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Virtual Reality Exposure Therapy for Social Anxiety Disorder: A Randomized Controlled Trial

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Objective: This is the first randomized trial comparing virtual reality exposure therapy to in vivo exposure for social anxiety disorder. ***Method:*** Participants with a principal diagnosis of social anxiety disorder who identified public speaking as their primary fear (N = 97) were recruited from the community, resulting in an ethnically diverse sample (M age = 39 years) of mostly women (62%). Participants were randomly assigned to and completed 8 sessions of manualized virtual reality exposure therapy, exposure group therapy, or wait list. Standardized self-report measures were collected at pretreatment, posttreatment, and 12-month follow-up, and process measures were collected during treatment. A standardized speech task was delivered at pre- and posttreatment, and diagnostic status was reassessed at 3-month follow-up. ***Results:*** Analysis of covariance showed that, relative to wait list, people completing either active treatment significantly improved on all but one measure (length of speech for exposure group therapy and self-reported fear of negative evaluation for virtual reality exposure therapy). At 12-month follow-up, people showed significant improvement from pretreatment on all measures. There were no differences between the active treatments on any process or outcome measure at any time, nor differences on achieving partial or full remission. ***Conclusion:*** Virtual reality exposure therapy is effective for treating social fears, and improvement is maintained for 1 year. Virtual reality exposure therapy is equally effective as exposure group therapy; further research with a larger sample is needed, however, to better control and statistically test differences between the treatments.

Keywords: virtual reality exposure therapy, social anxiety disorder, social phobia, cognitive behavioral therapy

Virtual reality exposure therapy (VRE) for the treatment of anxiety disorders has received considerable attention (Parsons & Rizzo, 2008). During VRE, a person encounters a feared stimulus in a computer-generated environment, often through the use of a head-mounted display and motion tracker that allows for multisensory input and natural movement. Several advantages of VRE have been noted—both clinical, such as treatment acceptability (Emmelkamp, 2005), and methodological, such as the ability to conduct exposure in a tightly controlled environment (Shiban, Pauli, & Mühlberger, 2013). Two recent meta-analyses conclude that VRE is better than a waiting list control and equally effective as in vivo exposure therapy, both as a stand-alone treatment (Powers & Emmelkamp, 2008) and as part of cognitive behavioral therapy (Opriş et al., 2012). A systematic review of studies, however, highlights that empirical support for VRE varies across anxiety disorders (Meyerbröker & Emmelkamp, 2010). Specifically, randomized controlled trials support the efficacy of VRE with fear of flying (e.g., Rothbaum, Hodges, Smith, Lee, & Price, 2000) and acrophobia (e.g., Emmelkamp et al., 2002) and show that it is equally effective as in vivo exposure. These phobias lend themselves well to VRE; the feared stimulus is circumscribed and contains powerful physical cues that can be produced within a virtual environment. There is less controlled research on the use of VRE for other anxiety disorders. The current study examines VRE for social anxiety disorder, which is characterized by fear of negative evaluation and thus may be more difficult to evoke and treat using a virtual environment.

VRE is effective for reducing symptoms of social anxiety disorder and public speaking fears as shown in case studies (Anderson, Rothbaum, & Hodges, 2003), an open clinical trial (Anderson, Zimand, Hodges, & Rothbaum, 2005), and a study using a matched design (Klinger et al., 2005). Two randomized trials have been conducted. Wallach, Safir, and Bar-Zvi (2009) found that individually administered cognitive behavioral therapy—with and without VRE—was more effective than wait list on most self-report measures and on self-ratings of anxiety during a behavioral task; these gains were generally maintained at 1-year follow-up (Safir, Wallach, & Bar-Zvi, 2012). This study, however, did not utilize participants with a clinical diagnosis of social anxiety

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disorder or report therapist adherence ratings. Bouchard et al. (2011) also reported on a randomized controlled trial that showed that VRE was superior to wait list and equally effective as individually administered in vivo exposure. This work was presented in a very brief report that did not include procedural details or data, making it difficult to evaluate the methodological strengths and weaknesses. The results from these two studies are promising but contain important methodological weaknesses. Further, no research to date has compared VRE and the gold standard treatment for social anxiety disorder—cognitive behavioral therapy in a group format.

The purpose of the current study is to compare VRE and exposure group therapy (EGT; Hofmann, 2004) to wait list in a sample of adults meeting criteria for social anxiety disorder with a primary fear of public speaking. It offers several methodological improvements to Wallach et al. (2009), including use of participants who meet criteria for social anxiety disorder, independent assessment of diagnostic status, independent ratings of therapist adherence and competence, and follow-up assessment of diagnostic status. It also compares the two treatment groups on a number of therapy process variables. It is hypothesized that, relative to wait list, those receiving treatment will improve on standardized measures of public speaking fears and fears of negative evaluation, as well as a behavioral avoidance task. Participants also are expected to maintain treatment gains at 3- and 12-month follow-up. Comparisons between the two active treatments also will be made.

Method

This section was prepared in accordance with guidelines outlined in the CONSORT (consolidated standards of reporting trials) statement (Schulz, Altman, & Moher, 2010).

Participants

Ninety-seven participants meeting criteria for social anxiety disorder (52.6% generalized subtype) were randomly assigned to one of three groups: VRE, EGT, and wait list. Participants were recruited through newspapers ads, flyers, Internet-based outlets, as well as referrals from professionals and other study participants. Inclusion criteria included speakers of English meeting *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., text. rev; *DSM–IV–TR*; American Psychiatric Association, 2000) criteria for a primary diagnosis of social anxiety disorder and self-identifying public speaking as their primary social fear. Participants were required to be stabilized on psychoactive medication(s) and dosage(s) for 3 months. Exclusion criteria were (a) history of mania, schizophrenia, or psychosis; (b) current suicidal ideation, alcohol, or substance dependence; (d) inability to tolerate the virtual reality helmet/environment; (e) history of seizures; (f) concurrent psychotherapy for social anxiety disorder.

Participants ranged from age 19 to 69 years, with an average age of 39.03 (SD = 11.26). The majority of the sample was female (61.9%). Participants self-identified as "Caucasian" (n = 45), "African American" (n = 35), "Hispanic" (n = 4), "Asian American" (n = 2), "Biracial" (n = 2), "Chinese" (n = 1); "African" (n = 1), "Eritrean" (n = 1) "Arabic" (n = 1), and "other" (n = 5). The majority of the sample (61.9%) reported that they had completed college, 43.2% reported an annual income of $50,000 or more, and 43.2% reported being "married." The majority (n = 74; 76.3%) did not have a comorbid diagnosis. Secondary diagnoses included specific phobia (n = 7), major depression (n = 4), generalized anxiety disorder (n = 3), dysthymia (n = 3), panic disorder (n = 2), alcohol abuse (n = 1), and obsessive-compulsive disorder (n = 3).

Measures

Structured Clinical Interview for the *DSM–IV* (SCID; First, Gibbon, Spitzer, & Williams, 1994). The anxiety, mood, and substance disorder modules were administered to assess inclusion and exclusion criteria and comorbidity. The anxiety module of the SCID was administered at the 3-month follow-up assessment to assess remission of social anxiety disorder.

Self-report of public speaking fears. The Personal Report of Confidence as a Speaker (PRCS; Paul, 1966) consists of 30 true/false items measuring public speaking confidence across three dimensions: before, during, and after delivering a speech. Summary scores range from 0 to 30, with higher scores indicating more public speaking discomfort. The PRCS demonstrates good internal consistency, α = .91 (Klorman, Weerts, Hastings, Melamed, & Lang, 1974). Internal consistency for the current study ranged from αs = 0.62–0.94.

Self-report of social anxiety disorder symptoms. The Fear of Negative Evaluation—Brief Form (FNE-B; Leary, 1983) is a 12-item questionnaire measuring the degree to which individuals fear being negatively evaluated by others across a number of social settings. Items are rated on a 5-point scale, and scores range from 12–60, with higher scores representing greater evaluative concerns. The FNE-B has excellent internal consistency (α = .97) and test–retest reliability (r = .94; Collins, Westra, Dozois, & Stewart, 2005). Internal consistency for the current study ranged from αs = 0.88–0.93.

Behavioral avoidance test. The behavioral avoidance test was based on a standardized speech assessment protocol (Beidel, Turner, Jacob, & Cooley, 1989), in which participants are given 3 min to prepare notes on five controversial topics (e.g., abortion, same-sex marriage). Participants are then asked to speak for 10 min on up to three topics and to rate how well they performed (0–10) and how anxious they felt (0–10), with higher numbers indicating better performance and higher anxiety. Audience members consisted of two to four trained undergraduate or graduate students; the therapist was never an audience member.

Ratings of overall improvement. The Clinician Global Impressions of Improvement (CGI; Guy, 1976) is a clinician-rated, global measure of change in severity of symptoms, ranging from 1 (*very much improved*) to 7 (*very much worse*). The CGI-I demonstrates good reliability in a sample of individuals with social anxiety disorder (Zaider, Heimberg, Fresco, Schneier, & Liebowitz, 2003).

Expectancy for treatment outcome. Outcome expectancy was assessed with a four-item questionnaire (Borkovec & Nau, 1972) that has shown good internal consistency ($\alpha > 0.80$; C. T. Taylor & Alden, 2010). Scores range from 4 to 36, with higher scores indicating more positive expectancies. Cronbach's alpha for the current study was α = .75.

Working alliance. The Working Alliance Inventory—Short Form (WAI-SF; Horvath & Greenberg, 1989) is a 12-item instrument used to evaluate the therapeutic alliance. Total scores range from 0 to

84, with higher scores indicating a stronger alliance. The WAI-SF is highly correlated with the original version (Busseri & Tyler, 2003). Internal consistency for the current study ranged from αs = 0.83 – 0.88.

Homework compliance. At the beginning of Sessions 2–8, clinicians rated homework compliance based on a review of completed handouts and readiness to perform in-session activities that relied on the completion of between session homework (i.e., prepared speeches) using the following: "did not understand"; "did not attempt"; "completed, but didn't bring in"; "completed a small part of homework"; "completed at least half of homework"; or "completed homework."

Satisfaction with treatment. The Client Satisfaction Questionnaire (CSQ-8; Attkisson & Greenfield, 1999) includes eight face-valid items rated on a 4-point Likert-type scale to assess client satisfaction with treatment. The authors report high internal consistency (Cronbach's α = .93). Cronbach's alpha for the current study was α = .76.

Procedure

This project was approved by the university's Institutional Review Board. Following consent, study candidates completed a phone interview to screen for obvious exclusion criteria (e.g., current treatment for social anxiety disorder) and then an in-person, pretreatment assessment consisting of the SCID, speech task, and the battery of self-report measures. Eligible participants were randomly assigned to virtual reality exposure therapy, exposure group therapy, or wait list by simple randomization using a computerized random number generator. Concealment procedures were used to prevent foreknowledge of treatment assignment from influencing enrollment. Each potential participant had a participant number, which was only known by the study coordinator. The first author kept a hard copy of a list linking participant number to condition assignment in a locked file drawer. Once a participant was enrolled, the study coordinator asked for the treatment condition for a particular participant number. The first author had no knowledge of which participant was linked with a participant number, and the study coordinator had no knowledge of which participant number was linked with treatment condition. Participants assigned to wait list were rerandomized to virtual reality exposure therapy or exposure group therapy following the waiting period (Figure 1). Participants completed all assessment and treatment sessions at a psychology clinic within at an urban research university that is accessible by public transportation.

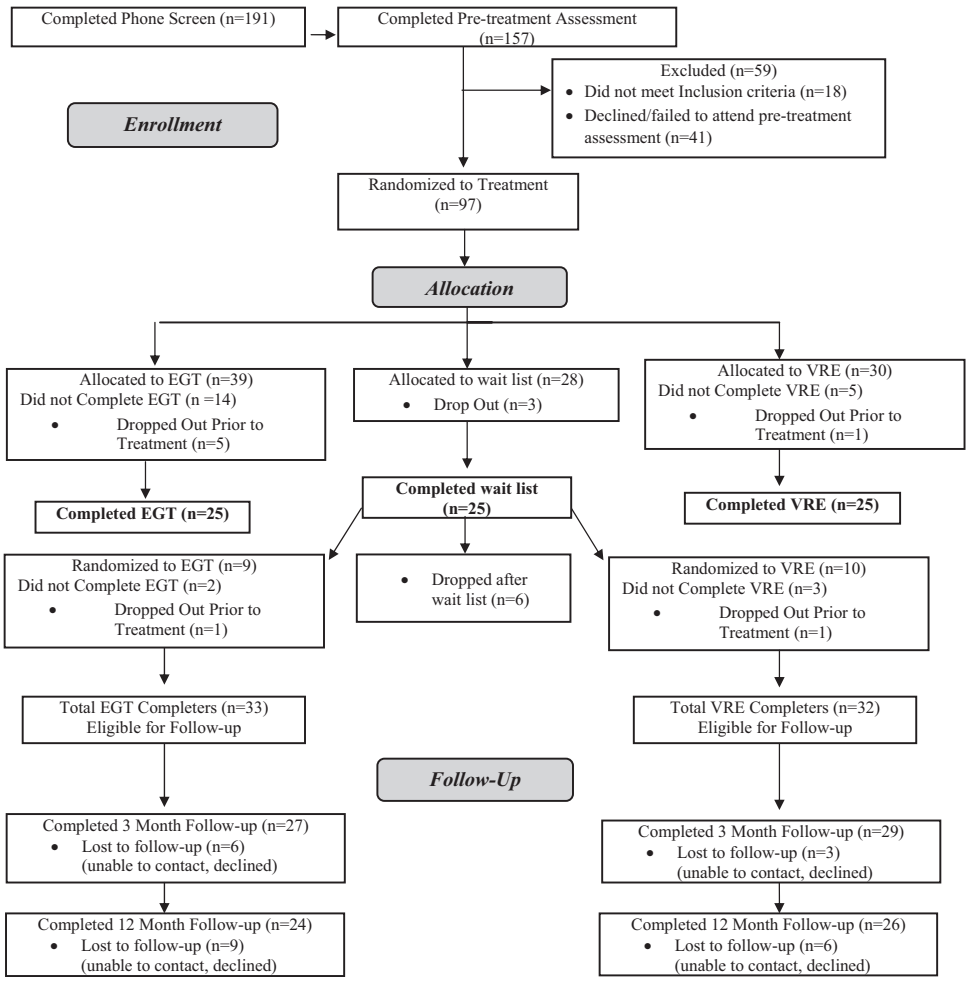

Figure 1. Participant flow chart. EGT = exposure group therapy; VRE = virtual reality exposure.

Assessments

Participants completed assessments at pretreatment, posttreatment, and follow-up. Self-report outcome measures were completed at each assessment point. Participants were asked to complete the behavioral avoidance task at pretreatment and posttreatment. The anxiety, mood, and substance use modules of the SCID were administered at pretreatment, and the anxiety module was administered at the 3-month follow-up. Therapy process measures were administered as following: outcome expectancy following the first session (after the delivery of the treatment rationale); working alliance following each session; homework completion following all sessions but the first; client satisfaction at posttreatment and follow-up.

All assessments were conducted by doctoral students who were blind to the type of treatment to be received. All pretreatment and follow-up diagnostic assessments were videotaped, and a randomly selected subset ($N = 10$) were reviewed by a licensed psychologist to calculate the interrater reliability of pretreatment assessment (100% agreement for primary diagnosis, with one disagreement on severity). Compensation was provided to participants who completed the self-report battery of measures administered at posttreatment, 3- and 12-month follow-up.

Treatment

Prior to administering therapy, study therapists attended 2-day training workshops for each treatment, led by the developers of the respective treatments. Each study therapist also received weekly supervision by the first author. There were five study therapists: two licensed clinical psychologists with experience in manualized treatment and three doctoral students with no experience with manualized treatments. All therapists administered both treatments.

Both treatments were administered according to a manualized protocol for eight sessions (Anderson et al., 2005; Hofmann, 2004). The VRE and EGT treatment groups were designed to be as similar as possible, with the exception of the modality for the delivery of exposure. Both treatments began with a treatment rationale and psychoeducation about social anxiety disorder. During Sessions 2–8, both treatments addressed specific aspects of social anxiety disorder identified in psychopathology literature, including self-focused attention, perceptions of self and others, perceptions of emotional control, rumination, realistic goal setting for social situations through the use of such techniques as cognitive preparation, and challenging of cost and probability biases. Session 8 also included relapse prevention. Homework was assigned for both treatments, including a daily mirror task, daily record of social situations, and identification of cognitive biases.

Virtual Reality Exposure (VRE)

Virtual environments included a virtual conference room (about five audience members), a virtual classroom (~35 audience members), and a virtual auditorium (100+ audience members). Therapists could manipulate audience reactions in a number of ways including making them appear interested, bored, supportive, hostile, distracted (i.e., cell phone ringing). Virtual audience members could also pose questions, either standardized (e.g., "I don't understand, could you explain again") or tailored to the client using therapist voiceover. Virtual environments were manipulated according to the participants fear hierarchy. Participants were exposed to each item on their hierarchy until their fear decreased.

Exposure Group Therapy (EGT)

EGT was conducted by a licensed clinical psychologist and an advanced doctoral student. Groups consisted of up to five participants. During exposure, participants gave a videotaped speech in front of the group. Group members were also asked to provide each other with positive feedback when the videotaped speeches were reviewed.

Every effort was made to equate time in exposure across treatment group. Participants receiving VRE completed four trials of exposure. Because of the risk of simulator sickness (e.g., headaches, nausea), exposure trials lasted no longer than 30 min, for a total of up to 120 min. Participants receiving EGT received six trials of exposure. The amount of time spent on each group member varied according to the number of participants in the group. On average, for a group with four participants, participants completed six trials of exposure for 20 min for a total of 120 min.

Wait List

After 8 weeks, wait list participants completed the self-report battery. Wait list participants were rerandomized to either virtual reality exposure or exposure group therapy following the waiting period and received the same 8-week treatment protocol described above.

Treatment Integrity and Competence

Ratings of adherence and competence in delivering the therapy were provided by the developers of the respective treatments for a randomly selected subset of videotaped sessions (14%). Compliance was good for each treatment, with 92% and 93% of the essential elements of the protocol completed for VRE and EGT, respectively, and one infraction for each treatment group across all sessions reviewed. The skill with which therapists delivered treatments was rated using a 7-point scale (1 = *very poor* to 7 = *excellent*), with a mean quality rating of 6.1 for VRE and 5.4 for EGT, which were not significantly different from one another ($p = .90$).

Data Analytic Plan

Analyses were conducted with an intent-to-treat (ITT) sample of individuals randomized to condition—wait list, EGT, or VRE ($N = 97$). A series of one-way analyses of variance (ANOVAs) were conducted to determine baseline differences among those who dropped out of treatment (27.5%) and those who completed treatment (72.5%). Dropout was defined as having missed two or more sessions of VRE or having missed three or more sessions of EGT. Stricter criteria were used for VRE because of the flexibility with which sessions could be rescheduled for participants randomized to that condition. There were no significant differences between treatment dropouts and completers on any of the demographic factors and pretreatment measures (ps = 0.09 to 0.94), and there were no significant difference between drop out between the

two active treatments: EGT (35.9%) and VRE (16.7%), $\chi^2(1) = 2.23$, $p = .14$. Missing data were handled with Last Observation Carried Forward (LOCF), which has proven a more conservative estimate of treatment effects than other imputation methods (Unnebrink & Windeler, 2001). ITT results are presented in text; ITT and completer results are reported in Tables 1 and 2. Distributions of variables met the assumptions of normality necessary for subsequent analysis. Power analyses used effect sizes from prior meta-analyses (S. Taylor, 1996), which indicated that in order to detect an effect of 0.81 standard deviation units at power of 0.80 with an $\alpha = .05$, a sample of 75 (25 per group) is needed.

The primary outcome analyses were assessed with a two-staged strategy. First, an analysis of covariance with posttreatment scores as outcomes and pretreatment scores entered as a covariate were conducted. Such an approach has been used in prior trials to analyze change with two measurement points (Clark et al., 2006; McGilloway et al., 2012) and has demonstrated greater power when treatment condition is determined through random assignment (Van Breukelen, 2006). Pairwise post hoc comparisons were conducted to identify differences among the three conditions during the treatment phase. Second, a 4 × 2 (Time × Condition) analysis of variance with post hoc comparisons was conducted to identify differences amongst the active treatment conditions during the treatment and follow-up phases of the intervention. Pretreatment, posttreatment, 3-month follow-up, and 12-month follow-up were used as the levels of time in the second step. Although not reported, results for the second step that included the sample of $n = 19$ of individuals rerandomized to treatment after wait list showed an identical pattern of results. Post hoc effect sizes were conducted with a Cohen's *d* using comparisons of posttreatment scores. Dichotomous outcomes, including diagnostic status, were assessed with a chi-square test of independence. A Bonferroni correction of $\alpha = .025$ was applied for significance for all outcomes to account for the use of multiple tests on the primary outcomes based on the number of tests within each category of outcome measure—self-report (PRCS, FNE-B) and behavioral avoidance task (length of speech and peak anxiety during speech).

Results

A series of analyses of variance and of chi-squares showed no differences in pretreatment symptoms (PRCS, FNE-B, length of speech, peak anxiety during speech) across the VRE, EGT, and wait list conditions (*p*s = 0.11 to 0.96) or demographic characteristics (gender, ethnicity, educational achievement, income, relationship status; *p*s = 0.34 to 0.87). Thus, random assignment successfully created three conditions that were comparable at pretreatment with regard to anxiety and demographic factors. Descriptive statistics are provided in Tables 1 and 2.

Comparison Across Virtual Reality Exposure Therapy, Exposure Group Therapy, and Wait List

Self-report measures. An analysis of covariance (ANCOVA) was used to determine outcomes on the PRCS and FNE (Table 1; Figure 2). The results for the PRCS showed a significant main effect for condition, $F(2, 96) = 12.82$, $p < .01$, partial $\eta^2 = 0.22$. Post hoc pairwise comparisons for posttreatment scores suggested that there was a significant difference between VRE and wait list (*M* difference = 5.01, $p = .01$), EGT and wait list (*M* difference = 6.61, $p < .01$), but not between VRE and EGT (*M* difference = 1.60, $p = .42$). For the FNE-B, there was a significant main effect for condition, $F(2, 96) = 4.53$, $p = .01$, partial $\eta^2 = 0.09$. Post hoc pairwise comparisons on posttreatment scores suggested that there was a significant difference between EGT and wait list (*M* difference = 5.28, $p = .01$), but not between VRE and wait list (*M* difference = 2.30, $p = .22$) or between VRE and EGT (*M* difference = 2.98, $p = .09$).

Behavioral avoidance task. An ANCOVA for peak anxiety during the speech task included a significant main effect for

Table 1
ANCOVA Comparing VRE, EGT, Wait List (WL) at Posttreatment Controlling for Pretreatment

Variable	VRE		EGT		Wait list		Main effect for condition		Cohen's *d*	
	Pre	Post	Pre	Post	Pre	Post	*F*	*p*	VRE-WL	EGT-WL
ITT ($N = 97$)										
PRCS	24.37 (2.54)	16.23 (7.61)	25.59 (2.59)	14.79 (8.53)	24.53 (2.73)	23.57 (4.28)	12.82	<.01	1.19	1.30
FNE-B	41.73 (10.22)	39.47 (10.70)	44.67 (8.35)	38.68 (9.31)	42.64 (9.74)	42.45 (10.07)	4.53	.01	0.29	0.39
Speech—Length in min	4.86 (2.93)	5.99 (2.63)	5.11 (2.91)	5.01 (2.70)	4.28 (2.75)	4.00 (2.50)	4.14	.01	0.78	0.39
Speech—Peak anxiety	6.93 (2.41)	6.13 (2.08)	7.42 (2.43)	6.37 (2.82)	7.50 (2.53)	7.68 (2.34)	3.79	.02	0.70	0.51
Completer ($N = 75$)										
PRCS	24.36 (2.68)	14.92 (7.55)	26.30 (2.55)	10.04 (6.25)	24.96 (2.89)	23.88 (4.43)	37.00	<.01	1.45	2.55
FNE-B	40.32 (10.01)	36.96 (9.65)	44.64 (7.79)	35.82 (8.27)	42.88 (9.68)	42.66 (10.07)	8.10	<.01	0.58	0.74
Speech—Length in min	4.68 (3.04)	5.60 (3.04)	5.62 (2.85)	5.56 (2.41)	4.53 (2.78)	3.77 (2.60)	2.28	.11	0.65	0.71
Speech—Peak anxiety	6.92 (2.53)	5.96 (2.11)	7.16 (2.56)	5.52 (2.80)	7.38 (2.66)	7.83 (2.30)	4.96	.01	0.85	0.90

Note. ANCOVA = analysis of covariance; VRE = virtual reality exposure; EGT = exposure group therapy; Pre = pretreatment; Post = posttreatment; WL = wait list; ITT = intent-to-treat; PRCS = Personal Report of Confidence as a Speaker (Paul, 1966); FNE-B = Fear of Negative Evaluation—Brief Form (Leary, 1983). Values in parentheses are standard deviations.

Table 2
4 × 2 (Time × Condition) ANOVA Comparing VRE and EGT at Pretreatment, Posttreatment, 3-Month, and 12-Month Follow-Up

Variable	VRE				EGT				Interaction		Cohen's *d*		
	Pre	Post	3-month	12-month	Pre	Post	3-month	12-month	*F*	*p*	Post	3-month	12-month
ITT (N = 69)													
PRCS	24.37 (2.54)	16.23 (7.61)	16.37 (7.63)	16.10 (7.52)	25.59 (2.59)	14.79 (8.53)	15.28 (8.24)	15.09 (8.04)	0.83	.48	0.18	0.14	0.13
FNE-B	41.73 (10.22)	39.47 (10.70)	38.23 (10.24)	34.73 (10.37)	44.67 (8.35)	38.68 (9.31)	37.64 (10.71)	35.77 (11.10)	0.09	.77	0.08	0.06	0.10
Completer (N = 50)													
PRCS	24.36 (2.68)	14.92 (7.55)	15.08 (7.62)	14.76 (7.42)	26.03 (2.55)	10.04 (6.25)	11.01 (6.38)	10.70 (5.74)	5.81	.01	0.70	0.58	0.61
FNE-B	40.32 (10.01)	36.96 (9.65)	35.48 (8.56)	31.28 (7.02)	44.64 (7.79)	35.82 (8.27)	34.19 (10.10)	31.28 (9.56)	2.79	.04	0.13	0.14	0.00

Note. ANOVA = analysis of variance; VRE = virtual reality exposure; EGT = exposure group therapy; Pre = pretreatment; Post = posttreatment; ITT = intent-to-treat; PRCS = Personal Report of Confidence as a Speaker (Paul, 1966); FNE-B = Fear of Negative Evaluation—Brief Form (Leary, 1983). Values in parentheses are standard deviations.

Figure 2. Difference scores (Pretreatment − Posttreatment) for self-report measures and speech task. Error bars correspond to 95% confidence intervals. VRE = virtual reality exposure; EGT = exposure group therapy; WL = wait list; PRCS = Personal Report of Confidence as a Speaker (Paul, 1966); FNE-B = Fear of Negative Evaluation—Brief Form (Leary, 1983).

condition, $F(2, 96) = 3.79$, $p = .021$, partial $\eta^2 = 0.08$. Post hoc pairwise comparisons for posttreatment scores suggested that there was a significant difference between VRE and wait list (M difference = 1.21, $p = .020$), EGT and wait list (M difference = 1.26, $p = .01$), but not between VRE and EGT (M difference = 0.05, $p = .91$). Similar effects were observed for the length of the posttreatment speech as shown by a significant main effect for condition, $F(2, 96) = 4.14$, $p = .01$, partial $\eta^2 = 0.09$. Post hoc pairwise comparisons for posttreatment scores suggested that there was a significant difference between VRE and wait list (M difference = 1.78, $p < .01$) but not between EGT and wait list (M difference = 0.71, $p = .24$), and not between VRE and EGT (M difference = 1.08, $p = .07$).

Comparing Virtual Reality Exposure Therapy to Exposure Group Therapy: Outcomes at Posttreatment and Follow-Up

Self-report measures. A 4 × 2 (Time × Condition) ANOVA was used to compare differences between VRE and EGT across pretreatment, posttreatment, 3-month follow-up, and 12-month follow-up (Table 2). For the PRCS, there was a significant main effect for Time, $F(3, 201) = 61.07$, $p < .01$, partial $\eta^2 = 0.48$, but not for condition, $F(3, 67) = 0.06$, $p = .81$, partial $\eta^2 = 0.01$, or for the Time × Condition interaction, $F(3, 201) = 0.83$, $p = .48$, partial $\eta^2 = 0.01$. For the FNE-B, there was a significant main effect for Time, $F(3, 201) = 25.76$, $p < .01$, partial $\eta^2 = 0.28$, but not for condition, $F(3, 67) = 0.09$, $p = .77$, partial $\eta^2 = 0.01$, or for the Time × Condition interaction, $F(3, 201) = 1.77$, $p = .19$, partial $\eta^2 = 0.03$. These findings suggest that there were no differences amongst the treatment conditions during treatment and follow-up but that scores declined from pretreatment through follow-up (Figure 3).

Clinician ratings of global improvement. At posttreatment, there was not a significant difference between EGT ($M = 1.90$) and VRE ($M = 1.90$) in clinician ratings of improvement following the final treatment session, $F(1, 68) = 0.03$, $p = .86$.

Diagnostic status at follow-up. A chi-square test of independence suggested that there was no significant difference between

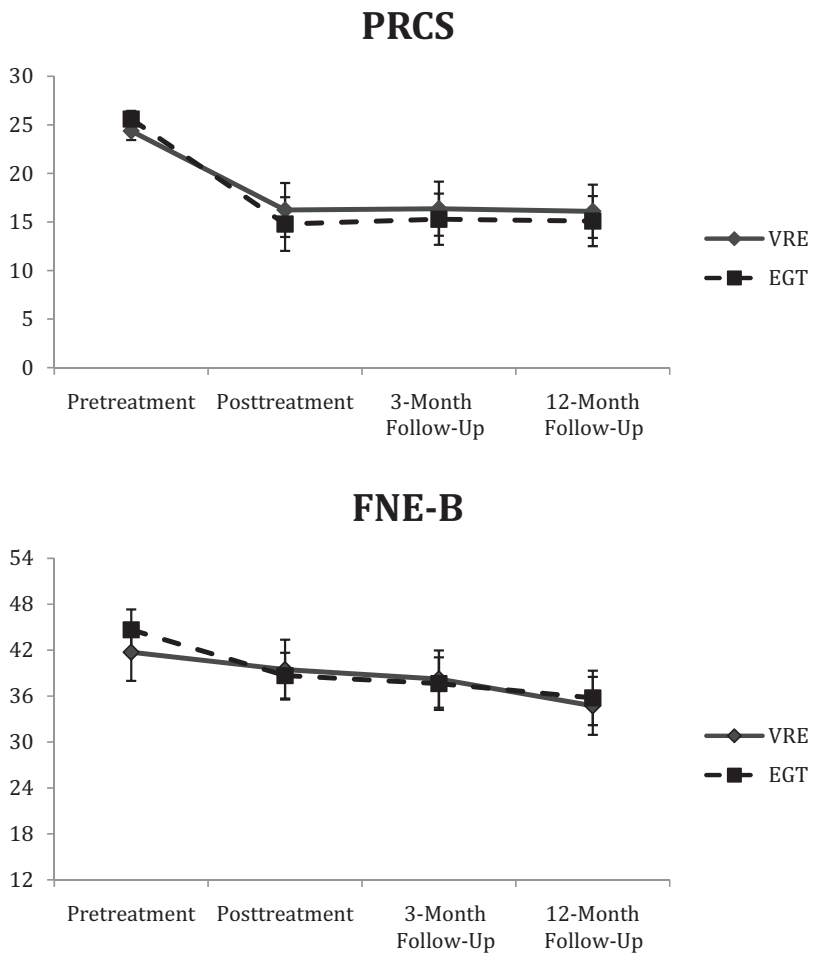

Figure 3. Scores on pretreatment, posttreatment 3-month follow-up, and 12-month follow-up for EGT and VRE. Error bars correspond to 95% confidence intervals. PRCS = Personal Report of Confidence as a Speaker (Paul, 1966); FNE-B = Fear of Negative Evaluation—Brief Form (Leary, 1983); VRE = virtual reality exposure; EGT = exposure group therapy.

treatment conditions in rates of full remission (VRE = 25.0%; EGT = 47.6%), partial remission (VRE = 37.5%; EGT 38.1%), and those who still met full criteria for a diagnosis (VRE = 37.5%; EGT = 14.3%) at 3-month follow-up $\chi^2(2) = 3.88$, $p = .14$, $\varphi = 0.29$ ($n = 44$).

Comparing Virtual Reality Exposure Therapy and Exposure Group Therapy: Process Measures

Outcome expectancy. Participants in both treatments reported high expectations for a positive outcome following the first session, with no differences between the VRE ($M = 28.33$) and EGT ($M = 30.71$) conditions, $F(1, 65) = 3.11$, $p = .12$, $d = 0.48$.

Working alliance. Working alliance ratings were high for both treatments, ranging from $M = 73.65$ to $M = 79.52$ (EGT) and from $M = 75.07$ to $M = 80.41$ (VRE) across sessions. There was no observed differences between the EGT and VRE conditions on the working alliance inventory across all eight sessions, Fs(1, 83) = 0.01 to 1.43, $p = .24$ to .94, ds = 0.02 to 0.33.

Homework compliance. Homework completion was operationalized as having finishing half or more of homework, and it ranged from 37% to 75% across sessions. Differences in homework completion between treatment groups was significant for Session 3, which consisted of completing a daily mirror task (VRE: 88.6%, EGT: 58.6%), $\chi^2(2) = 7.59$, $p = .006$, $\varphi = 0.34$. Significant differences were not observed at Session 2 (VRE: 91.2%, EGT 66.7%), Session 4 (VRE: 70.6%; EGT: 56.7%), Session 5 (VRE: 72.4%; EGT: 67.7%), Session 6 (VRE: 73.3%; EGT: 45.2%), Session 7 (VRE: 58.6%; EGT: 48.4%), and Session 8 (VRE: 63.0%; EGT: 50.0%), $\chi^2(2) = 0.83$ to 4.76, $p = .09$ to .659, $\varphi = 0.12$ to 0.28.

Treatment satisfaction. Finally, participants were very satisfied with treatment, with no differences across groups at posttreatment, VRE: $M = 27.25$, $SD = 2.09$; EGT $M = 26.40$, $SD = 2.43$; $F(1, 47) = 1.72$, $p = .20$, $d = 0.38$, and at 12-month follow-up, VRE: $M = 25.46$, $SD = 3.89$; EGT: $M = 25.75$, $SD = 3.22$; $F(1, 46) = 0.08$, $p = .78$, $d = 0.08$.

Discussion

A recent systematic review of VRE for anxiety disorders concluded that the current status of VRE research for anxiety disorders is "sobering" (Meyerbröker & Emmelkamp, 2010). That is, rigorous research with controlled designs is necessary to see if the benefit of VRE shown for specific phobias is also true for other anxiety disorders, such as social anxiety disorder. The results from this randomized clinical trial are a step in this direction, showing that VRE is effective for reducing public speaking fears among those diagnosed with social anxiety disorder. Data from all sources show that VRE is beneficial relative to wait list, including improvement on a standardized self-report measure of public speaking anxiety and on all aspects of the posttreatment speech. Furthermore, improvement is maintained at 1 year. These results are consistent with other research on VRE for social anxiety disorder that did not use random assignment (Anderson et al., 2003, 2005; Klinger et al., 2005). The results from this study also are consistent with the only randomized controlled trial testing VRE for public speaking fears (Wallach et al., 2009) and offers important methodological advantages, including the use of a clinical sample of people diagnosed with social anxiety disorder. Thus, the results increase confidence that VRE can effectively be used for exposure to a social fear, public speaking, within the context of social anxiety disorder.

Results from this study also show that exposure in the virtual world changed behavior in the real world. Relative to wait list, VRE participants reported less peak anxiety and spoke longer at the post treatment speech. These results are consistent with prior research examining in vivo behavioral avoidance tasks following VRE (e.g., Emmelkamp et al., 2002). One exception is that of Wallach et al. (2009), which showed no differences between wait list and VRE, although this research used a virtual audience for the speech.

Does VRE reduce symptoms of social anxiety disorder? The results from this study are somewhat mixed. Relative to wait list, those receiving VRE did not show improvement on self-reported fear of negative evaluation, a core feature of the disorder at posttreatment. However, at follow-up, there was improvement on this measure, relative to pretreatment. Furthermore, 63% of those assessed at 3-month follow-up achieved either partial or full remission of diagnostic status. These results bear on a question not often asked of VRE: Can fear reduction following VRE to a particular feared stimulus within a disorder (e.g., public speaking among those with social anxiety disorder) generalize to other disorder-relevant fears and the disorder itself? This is an important area for future research as VRE is increasingly used to treat anxiety disorders other than specific phobia (e.g., social anxiety disorder, posttraumatic stress disorder), particularly in light of research on the generalization of safety learning (e.g., Otto, Smits, & Reese, 2005) and evidence that generalization is influenced by the match between the context of extinction learning and the real world (Bouton, Woods, Moody, Sunsay, & Garcia-Gutiérrez, 2006).

The two active treatments (VRE and EGT) showed similar improvement on most metrics of outcome—self-report measures, peak anxiety on a behavioral avoidance task, clinician-reported global improvement, diagnostic status, and maintenance of gains at follow-up and all metrics of process. There were only two differences between the active treatments with regard to improvement. First, relative to wait list, those receiving VRE (but not EGT) spoke longer during the speech task; there were no differences, however, between VRE and EGT on length of speech. Second, those receiving EGT (but not VRE) improved on FNE-B scores (relative to wait list), but there were no differences between the VRE and EGT. These findings are generally consistent with prior research comparing VRE to in vivo exposure across a variety of anxiety disorders, in which there have been no differences between VRE and in vivo exposure, including specific phobia (e.g., Rothbaum et al., 2002), panic disorder and agoraphobia (e.g., Botella et al., 2007), and social fears (e.g., Wallach et al., 2009). These results (that virtual reality is as efficacious as in vivo exposure) are intriguing because the feared consequence (e.g., being negatively evaluated by others, being in a plane crash) is simply not possible within the virtual environment. Future research must explore mechanisms of virtual reality exposure therapy, such as whether virtual reality exposure therapy influences cognitive processes proposed to be central to social anxiety disorder (Clark & Wells, 1995; Hofmann, 2007).

Although the current study examined differences between EGT and VRE with analysis of variance, the hypothesis that there are no differences between the treatments is best addressed with noninferoriority or equivalence testing (Piaggio, Elbourne, Altman, Evans, 2006). The current trial was not sufficiently powered to conduct such analyses, which would require a completer sample size of $N = 788$ ($n = 394$ per group) to determine noninferoriority between the two conditions at a small effect size of $d = 0.20$. Thus, additional work is needed to draw firmer conclusions as to the equivalency of VRE and EGT for social anxiety disorder.

It is interesting that the completer sample (compared to the intent-to-treat sample) shows larger effect sizes for EGT than for VRE (see Tables 1 and 2). And, although not statistically different, fewer people continued to meet criteria for a diagnosis of social anxiety disorder at 3-month follow-up following EGT (14.3%) than VRE (37.5%). But more people dropped out of EGT (35.9%) than VRE (16.7%), although this difference is not statistically significant. Therapist notes were reviewed to try to decipher the reasons for attrition. We could not determine reasons for drop out for anyone assigned to VRE. Nor could we determine reasons for drop out for most people assigned to EGT, with the following exceptions: two people reported scheduling conflicts, one person did not come because she wanted to be in the VR condition, and for two participants, therapist notes indicated that the group was too challenging. Perhaps those who complete EGT are likely to benefit more from treatment than those who complete VRE, but perhaps people are also more likely to drop out of EGT. This question cannot be answered by the current study and is an area for future research.

Indeed, a primary limitation of the study is a function of the inherent difficulty of equating two treatments delivered in different formats—VRE as an individual treatment and EGT as a group treatment. A group treatment (Hofmann, 2004) was selected because it is the "gold standard" for treating social anxiety disorder. EGT was selected because it utilized exposure for public speaking fears only, and thus was most equivalent to the virtual environments that consisted of only public speaking scenarios. Although we strove to minimize differences, the interpersonal nature of the group itself cannot be discounted. Participants in EGT worked

with two therapists instead of one and received feedback from multiple people after exposure; participants in VRE worked with only one person: a therapist. Thus, participants in EGT may have received a stronger "dose" of exposure than those in VRE. To adequately address this issue, VRE would need to be compared to some other individually administered treatment that can equate these factors. The Wallach et al. (2009) utilized this approach and found no differences between the treatments. The difficulty in comparing similar treatments delivered across different modalities (such as VRE and EGT, or traditional in-person therapy and Internet-delivered therapy) is one we must address. Such research should examine not only the relative efficacy but also the relative acceptability, accessibility, and cost-effectiveness of treatments. With the increasing interest in various forms of technology for treatment, such research can inform the scientific community about how to best disseminate treatments that work, and inform the public about the potential trade-offs between access and efficacy.

This study is one of the first studies to examine process variables within virtual reality exposure therapy and compare them to in vivo exposure. There were no differences between treatment groups on any process variables: outcome expectancy, working alliance, homework compliance (except Session 3), and treatment satisfaction. The working alliance is of particular interest, as some scholars suggest that because the head mounted display precludes eye contact during virtual reality exposure therapy, the working alliance may be inhibited (Meyerbröker & Emmelkamp, 2008). Results from the current study show there were no differences in the working alliance across treatment groups. This research is very much in its infancy, and further work is needed in this area, not only comparing process variables across treatments but also how process variables function within virtual reality exposure therapy.

There are some limitations of generalizability for the study. The inclusion criteria specified that fear of public speaking must be the primary social fear, and others have argued that public speaking anxiety may be a specific subtype of social anxiety disorder (Blöte, Kint, Miers, & Westenberg, 2009). Also, the comorbidity in the current sample (12%) is lower than what is typically found for individuals with social anxiety disorder, although it is comparable to other research utilizing Internet-based or virtual reality for public speaking fears (7%−12.5%; Andersson et al., 2006; Botella et al., 2008). Finally, although the ethnic/racial diversity in the current sample represents the diverse community in which the study was conducted, such populations are underrepresented in treatment efficacy research (Whaley & Davis, 2007), including virtual reality exposure therapy.

Despite these limitations, this is the first randomized clinical trial to compare virtual reality exposure therapy to a "gold standard" treatment among people diagnosed with social anxiety disorder. Virtual reality exposure therapy appears effective for treating social anxiety disorder for those with public speaking fears. Further research is needed to determine whether it is equally effective as in vivo exposure administered in a group.

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