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Social interactions in virtual reality exposure therapy: a proof-of-concept pilot study

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ABSTRACT

Background and Objectives: Research on virtual reality exposure therapy (VRET) has demonstrated good treatment efficacy with regards to several anxiety disorders. Yet, there is lack of knowledge about the value of integrating interaction between clients and virtual humans in VRET. Such interaction might prove effective in treating psychological complaints that involve social interactions, such as social anxiety. *Methods:* A VRET system specifically designed to expose clients with social anxiety disorder to anxiety provoking social situations was applied to 16 and 18 individuals with high and low levels of social anxiety, respectively. Participants engaged in two exposure sessions in several free speech dialogues with virtual humans while being monitored by a therapist.

Results: Participants with high levels of social anxiety reported significantly lower levels of social anxiety three months after exposure to two virtual reality interaction sessions than before treatment ($p < .01$). In the group with low levels of social anxiety, no significant change of social anxiety was reported between pre-treatment and follow-up. Additionally, participants in both groups reported higher self-efficacy three months after treatment than before treatment ($ps \leq .001$).

Conclusion: These findings indicate that virtual reality technology that incorporates social interactions may be successfully applied for therapeutic purposes.

Key words: Virtual reality; exposure; social phobia; social anxiety

1. Introduction

Individuals with social anxiety disorder (SAD) persistently experience a strong fear of being judged negatively by others during situations that involve interaction with other people [1]. Feared situations might involve any interaction with others during which people with SAD have a perception of being observed and potentially being embarrassed or humiliated by others. SAD is one of the most prevalent mental disorders, with an estimated 12-month prevalence of 6.8 % in the United States population [2]. This disorder is further associated with increased risk for comorbid disorders [3] and functional impairment [4]. Group and individual cognitive behavior interventions have been shown to be effective in treating SAD [5]. The cognitive component of cognitive behavior therapy helps clients with SAD to identify and test dysfunctional beliefs accompanying certain behavior patterns [6]. The central behavioral component of cognitive behavior therapy is exposure in vivo, in which individuals with SAD are confronted with feared social interactions [7]. The rationale behind exposure is that experiencing feared social situations without avoidance will teach the client that the experienced anxiety will eventually decrease and that feared outcomes will not occur. Research indicates that interventions involving a combination of exposure and cognitive components were not significantly more effective than exposure alone [5].

In the last two decades, virtual reality exposure therapy (VRET) has increasingly been applied in treatment of several anxiety disorders. The therapeutic goals in VRET are based on treatment strategies used in behavior therapy while making use of virtual worlds that resemble feared real life situations. Accordingly, the used virtual worlds must elicit anxiety in order to enable systematic exposure to feared stimuli within a contextually relevant situation. VRET integrates real-time computer graphics, body tracking devices, visual displays and other sensory inputs to immerse individuals in computer-generated virtual environments. As a result, the perception of an interactive, three-dimensional world is constructed. In VRET, the

control of exposure elements is easier to control and manipulate by therapists than in exposure in vivo. A recent meta-analysis revealed that the association between sense of presence (i.e., the extent to which virtual reality worlds feel realistic to participants) and perceived anxiety within VRET depends on the disorder. Whereas large correlations were found in virtual reality trials involving fear of animals, there was no significant association between sense of presence and perceived anxiety in individuals with social anxiety [8]. Yet, the presence scales used in the studies included in the meta-analysis might not be capable of accurately measuring essential aspects of sense of presence in virtual environments used to treat SAD [8].

Research has demonstrated the efficacy of VRET for a variety of anxiety disorders [9,10]. Yet, there is lack of research on the extent to which the integration of verbal interaction with virtual humans into VRET can improve treatment outcome. Furthermore, certain psychological complaints are directly associated with social interactions, in particular complaints associated with SAD. Research on VRET for SAD has mainly focused on fear of public speaking, which represents one among many situations individuals with SAD fear [11-13]. In these trials verbal interaction between clients and virtual humans was rather limited to a restricted number of questions that the public audience would ask (such as “I don’t understand, could you explain again” [11]. Recent work indicates that more elaborate conversations with virtual humans can also elicit arousal, comparable to conversations in real life [14,15]. In a recent pilot study [16], participants took part in both a virtual reality condition and an “in vivo” condition. The study facilitator presented a topic to be conducted three minutes later either in virtual reality and then in vivo or vice versa. The study facilitator then engaged participants in two 5-minute conversations (i.e., one topic per condition). Participants rated their anxiety higher during virtual reality conversation than during in vivo conversation, whereas in vivo conversation was rated as more realistic than virtual reality conversation. Yet, the implications of this study for psychotherapy are rather limited given the

short duration of social interaction and the study context. Study participants had a virtual conversation with the research facilitator who was playing the virtual human and sitting on a couch next to the participant, whereas virtual social conversations should rather be used for situations that resemble real world situations outside the therapist's office.

In summary, research investigating the extent to which verbal interaction can be applied in VRET is lacking. Against this background, we evaluated whether verbal interaction between humans and virtual humans can be successfully applied to reduce social anxiety. We first developed a virtual reality exposure program for treating individuals with SAD that includes a wide variety of verbal interactions between the client and virtual humans. Then we designed a proof-of-concept pilot study to examine the efficacy of the program in reducing levels of social anxiety and increasing levels of self-efficacy. According to the social learning theory by Bandura [17], successful psychological interventions strengthen self-efficacy by confronting clients with their fears and providing them with successful experiences of coping with them. Self-efficacy can be defined as the subjective conviction of possessing the needed competence to mobilize the cognitive, behavioral, motivational, and social skills to cope with life demands [17]. Accordingly, anxiety reduction should be accompanied by enhancing and strengthening self-perceptions of ones coping efficacy. Initial research with clients with specific phobias indicates that VRET can significantly increase self-efficacy [18-20].

To provide a first examination of our virtual reality-based program for treating social anxiety, we conducted the study with a non-clinical sample and applied two sessions of exposure only. Based on levels of social anxiety, the sample was divided into high social anxiety group and low social anxiety group. We hypothesized that VRET will lead to a reduction of social anxiety and an increase of self-efficacy in the high social anxiety group as measured three months after treatment. With regard to the low social anxiety group, we did

not expect any significant change between pre-treatment and three-month follow-up neither regarding social anxiety nor self-efficacy.

2. Method

2.1. Virtual reality exposure program

The Delft Remote VRET (DRVRET) platform [21] was used in this study. The platform includes virtual environments that were created with Vizard 3.0 using vizard complete characters library which includes 100 human characters from WorldViz. The 3D models for the virtual environments and objects were created with Autodesk Maya and later exported to the Vizard environment. To incorporate verbal interactions between a human and virtual humans that would enable clients with social anxiety to be exposed to free speech dialogues, the platform applied the technique of semi-scripted dialogues. First, we wrote and recorded several semi-scripted dialogues applying Editor3 [22]. The dialogues were developed to serve as comments, responses or questions to be used in social interactions in several situations that many individuals with social phobia might fear. The situations in our VRET include buying clothes (for e.g., a bra or baby clothes) in a shop; attending a job interview; dining in a restaurant (for e.g., with a blind date or a friend); talking to strangers; being interviewed by a journalist; or giving a presentation to an audience, followed by a question and answer round (see Figure 1). During treatment, the therapist selects comments, questions or answers to be said by virtual humans based on the therapeutic task and the way the client interacts with the virtual human. Practically, the program consists of a list of written and recorded sentences that the therapist can select throughout the verbal interaction between the client and the virtual human. The dialogues were prepared as such that they follow a main story line within a given virtual world. Yet, the potential responses to be said by the virtual human are still flexible enough to have different verbal interaction experiences each time the

client is exposed to the same virtual social world. In accordance with the therapeutic needs throughout treatment, the therapist has the possibility of changing several aspects of the VRET program. First, the therapist can choose to use either male or female virtual human in a given virtual world. Second, narrative stories are used to introduce the client to a specific virtual world before entering it or to certain actions that are expected from the client in the virtual world (e.g., say no to a specific request by the virtual human). The therapist can choose to adjust the narrative text later in treatment and for example make the text more anxiety provoking than during the first sessions. Third, the therapist can choose to make the dialogue style friendly or unfriendly. Finally, the therapist can control the gaze of the virtual human by fixating his/her eyes on the client or looking at the client rather randomly. The program further enables the registration of client's anxiety. The subjective anxiety level reported by the client can be recorded in the program on a scale from 1 to 10.

2.2. Participants and Procedure

In total, 43 university psychology students were offered course credit for participation in the study. Of these, five participants had missing values at pre-assessment and they were excluded from the study. Accordingly, the final sample consisted of 38 individuals (32 females; mean age=22.3, $SD=5.7$, range 18-51). Participants were randomly assigned to either a high quality head-mounted display (HMD: Nvisor SX 60; high-resolution SXGA {1280 x 1024} stereoscopic HMD; Liquid Crystal On Silicon display; flock-of-bird head tracker updated at 115.200 Hz with 180 degree azimuth and roll, 90 degree elevation; 60 degree diagonal field of view) condition ($n=21$ participants) or a one-screen projection-based virtual reality display condition ($n=22$ participants) using a projector (Toshiba WX Series; Resolution: WXG {1280x1024}) and a projector screen (190x145 cm) where participants were located about two meters in front of (62 degree diagonal field of view). Exposure to the virtual worlds consisted of two times up to 30 minutes with a break of ten minutes to prevent

cyber sickness. Participants in both conditions were exposed to the same virtual social situations described above.

The goals of our project were twofold. First, we aimed at examining the extent to which exposure to our VRET program will increase levels of social anxiety. The second goal was to investigate whether two-session exposure to our virtual worlds will lead to a reduction of social anxiety as measured three months after exposure. Results of the first goal (i.e., does exposure to our VRET program increase levels of social anxiety) based on 38 participants were recently published elsewhere [23]. Findings revealed that both forms of display (HMD vs. one-screen projection-based virtual reality display) were able to elicit moderate levels of anxiety. Most importantly, neither the average level of anxiety nor the highest level of anxiety during exposure to virtual environments differed between the groups using different displays.

The current report is about the extent to which exposure to virtual social interactions can lead to a reduction of social anxiety. All 38 participants received two VRET sessions as outlined above and were invited to a follow-up assessment three-months following exposure to our two-session intervention. Altogether 34 participants out of 43 followed our invitation and thus were part of the study on the efficacy of the program in reducing social anxiety.

This study was set up as a proof-of-concept and conducted with a non-clinical sample of individuals with different levels of social anxiety. Accordingly, we divided the group of 34 participants into those with high levels of social anxiety ($n = 16$) and those with low levels of social anxiety ($n = 18$). This was based on the mean of the Social Interaction Anxiety Scale (SIAS; see below) that was 21.19 (range: 10.36 – 52.0). Accordingly, those with a SIAS score of higher than 21.19 were labelled as high social anxious and those with a lower SIAS score than 21.19 were labelled as low social anxious. Participants in the low anxiety group had a mean age of 21.2 years ($SD = 2.6$) and participants in the high anxiety group had a mean age of 23.4 ($SD = 8.3$). Further, 66.7 % of participants in the low anxiety group were female as

compared to 87.5 % of those in the high anxiety group. None of the participants in any of the groups met criteria for SAD according to the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders (see below). Given the short duration of exposure (two sessions only within seven days), we decided to measure the efficacy of VRET at a three-month follow-up.

2.3. Ethics statement

Written informed consent was obtained from all participants before the experiment. The study was approved the Institutional Review Board of the University of Amsterdam, The Netherlands (reference number 2011-CP-1706).

2.3.1. Measures

Social anxiety symptoms were assessed with the Social Interaction Anxiety Scale (SIAS) [24]. This scale consists of 19 items that assess the tendency to fear and avoidance of evaluation in social situations (e.g., “I have difficulty talking with other people”). Responses range from 0 (not at all) to 4 (extremely). The authors have reported good psychometric properties for the SIAS [24].

The SAD of the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders (4th ed.; DSM–IV) [25] was applied to assess the diagnosis of SAD. This structured interview is considered the golden standard for assessing mental disorders formulated in the DSM-IV [26].

The Self-efficacy for Social Situations (SESS) [27] was applied to assess self-efficacy in social situations. This questionnaire consists of 9 items measuring self-efficacy on a 10-point Likert-type scale that can be defined as a person's confidence in being able to convey a favorable impression to others. The SESS has good psychometric properties and is sensitive for treatment change in generalized SAD [27].

3. Results

Mean scores and standard deviations of levels of social anxiety and self-efficacy for both groups at pre-assessment and three-month follow-up are reported in Table 1. As reported above, the level of social anxiety was used to divide participants into groups with high or low levels of social anxiety, respectively. Consequently, groups differed with regard to levels of social anxiety. An independent samples t-test was conducted to examine the extent to which the groups differed on levels of self-efficacy for social situations at pre-assessment.

Participants with low levels of social anxiety reported significantly higher scores of self-efficacy than those in the group with high levels of social anxiety, $t(32) = 2.46, p = 0.02$.

To determine whether levels of social anxiety and self-efficacy had significantly changed from pre-treatment to follow-up, we conducted a 2x2 repeated measures analysis of variance (ANOVA) with time (pre-follow-up) as a within-groups factor and anxiety level at pre-treatment (high social anxiety vs. low social anxiety) as a between-groups factor. With regard to social anxiety, no significant difference existed in the time main effect ($F = 3.88, p = 0.06$). Yet, there was a significant time by group interaction ($F = 10.95, p = 0.002$).

Dependent t-tests revealed that participants in the high social anxiety group reported significantly lower scores of social anxiety three-months following exposure to virtual social worlds as compared to pre-treatment, $t(15) = 2.99, p = 0.009$; Cohen's d effect size = 0.62. In the low social anxiety group, there was no significant change on the scores of social anxiety between pre-treatment and follow-up, $t(17) = -1.283, p = 0.217$; Cohen's d effect size = -0.14.

The ANOVA results on self-efficacy showed a significant difference in the time main effect ($F = 54.14, p = <0.001$). Both, participants in the high social anxiety group and those in the low social anxiety group reported higher levels of self-efficacy three months after VRET than at pre-assessment; $t(15) = 4.197, p = 0.001$; Cohen's d effect size = 0.98; and $t(17) = 6.67, p = <0.001$; Cohen's d effect size = 1.77, respectively (see Table 1 for detailed scores of

self-efficacy at pre-assessment and follow-up). No significant time by group interaction was found ($F = 3.56, p = 0.78$).

4. Discussion

Our results provide preliminary evidence that verbal interactions can be successfully incorporated into VRET and effectively used for therapeutic purposes. In the group of individuals with high levels of social anxiety, verbal interactions with virtual humans resulted in significant reduction of levels of social anxiety as measured three months after two verbal interaction sessions. Exposure to verbal interactions with virtual humans further led to an increase of self-efficacy at follow-up.

First and foremost, the results are in line with findings from several trials showing that VRET can be successfully applied to treat specific phobias and several anxiety disorders [20]. Previous trials have shown that VRET can be effectively used to treat fear of public speaking [11,13]. Current literature further indicates that verbal interactions with virtual humans can lead to similar levels of social anxiety as real life conversations [14-16], suggesting that verbal interactions can be successfully applied in virtual reality interventions. Our results extend these findings by showing that verbal interactions may lead to significant long-term reductions of social anxiety, which may enable VRET to be applied to all relevant aspects of SAD involving social interaction. Future research needs to examine the extent to which VRET involving social interaction can be as effective in treating SAD as other efficacious interventions, such as cognitive behavior therapy or exposure in vivo [5].

Our findings further revealed that verbal interactions with virtual humans led to an increase of self-efficacy for social situations as measured three months after treatment. This is in line with the social learning theory [17] that suggests that confronting clients with their fears in a productive way has an impact on self-perceptions of ones coping efficacy. This

expands previous research with clients with specific phobias indicating that VRET can significantly increase levels of self-efficacy [18-20]. An important aspect of our findings is that levels of self-efficacy increased even in the group of individuals with low levels of social anxiety that reported higher levels of self-efficacy at pre-treatment than participants with high levels of social anxiety. This may indicate that virtual worlds involving social interactions with virtual humans can increase self-efficacy even in the absence of high levels of anxiety. Our virtual worlds might have helped participants with low levels of social anxiety to more positively reflect on their ability to productively shape social interactions.

The magnitude of change regarding social anxiety was relatively small. However, considering the fact that participants had rather low levels of social anxiety, received two exposure sessions only, and the impact of treatment was measured three months after treatment the results are promising. This might indicate that a more intense treatment involving virtual verbal interactions could produce stronger and clinically more relevant findings. Future research should investigate whether VRET programs involving verbal interactions with virtual humans and offering a higher number of sessions than in the present study can be successfully applied to treat SAD and other psychological complaints directly related to social interactions. Furthermore, prospective research should also investigate the value of applying such programs to increase positive emotions and positive individual traits. Research has shown that focusing on improving positive emotions, individuals traits and virtues can not only increase positive individual traits and virtues but in turn also decrease levels of psychopathology [28].

The current study has several limitations. First, the use of a non-clinical sample limits the generalization of our findings. Second, as we did not use a comparison group, we were not able to assess factors not related to our intervention that might have acted as mediating or confounding variables regarding the changes of social anxiety complaints from pretreatment

to follow-up. Third, exposure to virtual worlds was conducted by a research assistant without prior experience in conducting psychotherapy. Virtual exposure conducted by mental health professionals may further improve the efficacy of VRET for social anxiety. Finally, we applied two sessions of virtual exposure only and thus our findings need to be seen in the context of brief exposure to interactions between humans and virtual humans only. Given the pilot character of this study and the aim at assessing the extent to which verbal interaction between humans and virtual humans can be successfully applied to reduce social anxiety, the study was conducted with students only rather than individuals with clinical levels of social anxiety. Accordingly, it was reasoned that two sessions of virtual exposure should be enough to achieve some significant change in levels of social anxiety in this population. Future research needs to address the potential of verbal interaction between humans and virtual humans in treating individuals with clinical levels of social anxiety.

In conclusion, this study's results suggest that verbal interactions can be successfully incorporated into VRET. The reduction of social anxiety complaints and the increase of self-efficacy scores as measured three months after two sessions of virtual social interactions indicate that social interactions with virtual humans are possibly effective in treating psychological complaints related to social interactions. First and foremost, this might improve the efficacy of VRET for individuals with SAD. Yet, sophisticated verbal interactions between humans and virtual humans can be successfully applied to not only treat psychological complaints, but also to better understand the role of social interactions in maintaining psychological complaints as well to foster positive emotions and positive individual traits.

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Conflicts of interest

The authors have no relevant conflicts of interest to declare.

References

- [1] American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders, 5th ed. (DSM-5). Arlington, VA: American Psychiatric Association; 2013.
- [2] Kessler RC, Chiu WT, Demler O, Merikangas KR, Walters EE. Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the national comorbidity survey replication. *Arch Gen Psychiat* 2005 Jul;62(6):617-627.
- [3] Ruscio AM, Brown TA, Chiu WT, Sareen J, Stein MB, Kessler RC. Social fears and social phobia in the USA: results from the National Comorbidity Survey Replication. *Psychol Med* 2008 JAN;38(1):15-28.
- [4] Schneier FR, Heckelman LR, Garfinkel R, Campeas R, Fallon BA, Gitow A, et al. Functional Impairment in Social Phobia. *J Clin Psychiatry* 1994 AUG;55(8):322-329.
- [5] Powers MB, Sigmarsson SR, Emmelkamp PMG. A Meta-Analytic Review of Psychological Treatments for Social Anxiety Disorder. *International Journal of Cognitive Therapy* 2008 JUN;1(2):94-113.
- [6] Stangier U, Heidenreich T, Peitz M, Lauterbach W, Clark D. Cognitive therapy for social phobia: individual versus group treatment. *Behav Res Ther* 2003 SEP;41(9):991-1007.
- [7] Emmelkamp P, Mersch P, Vissia E, Van der helm M. Social Phobia - a Comparative-Evaluation of Cognitive and Behavioral Interventions. *Behav Res Ther* 1985;23(3):365-369.
- [8] Ling Y, Nefs HT, Morina N, Heynderickx I, Brinkman W. A Meta-Analysis on the Relationship between Self-Reported Presence and Anxiety in Virtual Reality Exposure Therapy for Anxiety Disorders. *Plos One* 2014 MAY 6;9(5):e96144.
- [9] Clough BA, Casey LM. Technological adjuncts to increase adherence to therapy: a review. *Clinical psychology review* 2011 Jul;31(5):697-710.

- [10] Meyerbroeker K, Morina N, Kerkhof GA, Emmelkamp PMG. Virtual Reality Exposure Therapy Does Not Provide Any Additional Value in Agoraphobic Patients: A Randomized Controlled Trial. *Psychother Psychosom* 2013;82(3):170-176.
- [11] Anderson PL, Price M, Edwards SM, Obasaju MA, Schmertz SK, Zimand E, et al. Virtual Reality Exposure Therapy for Social Anxiety Disorder: A Randomized Controlled Trial. *J Consult Clin Psychol* 2013 OCT;81(5):751-760.
- [12] Anderson PL, Zimand E, Hodges LF, Rothbaum BO. Cognitive behavioral therapy for public-speaking anxiety using virtual reality for exposure. *Depress Anxiety* 2005;22(3):156-158.
- [13] Wallach HS, Safir MP, Bar-Zvi M. Virtual Reality Cognitive Behavior Therapy for Public Speaking Anxiety A Randomized Clinical Trial. *Behav Modif* 2009 MAY;33(3):314-338.
- [14] Hartanto D, Kampmann IL, Morina N, Emmelkamp PGM, Neerincx MA, Brinkman W. Controlling Social Stress in Virtual Reality Environments. *Plos One* 2014 MAR 26;9(3):e92804.
- [15] Qu C, Brinkman W, Ling Y, Wiggers P, Heynderickx I. Conversations with a virtual human: Synthetic emotions and human responses. *Comput Hum Behav* 2014 MAY;34:58-68.
- [16] Powers MB, Briceno NF, Gresham R, Jouriles EN, Emmelkamp PMG, Smits JAJ. Do conversations with virtual avatars increase feelings of social anxiety? *J Anxiety Disord* 2013 MAY;27(4):398-403.
- [17] Bandura A. Self-Efficacy - Toward a Unifying Theory of Behavioral Change. *Psychol Rev* 1977;84(2):191-215.
- [18] Krijn M, Emmelkamp PMG, Olafsson RP, Schuemie MJ, Van der Mast CAPG. Do self-statements enhance the effectiveness of virtual reality exposure therapy? A comparative evaluation in acrophobia. *Cyberpsychology & Behavior* 2007 JUN;10(3):362-370.
- [19] Cote S, Bouchard S. Cognitive mechanisms underlying virtual reality exposure. *Cyberpsychology & Behavior* 2009 Apr;12(2):121-129.
- [20] Meyerbroeker K, Emmelkamp PM. Virtual reality exposure therapy in anxiety disorders: a systematic review of process-and-outcome studies. *Depression and anxiety* 2010 Oct;27(10):933-44.
- [21] Brinkman WP, Hartanto D, Kang N, de Vliegher D, Kampmann IL, Morina N, et al. A virtual reality dialogue system for the treatment of social phobia. *Proceedings of the 30th international conference on Human factors in computing systems (CHI'12); 2012: 1099-1102.*
- [22] Ter Heijden N, Qu C, Wiggers P, Brinkman WP. Developing a dialogue editor to script interaction between virtual characters and social phobic patients. *Proceedings of the ECCE2010 workshop: Cognitive engineering for technology in mental health care and rehabilitation; Delft University of Technology: The Netherlands; 2010. p. 111-123.*

[23] Morina N, Brinkman W, Hartanto D, Emmelkamp PM. Sense of presence and anxiety during virtual social interactions between a human and virtual humans. *PeerJ* 2014;2:e337.

[24] Mattick R, Clarke J. Development and validation of measures of social phobia scrutiny fear and social interaction anxiety. *Behav Res Ther* 1998 APR;36(4):455-470.

[25] First MB, Spitzer RL, Gibbon M, Williams JBW. Structured Clinical Interview for DSM-IV Axis I Disorders, Clinician Version (SCID-CV). Washington, D.C.: American Psychiatric Press, Inc.; 1996.

[26] American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders DSM-IV-TR Fourth Edition (Text Revision). Washington, D.C.: American Psychiatric Association; 2000.

[27] Gaudiano B, Herbert J. Preliminary psychometric evaluation of a new self-efficacy scale and its relationship to treatment outcome in social anxiety disorder. *Cognitive Therapy and Research* 2003 OCT;27(5):537-555.

[28] Seligman MEP, Rashid T, Parks AC. Positive psychotherapy. *Am Psychol* 2006 NOV;61(8):774-788.

Table 1

Pre-treatment and 3-month follow-up mean and standard deviation (SD) scores of social anxiety and self-efficacy in individuals with low social anxiety (LSA) and high social anxiety (HSA)

	SIAS				SESS			
	Pre-assessment		Follow-up		Pre-assessment		Follow-up	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
LSA (n = 18)	12.8	5.1	14.5	5.0	60.8	5.8	73.5	8.3
HSA (n = 16)	29.4	7.3	22.8	13.1	54.1	9.9	65.8	13.6

Note. SIAS = Social Interaction Anxiety Scale; SESS = Self-efficacy for Social Situations.



Figure 1: Examples of social virtual environments used in our virtual reality exposure program. From left to right: Virtual Blind Date, Virtual Job Interview, Virtual conversation to a Stranger, Virtual Shop.