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Virtual reality in the treatment of spider phobia: a controlled study

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Abstract

This study explored whether virtual reality (VR) exposure therapy was effective in the treatment of spider phobia. We compared a treatment condition vs. a waiting list condition in a between group design with 23 participants. Participants in the VR treatment group received an average of four one-hour exposure therapy sessions. VR exposure was effective in treating spider phobia compared to a control condition as measured with a Fear of Spiders questionnaire, a Behavioural Avoidance Test (BAT), and severity ratings made by the clinician and an independent assessor. Eighty-three percent of patients in the VR treatment group showed clinically significant improvement compared with 0% in the waiting list group, and no patients dropped out. This study shows that VR exposure can be effective in the treatment of phobias.

Keywords: Virtual reality; Exposure therapy; Spider phobia

1. Introduction

An estimated 10–11% of the US population experiences a specific phobia at some point in their lives, (American Psychiatric Association, 1994; Magee, Eaton, Wittchen, McGonagle & Kessler, 1996). Approximately 40% of specific phobias belong to the category of "bugs (including

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spiders), mice, snakes or bats" (Chapman, 1997). Spider phobics characteristically display a persistent fear of spiders, an immediate anxiety response upon exposure to a spider, and avoidance of spiders. Phobics often recognize that their fear is excessive or unreasonable (American Psychiatric Association, 1994). In fact, for some, fear of the irrational reaction they will have when encountering a spider (losing control, panic attack) is a major source of their anxiety. Consistent with Rachman's theory (1976, 1977) about the acquisition of phobias, Ost and Hugdahl (1981) found that the majority of phobics reported acquiring their fear via conditioning (58%). Others reported instruction (e.g. by their parents) as the source of their phobia (10%), acquired their fear vicariously (15%), or couldn't remember (10%).

'In vivo' exposure therapy has been used successfully with a wide range of phobias including fear of spiders (Craske & Rowe, 1997; Marks, 1987; Ost, 1997) and is considered to be the treatment of choice for specific phobias (Antony & Swinson, 2000; Marks, 1987; Mathews, 1978). With in vivo therapy for spider phobia, patients gradually and systematically approach closer to a live spider over a period of several one-hour sessions. Some researchers have had great success treating spider phobics in an accelerated single massed three-hour in vivo exposure session, both with individuals and group sessions (see Ost, 1997 for a review). However, the experience is likely more distressing for the patients than multiple sessions distributed over a period of days, weeks or months. In general, for patients motivated enough to seek therapy for their phobia, single session in vivo exposure therapy has a high success rate (Ost, 1996), and fear reduction tends to be long term, with low relapse rates. Imagery exposure therapy, having the patient imagine situations involving spiders, can also be effective (Hecker, 1990), but is limited by the fact that some patients have trouble imagining spiders, and/or the imagined spiders do not elicit sufficient anxiety to be valuable.

Unfortunately, around 60–85% of those afflicted with specific phobias never seek treatment for their problem (Agras, Sylvester, & Oliveau, 1969; Boyd et al., 1990; Magee et al., 1996). Many phobics are probably too afraid of confronting the feared object or situation to seek therapy (Marks, 1992). Now that researchers and therapists have succeeded in developing and testing effective ways of treating phobias, new efforts are needed to increase the number of phobia sufferers who seek treatment.

In a recent study, Garcia-Palacios, Hoffman, Kwong See, Tsai, & Botella (2001) surveyed a total of 777 undergraduate students. Participants read a brief general description of how exposure therapy works, and were asked about their willingness to get involved in two different ways of applying the therapy to spider phobia, in vivo exposure or virtual reality (VR) exposure. Garcia et al. found that people high in fear of spiders (over one SD above the sample mean on a fear of spiders questionnaire) strongly preferred VR exposure treatment (81% in study 1 and 89% in study 2) compared to in vivo exposure therapy. Furthermore, in study 2, only 8% of fearful students said they would 'absolutely not' be willing to come in for three, one-hour VR exposure therapy sessions, whereas 34% of fearful students said 'absolutely not' to one massed three-hour in vivo therapy session.

Immersive VR works as follows. The subject dons a 'VR Helmet' that positions two goggle sized TV screens close to the user's eyes. Each eye gets a slightly different image of the virtual world. The image shown to the left eye is offset slightly from that seen by the right eye. The brain fuses these two images into a single 3-D image, helping to give users the illusion that the virtual environment has depth. Position tracking devices keep the computer informed of changes

in the user's head and hand locations. The scenery in VR changes as the user moves his/her head orientation (e.g. virtual objects in front of the user in VR get closer as the user, wearing his/her VR helmet, leans forward in the real world). Any one of these techniques alone might be unconvincing, but combined, they give users a uniquely compelling experience of 'being there' in the virtual world. The essence of immersive VR is the illusion it gives users that they are inside the computer-generated environment, as if they are 'there' in the virtual world. In the present study, the place our patients visited was a virtual kitchen, and the virtual object they picked up was the plump furry body of a virtual Guyana bird-eating tarantula.

To make VR more convincing, tactile augmentation can enhance the quality of the virtual world. With this technique, real objects are used as props in the interaction with 3-D VR graphics (Hoffman, 1998; Hoffman et al., 1996; Hoffman, Holander, Schroder, Rousseau, & Furness, 1998). Pilot studies and case reports suggest that VR exposure therapy can be an effective medium for the reduction of specific phobias such as fear of heights (Rothbaum et al., 1995), fear of flying (Hodges, Rothbaum, Watson, Kessler, & Opdyke, 1996), claustrophobia (Botella et al., 1998; Botella, Baños, Villa, Perpiñà, & Garcia-Palacios, 2000) and spider phobia (Carlin, Hoffman, & Weghorst, 1997). Recent controlled studies have shown that VR exposure therapy was as effective as in vivo exposure to treat flying phobia (Rothbaum, Hodges, Smith, Lee, & Price, 2000) and fear of heights (Emmelkamp et al., in press).

The present study is the first controlled study to test whether immersive VR exposure therapy is effective for treating spider phobia. We compared the effectiveness of VR exposure vs. a waiting list condition. Practical implications of our findings are discussed.

2. Method

2.1. Participants

Participants were recruited from different sources: (a) mass testing in an introductory Psychology class; (b) through advertisements in the University newspaper and (c) from people who contacted us requesting treatment for their fear of spiders. Participants from mass testing completed a fear of spiders questionnaire (Szymanski & O'Donohue, 1995). Students scoring over two standard deviation above the class mean in fear of spiders (i.e. a score greater than 97) were invited to undergo exposure therapy for fear of spiders. These students received extra credit in their class for participating. Thirty participants were invited. To participate in the study, subjects had to meet the following criteria: (1) meet DSM-IV (American Psychiatric Association, 1994) criteria of Specific Phobia, Animal Type (spiders) according to the judgement of two clinical Psychologists, one of them, blind to the conditions of the study; (2) a minimum of one-year duration of the phobia; (3) patient must not be able to remove the lid of a cage with a tarantula prior to treatment, during the Behavioural Avoidance Test (BAT); (4) have no other psychiatric problem in immediate need of treatment; (5) no current alcohol or drug dependence; (6) no severe physical illness.

Twenty-three participants met the inclusion criteria and took part in the study. Of the thirty persons invited to participate, four were excluded from the experiment because they did not meet the DSM-IV criteria for Specific Phobia according to the judgement of the interviewer or of a

blind clinician who made a diagnostic judgement after listening to the interviews. Three more participants were excluded because they were able to remove the lid during the BAT.

The average age was 29.25 years (SD=10.79; range 18–58). Most participants were female (90.9%) and only 9.1% were male. The mean reported duration of their fear was 21 years (SD=11.76; range 6–50 years). One participant had received previous psychological treatment for fear of spiders without success.

2.2. Equipment

A Silicon Graphics[1] Octane MXE with Octane Channel Option (allowing stereo vision) coupled with a relatively wide field-of-view (60° diagonal) head mounted visual display (www.VirtualResearch.com) V8 helmet was used to create an immersive, 3-D, interactive, computer-simulated environment. A Polhemus™ Fastrak position tracking system was used to measure the position of the user's head and hand position, and the location of the virtual spider. The patients experienced SpiderWorld, a modified version of KitchenWorld[2].

2.3. Measures

2.3.1. Anxiety Diagnostic Interview Schedule IV (ADIS-IV)

During this ADIS-IV (Di Nardo, Brown, & Barlow, 1994), the patient was asked about each criteria of DSM-IV specific phobia, animal type (American Psychiatric Association, 1994). We also obtained information on demographic and clinical variables: the duration of the problem, severity of the phobia as perceived by the patient, former treatments, and presence of other psychological or physical problems.

2.3.2. Fear of spiders questionnaire

This questionnaire (Szymanski & O'Donohue, 1995) was chosen as a subjective measure of the efficacy of VR treatment. Previous researchers have found this questionnaire to have excellent split half reliability and internal consistency, good test–retest consistency, convergent validity due to its highly significant correlations with a BAT (r=0.65, $p<0.001$), and construct validity in its ability to discriminate phobics from non-phobics as measured by a BAT (O'Donohue & Szymanski, 1993; Szymanski & O'Donohue, 1995; see also Muris & Merckelbach, 1996). The questionnaire has 18 items rated on a 1–7 scale (1=does not apply to me, 7=very much applies to me) about fear and avoidance regarding spiders.

2.3.3. Behavioural Avoidance Test (BAT)

The BAT is a popular objective measure of clinical progress in overcoming phobias. A large spider (tarantula) was placed in a glass cage with a lid. The cage was placed on a table at the far end of a room 5 m from the entrance. The patient was instructed to enter the room, walk up to the cage and remove the lid. Participants were informed that the BAT was an objective measure

[1] Silicon Graphics, Inc. 2011 N. Shoreline Blvd. Mountain View, CA 94043, USA, http://www.sgi.com
[2] Division Incorporated, 1400 Fashion Island Blvd, Suite 510, San Mateo, CA 94404, http://www.division.com/

of how afraid they were of spiders and not part of the therapy. During the test, the experimenter remained just outside the door of the room to minimize the possible impact of his presence. When the participants approached as close to the spider as they could, the distance in meters from the participant to the spider was measured, and participants rated their anxiety using the subjective units of discomfort scales (Wolpe, 1969). The distance measure was converted to a behavioural score that ranged from 0 to 8; where 0=refuses to enter the room, 1=stops 5 m from the container, 2=stops 4 m from the container, 3=stops 3 m from the container, 4=stops 2 m from the container, 5=stops 1 m from the container, 6=stops close to the container, 7=touches the container, 8=removes the lid. After the BAT, the experimenter, who was blind to the experimental condition to which the patient belonged, rated the severity of the patient's phobia on a scale from 0 to 8; where 0=free of symptoms and 8=extremely disabling.

2.3.4. Clinician rating

This scale was the same as that used by Ost, Stridh and Wolf (1998). The clinician rated the severity of the patient's phobia on a scale from 0 to 8 where 0=symptom free and 8=extremely severe and disabling, all aspects of life affected.

2.3.5. Clinically significant improvement

We choose our criteria to decide when a patient had achieved a clinically significant improvement following Ost et al. (1998) criteria, based on the Jacobson, Follette, & Revenstorf (1984) guidelines. To meet the criterion for a clinically significant improvement in spider phobia, the change from pre- to post-treatment must be statistically significant and the post-test score must be within the range of a normal sample or outside the range of the patient group, that is, $M \pm 2SD$ in the direction of functionality.

BAT score (0–8): The change must be 2 points and the cut-off score 7 (touching the container).
BAT assessor rating of phobic severity (0–8): The change must be 2 points and the cut-off score 4.
Clinician rating of phobic severity (0–8): The change must be 2 points and the cut-off score 4[3].
Fear of spiders questionnaire: The score must be outside the range of the patient group, that is, $M \pm 2SD$ in the direction of functionality. The mean was 98.65 and the standard deviation was 15.73. The cut-off score was 67.

2.4. Procedure

During the pre-treatment assessment, participants were interviewed to determine if they met criteria for specific phobia, animal type, spiders (DSM-IV, American Psychiatric Association, 1994) using the structured interview ADIS-IV (Di Nardo et al., 1994). These interviews were

[3] We used two measures of severity, the assessor rating during the BAT and the clinician rating. It could be argued that those measures are too similar. The reason for doing so was to control assessor's bias. The measure during BAT was done by an independent assessor, blind to the experimental conditions and the clinician rating was done by the clinicians who carried out the diagnostic interviews and the treatments and who were aware of the experimental condition the participants belonged to.

audiotaped and another clinician, blind to the study, made a diagnosis. Then patients completed a questionnaire assessing their fear of spiders, and were given the BAT. The participants who satisfied the entry criteria were randomly assigned to one of the two conditions: VR exposure group or waiting list control group.

During the post-treatment assessment, participants were given the same measures as pre-treatment except the diagnostic interview. Participants in the waiting list group went through the two assessment sessions within one or two weeks with no treatments between assessments. Afterwards they were offered treatment. The participants in the treatment group received several one-on-one clinical VR exposure therapy sessions for treatment of spider phobia. Each session lasted approximately one hour and participants completed all sessions and the post-treatment assessment within two or three weeks of beginning treatment.

2.4.1. Treatment

Treatment consisted of a standardized exposure protocol delivered by two experienced clinical psychologists trained in Experimental Psychology (authors A.G. and A.C.). The treatment was composed of gradual exposure tasks. There was no fixed number of sessions. We established a criterion to define the completion of treatment. To have completed treatment the patient must be able to achieve a final exposure goal, holding a big virtual spider with tactile feedback while reporting low levels of anxiety. The average number of sessions to achieve this goal was four and it ranged from 3 to 10. On the first sessions, participants saw a virtual spider in a virtual kitchen and approached as closely as they could using their 3-D wand to navigate through the virtual world. The goal was to come within arms reach of the virtual spider. During the following session/s, participants touched the virtual spider with their cyber hand (with no tactile feedback). The virtual spider responded to being touched by fleeing. Patients then picked up a virtual 'spider vase' with their cyberhand. When they let go of the virtual vase, an animated spider with wiggly legs drifted to the floor of the virtual kitchen accompanied by a brief sound effect from the movie Psycho. Participants repeated this task until they reported little anxiety. During the last therapy sessions, the participants were encouraged to touch the virtual spider image with their cyberhand. Participants reached out their cyberhand and physically touched the visual image of the wiggly legged virtual Guyana bird-eating tarantula. As the patients reached out with their cyberhand to explore the virtual spider, their real hand explored the toy spider attached to a stationary Polhemus position sensor. The virtual spider now felt furry and solid (Hoffman, 1998).

2.5. Results

2.5.1. Pre-treatment tests

No differences were found between the waiting list condition and the treatment condition at pretreatment in demographic and clinical variables: age, t (19) =0.67, $p>0.05$, NS, duration of the fear, t (18) =0.89, $p>0.05$, NS, and level of perceived impairment, t (21) =1.31, $p>0.05$, NS. The t-tests showed no significant differences between the two groups with respect to the measures of the behavioural avoidance test at pretreatment: avoidance, t (21) =1.71, $p>0.05$, NS, level of anxiety reported during the bat, t (21) =0.78, $p>0.05$, NS, and independent assessor rating of phobic severity on the bat, t (21) =0.78, $p>0.05$, NS. With regard to other measures, no differences between the two groups were found in the subjective measure of fear of spiders (FSQ) at pretreat-

ment, t (21) =0.39, $p>0.05$, NS, nor in the clinician rating of phobic severity, t (21) =0.21, $p>0.05$, NS.

2.5.2. Pre-Post tests

We conducted a 2 (group) by 2 (time=pre- vs. post-treatment) repeated measures ANOVA for each outcome measure to test the effectiveness of VR exposure. Means and standard deviations at the pre- and post-test assessments are shown in Table 1.

2.5.2.1. Score on the BAT For the BAT, the ANOVA regarding avoidance showed a significant Group effect, $F(1,21)=17.10$, $p<0.001$, MSe=7.37, with an effect size of 0.45, a significant Time effect $F(1,21)=25.25$, $p<0.001$, MSe=2.08, with an effect size of 0.55, and a significant Group by Time interaction $F(1,21)=17.40$, $p<0.001$, MSe=2.08, with an effect size of 0.45. The interaction indicates that the groups differed in amount of improvement. As shown in Table 1, the VR exposure group showed greater improvement than the waiting list group.

2.5.2.2. Anxiety during the BAT The mixed-model ANOVA showed no significant Group effect, $F(1,21)=1.29$, NS, with an effect size of 0.06, a significant Time effect $F(1,21)=18.23$, $p<0.001$, MSe=284.79, with an effect size of 0.48, and a significant Group by Time interaction $F(1,21)=5.99$, $p<0.05$, MSe=284.79, with an effect size of 0.23. The interaction indicates that the VR treatment group showed significantly greater reduction in anxiety than the control group.

Table 1
Mean and standard deviations for the outcome measures at pre- and post-treatment (note: VRE=Virtual Reality Exposure; WL=Waiting List; BAT=Behavioural Avoidance Test)

	VRE (N=12)		WL (N=11)	
Variable	*M*	SD	*M*	SD
BAT score				
Pretreatment	3.08	2.19	1.54	2.12
Postreatment	7.00	2.29	1.90	2.07
BAT anxiety				
Pretreatment	82.36	14.44	76.73	14.03
Postreatment	48.18	27.59	67.45	14.01
BAT assessor rating				
Pretreatment	6.79	0.89	6.50	0.89
Postreatment	1.74	2.11	6.27	0.65
Fear of spider questionnaire				
Pretreatment	97.42	17.51	100.00	14.25
Postreatment	57.42	19.07	97.09	13.44
Clinician rating				
Pretreatment	6.08	1.24	6.18	0.98
Postreatment	2.42	1.68	5.91	0.94

2.5.2.3. Independent assessor rating of phobic severity on the BAT The ANOVA showed a significant Group effect, $F(1,21)=22.23$, $p<0.001$, MSe=2.32, with an effect size of 0.51, a significant Time effect $F(1,21)=79.89$, $p<0.001$, MSe=1.00, with an effect size of 0.79, and a significant Group by Time interaction $F(1,21)=66.72$, $p<0.001$, MSe=1.00, with an effect size of 0.76. Again, these results revealed that the VR treatment group showed significantly greater reduction than the waiting list group in the severity perceived by an independent assessor on the BAT.

2.5.2.4. Fear of spiders questionnaire A mixed-model ANOVA regarding this measure showed a significant Group effect, $F(1,21)=14.09$, $p<0.001$, MSe=363.68, with an effect size of 0.40, a significant Time effect (pre-treatment vs. post-treatment), $F(1,21)=31.07$, $p<0.001$, MSe=170.07, with an effect size of 0.60, and a significant Group by Time interaction $F(1,21)=23.21$, $p<0.001$, MSe=170.07, with an effect size of 0.53. The interaction reveals that the amount of fear of spiders reduction was not the same for each group. The treatment group achieved greater improvement than the waiting list control group.

2.5.2.5. Clinician rating of phobic severity The analysis showed a significant Group effect, $F(1,21)=14.67$, $p<0.001$, MSe=2.52, with an effect size of 0.41, a significant Time effect, $F(1,21)=69.67$, $p<0.001$, MSe=0.64, with an effect size of 0.77, and a significant Group by Time interaction $F(1,21)=51.71$, $p<0.001$, MSe=0.64, with an effect size of 0.71. The interaction reveals that the reduction in severity rated by the therapist was not the same for each group. The treatment group achieved greater improvement than the waiting list control group.

2.5.2.6. Clinically significant improvement Eighty-three percent of the participants in the VR exposure group achieved a clinically significant improvement using strict criteria. None of the participants in the waiting list group showed clinically significant improvement on the post-test.

2.5.2.7. Drop-out None of the participants refused treatment, and none of them dropped out of the study.

3. Discussion

Using both objective and subjective measures of fear, VR exposure with tactile augmentation significantly reduced fear and avoidance of spiders after an average of four, one-hour VR therapy sessions. This is the first controlled study to demonstrate the effectiveness of VR exposure therapy for treatment of fear of spiders.

VR exposure was more effective than a waiting list control condition in reducing the main features of a specific phobia. Fear and avoidance were measured with a fear of spiders questionnaire, a BAT, and severity ratings made by the clinicians and an independent assessor. The VR treatment group showed improvement on all measures, whereas the control group showed no improvement.

The change was not only statistically significant, but also clinically significant. Eighty-three percent of the participants in the treatment condition met strict criteria of clinically improved and

none of the patients in the waiting list condition did so. Most of the patients in the VR group achieved a significant change ($M \pm 2$SD in the direction of functionality) in important outcome variables such as avoidance measured in the BAT, the fear of spiders questionnaire, and severity ratings by an independent assessor and the therapist.

None of the participants who started the VR treatment dropped out. This result supports the idea that VR exposure is an attractive technique for phobic sufferers that may help to increase the number of phobics who complete treatment.

In the present study, desensitization to the virtual spider generalized to real spiders. After treatment, participants were able to approach a large live tarantula on the BAT with low to moderate levels of anxiety.

Despite these findings we would like to address some of the limitations of our study. The sample was carefully selected, but relatively small. Studies with larger samples are needed. Another limitation is that we did not include a follow-up assessment (e.g. 6 months later).

Our results support our prediction that VR can be used to effectively treat a specific phobia. However, why use VR when in vivo exposure therapy is so effective? VR gives the patient and therapist the ability to control the feared object. For example, unlike a real spider, virtual spiders obey commands, can be placed in various positions and orientations, and can be touched without danger. VR allows the therapist to control how frightening the spider appears and allows patients to confront fears that are not easily accessible. For example, in vivo exposure of fear of flying can be an expensive project. Therapists report difficulty with numerous logistic problems and expenses, such as getting to the airport and renting a commercial jet for the purpose of treating patients and having to buy airline tickets (Hodges et al., 1996). Confidentiality is another problematic issue for in vivo exposure sessions such as treating fear of heights in a hotel elevator, where the public can see the patient getting treated. Another advantage of VR is the possibility of treating 'residual fears', given the fact that VR can go beyond what a real situation would allow, making overlearning easier to perform (Botella et al., 1998). VR provides a controlled and protected environment that allows patients who were reluctant to start an exposure program more willing to get involved in treatment (Garcia-Palacios et al., 2001). VR treatment is presently a relatively expensive treatment, due to the additional equipment and software required. However, the price of VR systems is dropping quickly and dramatically, largely because conventional desktop PC systems are becoming powerful enough to handle the computational demands of real time VR (Botella et al., 1999). Emmelkamp has reported results of a VR exposure treatment as effective as an in vivo treatment for acrophobia using a conventional PC (Emmelkamp et al., in press).

Results of the present study indicate that VR exposure could offer an attractive alternative for patients unwilling or unable to complete in vivo exposure therapy. VR exposure has potential as a new medium for an old, well-established technique (graded exposure therapy). A medium that makes exposure less aversive and more attractive to patients is likely to increase the proportion of phobia sufferers who seek treatment. The high success rate of VR therapy found in the present study, and its appeal to people with fear of spiders suggest that VR is a medium worthy of further exploration for clinical applications.

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