three evaluations in time. Friedman's test was used for the following variables: CGI severity of disease; CGI severity of disease – final measure (FM); CGI severity of disease – follow-up (FU); CGI overall improvement FM; CGI overall improvement FU; SF-36 functional capacity; SF-36 functional capacity FM; SF-36 functional capacity FU; SF-36 limitation physical aspects; SF-36 limitation physical aspects FM; SF-36 limitation physical aspects FU; Sheehan 3 family life; Sheehan 3 family life FM; and Sheehan 3 family life FU.

Additionally, some scales were compared for specific variables, such as gender, age, severity of the social phobia, and educational attainment, using the Mann-Whitney (CGI severity of disease FU) and Kruskal-Wallis (CGI severity of disease) tests.

For all other variables with non-rejection of the null hypothesis of normality, MANOVA (GLM) was performed. The main results are presented in Tables 3 and 4.

A *t* test was used to verify the proportional change in the anxiety of participants relative to baseline scores at the start of exposure. Bonferroni correction was used to control the significance level. For comparisons of results, a 5% significance level was adopted.

Regarding the homogeneity criterion of variances between all possible groups of variables, the Sheeran1_T variable rejected the null hypothesis of Mauchly's sphericity test (considering a significance level of 1%).

Results

Tables 3 and 4 show the results of the evaluation instruments. We observed a significant decrease in post-treatment scores, which persisted at follow-up assessment, for scales that evaluated anxiety, phobia, depression, and cognitive dysfunctions (LSAS, ATQ, BDI, and SAS). The CGI revealed a decrease in the severity of illness after treatment, which remained in the follow-up period. The Sheehan Disability Scale showed significant improvements in professional, social, and family life. On the DAS, we also observed significant improvement, as demonstrated by an increase in scores after treatment, which was maintained at follow-up.

As for quality of life (SF-36), the pain, general health, functional capacity, and physical aspects domains did not demonstrate any significant difference. There was a significant difference between the pre-treatment and post-treatment phases for the parameters of vitality, emotional aspects, and mental health. Only the improvements in emotional aspects and mental health parameters were preserved at follow-up (Tables 3 and 4). The study intervention, a psychological treatment, had no impact on physical health.

As for the participants' perception of the scenes presented to them, as a rule, they assigned high values for the realism of the scenes and for how much the scenes resembled situations they face in their lives. Participants

Table 3 Baseline, final, and follow-up measures by Friedman test (n=21)

	Baseline			Final			Mean diff. (final - baseline)	Follow-up			Mean diff. (follow-up - baseline)
	Mean ± SD	Median	Range	Mean ± SD	Median	Range		Mean ± SD	Median	Range	
Sheehan 3 family life/home responsibilities*	3.24±3.02	3.00	0.00-10.00	0.86±1.49	0.00	0.00-5.00	-2.38	1.29±1.85	0.50	0.00-7.00	-2.38
SF-36 functional capacity	89.05±18.95	95.00	20.00-100.00	89.76±14.27	95.00	45.00-100.00	0.71	80.00±23.66	85.00	0.00-100.00	0.71
SF-36 physical aspects	76.19±35.77	100.00	0.00-100.00	85.71±25.7	100.00	0.00-100.00	9.52	75.00±40.31	100.00	0.00-100.00	9.52
SF-36 emotional aspects†	33.33±40.82	0.00	0.00-100.00	85.71±29.00	100.00	0.00-100.00	52.38	63.49±44.60	83.33	0.00-100.00	52.38

The null hypothesis for the Friedman test is that there are no differences between related variables.
diff = difference; SD = standard deviation.
* $p \leqslant 0.01$; † $p \leqslant 0.001$.

Table 4 Baseline, final, and follow-up measures by MANOVA (n=21)

	F	Baseline mean ± SD	Final mean ± SD	Mean diff. (final - baseline)	Follow-up mean ± SD	Mean diff. (follow-up - baseline)
LSAS fear	50.63*	37.33±15.24	17.43±13.41	-19.90*	20.10±13.73	-17.24*
LSAS avoidance	28.81*	36.62±14.73	15.57±14.78	-21.05*	21.38±14.41	-15.24*
LSAS total	42.12*	73.95±28.32	33.00±27.42	-40.95*	41.48±26.89	-32.48*
ATQ automatic thoughts	21.64*	85.19±26.33	55.57±20.92	-29.62*	61.19±22.99	-24.00†
Sheehan 1 work/school	32.55*	5.95±2.60	1.95±2.16	-4.00*	1.57±1.89	-4.38*
Sheehan 2 social life	29.72*	6.14±3.07	2.48±2.18	-3.67*	2.24±2.00	-3.90*
SF-36 pain	2.87	83.48±20.02	83.71±15.84	0.24	72.80±26.29	-11.19
SF-36 general health	2.07	71.52±17.24	79.19±20.11	7.67	75.52±21.78	4.00
SF-36 vitality	12.59†	42.86±22.28	65.95±16.25	23.09*	51.43±24.86	8.57
SF-36 social aspects	6.04	55.36±28.11	79.17±17.82	23.81*	60.12±31.03	4.76
SF-36 mental health	9.83‡	49.52±21.11	70.10±16.81	20.57*	61.90±22.83	12.38
DAS	11.60†	107.76±29.69	133.00±25.84	25.24‡	131.38±31.61	23.62‡
BDI	5.37§	12.62±6.74	7.00±5.80	-5.61‡	11.33±9.35	-1.29

ATQ = Automatic Thoughts Questionnaire; BDI = Beck Depression Inventory; DAS = Dysfunctional Attitude Scale; diff = difference; LSAS = Liebowitz Social Anxiety Scale; MANOVA = multivariate analysis of variance; SD = standard deviation.
*$p \leqslant 0.0001$; †$p \leqslant 0.001$; ‡$p \leqslant 0.01$; §$p \leqslant 0.05$.

assigned moderate values for the degree of maximum anxiety they felt when viewing the scenes (Table 5).

An average reduction in anxiety of 72.5% was observed after exposure to the scenes (0.725±1.148, p = 0.009).

The average number of sessions needed to complete treatment was seven, and the average duration of exposure until habituation was achieved was 21.29 minutes (Table 1).

Discussion

All patients who completed the treatment exhibited improvement, reporting decreases in fear, anxiety, and avoidance of social situations. This improvement had effects on other evaluated areas, such as depressive symptoms, quality of life, dysfunctional attitudes, and ways of thinking. Patients also reported positive repercussions in their professional, social, and family lives.

These results, which were obtained with the use of a software that provides exposure to 3D, computer-generated images, corroborate other reports of the efficacy of this modality of treatment.[8-13,22] However, many of these studies[8-10,12,13,22] employed virtual reality systems with immersive headsets, while the virtual reality system used in this study is easier for clinicians to obtain and use in their offices. One study used computer-generated 3D scenes, but the sample was composed only by individuals with public-speaking anxiety,[11] which limits the generalizability of its results.

Despite its open design, the present study used VRE exclusively, whereas the studies of Klinger et al.[9] and Robillard et al.[12] used VRE combined with CBT, making it difficult to identify which of the two treatments was responsible for improvements. The psychological assessments carried out in the present study were more complete; other studies have measured only the decrease in anxiety, omitting the impact of therapy on social, family, and business aspects.[8,11-13,22] Price et al.[22] assessed the experience of people who underwent VRE, and reported the importance of immersion in the virtual world by darkening the environment and requiring participants to wear the same kind of clothes they would wear in real-life situations, or hold relevant objects. The present study also provided a strongly immersive experience. Participants assigned high ratings to the realism of the scenes and how closely those scenes resembled the situations they face in their lives. Exposure to the scenes elicited moderate anxiety, corroborating the realism of phobia-inducing situations, but not to the point of avoidance due to excessive uneasiness. The average number of sessions necessary to decrease social anxiety in this study was seven, less than the number observed in a comparable study.[9]

In the present study, only one participant left treatment, because of time constraints. Wallack et al. also found a low dropout rate in the group receiving a virtual reality intervention as compared to patients receiving CBT alone.[10]

The therapeutic outcomes obtained persisted throughout the 6-month study period. This is consistent with other studies, which have shown a persistence of therapeutic effects for as long as 1 year.[8,13]

In short, the aim of this study was achieved. A program was created and developed to treat social phobia through VRE. The main limitations were the small sample size and the fact that participants were self-selected, which makes it difficult to generalize the results. Future controlled studies are needed to confirm these preliminary findings.

Table 5 Participants' perception of the scenes (n=21)

	Mean ± SD	Range
Realistic	4.19±0.69	2.5-5.0
Resembled own life	4.24±0.55	3.0-5.0
Maximum degree of anxiety	3.23±0.45	2.3-3.8

SD = standard deviation.

Disclosure

The authors report no conflicts of interest.

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