

Garcia-Palacios, A., Hoffman, H. G., Carlin, C., Furness, T.A. III, Botella-Arbona, (2002). Virtual reality in the treatment of spider phobia: A controlled study. Behaviour Research and Therapy, 40:9;983-993.

Virtual reality in the treatment of spider phobia: A controlled study.

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Abstract

This study explored whether 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. Virtual Reality exposure was effective in treating spider phobia compared to a control condition as measured with a Fear of Spiders questionnaire, a Behavioural Avoidance Test, 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

Virtual reality and tactile augmentation in the treatment of spider phobia: A controlled study.

An estimated 10-11% of the U.S. population experiences a specific phobia at some point in their lives, (The American Psychiatric Association, 1994; Magee, Eaton, Wittchen, McGonagle & Kessler, 1996). Approximately 40% of specific phobias belong to the category of “bugs (including 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 about the acquisition of phobias (1976, 1977), 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 (e.g., 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 (e.g. 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 to 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 and Botella, (in press) 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 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 virtual reality 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 their head orientation (e.g., virtual objects in front of the user in VR get closer as the user, wearing their 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 virtual reality 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, Hollander, Schroeder, Rousseau & Furness, 1998).

Pilot studies and case reports suggest that Virtual Reality (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, Banos, Villa, Perpina & 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.

Method

Participants

Participants were recruited from different sources: a) mass testing in an introductory Psychology class, b) through advertisements in the university journal 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 (APA, 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 30 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 Behavioural Avoidance Test.

The average age was 29.25 years ($SD = 10.79$; range 18-58). Most participants were female (90.9%) and only a 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 their fear of spiders without success.

Equipment

A Silicon Graphics¹ Octane MXE with Octane Channel Option (allowing stereo vision) coupled with a wide field-of-view (40 degrees horizontal by 105 degrees horizontal with 40 degrees overlap) head mounted visual display (www.VirtualResearch.com) V8 helmet was used to create an immersive, 3-D, interactive, computer-simulated environment. A PolhemusTM 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 KitchenWorld².

Measures

Anxiety Diagnostic Interview Schedule IV (ADIS-IV, Di Nardo, Brown & Barlow, 1994): During this interview, the patient was asked about each criteria of DSM-IV specific

phobia, animal type (APA, 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.

Fear of Spiders Questionnaire (Szymanski & O'Donohue, 1995): This questionnaire 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 behavioural avoidance test ($r = .65$, $p < .001$), and construct validity in its ability to discriminate phobics from non-phobics as measured by a behavioural avoidance test (O'Donohue & Szymanski, 1993; Szymanski & O'Donohue, 1995; see also Muris, & Merckelbach, 1996). The questionnaire has 18 items rated in a 1 to 7 scale (1 = does not apply to me, 7 = very much applies to me) about fear and avoidance regarding spiders.

Behavioural Avoidance Test (BAT). The behavioural avoidance test 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 in the far end of a room 5 meters 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 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 behavioral score that ranged from 0 to 8; where 0 = refuses to enter the room, 1 = stops 5 meters from the container, 2 = stops 4 meters from the container, 3 = stops 3 meters from the container, 4 = stops 2 meters from the container, 5 = stops 1 meter 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.

Clinician rating. This scale was the same that the used by Ost, Stridh & 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.

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, $M \pm 2 SD$ in the direction of functionality.

Behavioral Avoidance Test score (0-8): The change must be 2 points and the cuff-off score 7 (touching the container).

Behavioral Avoidance Test assessor rating of phobic severity (0-8): The change must be 2 points and the cuff-off score 4.

Clinician rating of phobic severity (0-8): The change must be 2 points and the cuff-off score 4³.

Fear of Spiders questionnaire: the score must be outside the range of the patient group, that is, $M \pm 2 SD$ in the direction of functionality. The mean was 98.65 and the standard deviation was 15.73. The cut-off score was 67.

Procedure

During the pre-treatment assessment, participants were interviewed to determine if they met criteria for specific phobia, animal type, spiders (DSM-IV, APA, 1994) using the structured interview ADIS-IV (Di Nardo et al., 1994). These interviews were 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 behavioural avoidance test. 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 1 hour and participants completed all sessions and the post-treatment assessment within two or three weeks of beginning treatment.

Treatment: Treatment consisted of a standardized exposure protocol delivered by two experienced clinical psychologists trained in Experimental Psychology (authors AG and AC).

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 had to 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 4 and it ranged from 4 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 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).

Results

Pre-treatment Tests.

No differences were found between the waiting list condition and the treatment condition at pretreatment in demographic and clinical variables: age, $t(19) = 0.67$, $p > .05$, NS, duration of the fear, $t(18) = 0.89$, $p > .05$, NS, and level of perceived impairment, $t(21) = 1.31$, $p > .05$,

NS. T-tests showed no significant differences between the 2 groups with respect to the measures of the Behavioral Avoidance Test at pretreatment: Avoidance, $t(21) = 1.71$, $p > .05$, NS, level of anxiety reported during the BAT, $t(21) = 0.78$, $p > .05$, NS, and independent assessor rating of phobic severity on the BAT, $t(21) = 0.78$, $p > .05$, NS. With regard to other measures, no differences between the two groups were found in the subjective measure of fear of spiders (FSQ) at pre-treatment, $t(21) = 0.39$, $p > .05$, NS, nor in the clinician rating of phobic severity, $t(21) = 0.21$, $p > .05$, NS.

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.

Score on the Behavioural Avoidance Test. On the Behavioural Avoidance Test, the ANOVA regarding avoidance showed a significant Group effect, $F(1,21) = 17.10$, $p < .001$, $MSe = 7.37$, with an effect size of 0.45, a significant Time effect $F(1,21) = 25.25$, $p < .001$, $MSe = 2.08$, with an effect size of 0.55, and a significant Group by Time interaction $F(1,21) = 17.40$, $p < .001$, $MSe = 2.08$, 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.

Anxiety during the Behavioural Avoidance Test. The mixed-model ANOVA showed no significant Group effect, $F(1,21) = 1.29$, NS, with an effect size of 0.061, a significant Time effect $F(1,21) = 18.23$, $p < .001$, $MSe = 284.79$, with an effect size of 0.48, and a significant Group by Time interaction $F(1,21) = 5.99$, $p < .05$, $MSe = 284.79$, 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.

Independent assessor rating of phobic severity on the Behavioural Avoidance Test. The ANOVA showed a significant Group effect, $F(1,21) = 22.23$, $p < .001$, $MSe = 2.32$, with an effect size of 0.51, a significant Time effect $F(1,21) = 79.89$, $p < .001$, $MSe = 1.00$, with an effect size of 0.79, and a significant Group by Time interaction $F(1,21) = 66.72$, $p < .001$, $MSe = 1.00$, 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.

Insert table 1 around here

Fear of Spiders Questionnaire. A mixed model ANOVA regarding this measure showed a significant Group effect, $F(1,21) = 14.09$, $p < .001$, $MSe = 363.68$, with an effect size of 0.40, a significant Time effect (pre-treatment vs. post treatment), $F(1,21) = 31.07$, $p < .001$, $MSe = 170.07$, with an effect size of 0.60, and a significant Group by Time interaction $F(1,21) = 23.21$, $p < .001$, $MSe = 170.07$, 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.

Clinician rating of phobic severity. The analysis showed a significant Group effect, $F(1,21) = 14.67$, $p < .001$, $MSe = 2.52$, with an effect size of 0.41, a significant Time effect, $F(1,21) = 69.67$, $p < .001$, $MSe = 0.64$, with an effect size of 0.77, and a significant Group by Time interaction $F(1,21) = 51.71$, $p < .001$, $MSe = 0.64$, 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.

Clinically significant improvement. Eighty-three percent of the participants in the VR exposure group achieve a clinically significant improvement regarding strict criteria. None of the participants in the Waiting list group were clinically improved at posttreatment.

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

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 Behavioural Avoidance Test, 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 ($M \pm 2SD$ 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 Behavioural Avoidance Test with low to moderate levels of anxiety.

Despite these findings we would like to address some of the limitations of our study. Although the selection of the sample was well done, it was small. Studies with larger samples are needed. Another limitation is that we did not include a follow-up assessment.

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 allow patients who were reluctant to start an exposure program more willing to get involved in treatment (Garcia-Palacios et al., in press). 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.

Acknowledgements

Thanks to Ian Dillon and Silicon Graphics Inc for their invaluable equipment support, Division LTD. for VR software, Ari Hollander (www.imprintit.com) and Duff Hendrickson for virtual spider programming and modelling, and Ross Chambers for fundraising.

The research presented in this paper was funded by Pla de Promocio de la Investigacio, Fundacio Caixa Castello-Bancaixa 1999, 2000, the University of Washington Royalties Research Fund, the E.K. and Lillian F. Bishop Foundation, the Paul Allen Foundation for Medical Research, and the industrial consortium of the Human Interface Technology Laboratory.

Footnotes

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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 the 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.

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Table 1: Mean and Standard Deviations for the outcome measures at Pre- and Posttreatment.

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

Note: VRE = Virtual Reality Exposure; WL = Waiting List; BAT = Behavioural Avoidance Test.