

Effectiveness of Computer-Generated (Virtual Reality) Graded Exposure in the Treatment of Acrophobia

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***Objective:** The authors' goal was to examine the efficacy of computer-generated (virtual reality) graded exposure in the treatment of acrophobia (fear of heights). **Method:** Twenty college students with acrophobia were randomly assigned to virtual reality graded exposure treatment (N=12) or to a waiting-list comparison group (N=8). Seventeen students completed the study. Sessions were conducted individually over 8 weeks. Outcome was assessed by using measures of anxiety, avoidance, attitudes, and distress associated with exposure to heights before and after treatment. **Results:** Significant differences between the students who completed the virtual reality treatment (N=10) and those on the waiting list (N=7) were found on all measures. The treatment group was significantly improved after 8 weeks, but the comparison group was unchanged. **Conclusions:** The authors conclude that treatment with virtual reality graded exposure was successful in reducing fear of heights.*

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Behavioral therapy of acrophobia usually includes exposing the patient to anxiety-producing stimuli while allowing anxiety to attenuate (1, 2). Since exposure to relevant stimuli usually requires leaving the therapist's office, it is important to identify alternatives to such exposure. One possible alternative to standard in vivo exposure may be computer-generated (virtual reality) graded exposure. Virtual reality integrates real-time computer graphics, body tracking devices, visual displays, and other sensory input devices to immerse a participant in a computer-generated virtual environment. Kijima and Hirose (unpublished 1993 paper) reported that virtual reality was used in Japan to simulate the sand play projective technique with autistic children. These authors presented no data, but they contended that the virtual reality sand play was useful. In a single case study (3), we found that treatment with virtual reality graded exposure was effective for reducing fear of heights.

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To our knowledge, this report represents the first controlled study of virtual reality in the treatment of a psychological disorder. The purpose of this study was to examine the efficacy of a treatment for acrophobia by using virtual reality graded exposure treatment in a methodologically controlled design. Treatment with virtual reality graded exposure has the advantages of conducting time-consuming exposure therapy without the patient's leaving the office, potentially offering more control over exposure stimuli. Thus, it may offer a time- and cost-effective way to conduct exposure therapy.

METHOD

Four hundred seventy-eight college students were screened for acrophobia. Twenty students who indicated substantial fear and avoidance of heights entered the study. Twelve were men, 18 were Caucasian, and their mean age was 20 years (SD=4); 17 of the 20 students completed the study. Students with concomitant panic disorder were excluded because wearing the virtual reality helmet might cause them distress.

Measures included the Acrophobia Questionnaire (4), a screening questionnaire, the Attitude Towards Heights Questionnaire (adapted from the work of Abelson and Curtis [1]), and the Rating of Fear Questionnaire. The students given virtual reality treatment also rated their levels of subjective discomfort (range=0-100) every 5 minutes during exposure.

Hardware consisted of a head-mounted display and an electromagnetic sensor that was used to track the head and right hand so that the user could interact with objects in the virtual environment. Virtual reality hardware and software were integrated with a square platform (4 ft by 4 ft) surrounded by a railing. This platform aided exposure by giving the subject railings to hold and an edge to ap-

TABLE 1. Anxiety Scores of College Students With Acrophobia Treated or Not Treated With Virtual Reality Graded Exposure Before and After Treatment

Measure ^a	Received Treatment				Did Not Receive Treatment				Analysis	
	Baseline (N=12)		After 8 Weeks (N=10)		Baseline (N=8)		After 8 Weeks (N=7)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	χ^2 (df=1)	p
Acrophobia Questionnaire										
Anxiety	54.4	24.4	17.1	11.7	54.3	11.4	46.1	15.3	14.79	<0.0001
Avoidance	16.5	10.8	3.2	2.7	15.8	7.8	16.7	7.7	14.10	<0.0002
Total	70.9	34.4	20.3	13.2	70.0	17.7	62.9	19.1	16.14	<0.0001
Attitudes Towards Heights Questionnaire										
Bad	6.6	1.7	2.9	1.8	5.0	2.1	5.6	0.5	18.91	<0.0001
Awful	6.0	1.5	2.9	1.6	5.3	2.3	6.0	0.6	14.69	<0.0001
Unpleasant	5.7	3.1	3.5	1.7	6.0	2.4	7.0	1.5	4.43	<0.04
Dangerous	7.4	2.5	3.0	2.3	6.5	2.6	7.3	1.6	14.71	<0.0001
Threat	7.0	2.0	3.0	1.9	6.6	2.7	6.9	1.9	11.76	<0.0006
Harmful	6.8	2.0	2.7	1.8	6.1	2.0	6.7	1.8	18.31	<0.0001
Total	39.5	9.8	18.0	10.3	35.5	12.6	39.4	6.4	18.14	<0.0001
Rating of Fear Questionnaire	4.1	1.8	1.9	1.3	3.5	1.3	3.3	1.5	9.33	<0.002

^aA higher rating indicates greater distress.

proach; it also kept the subject within tracking range of the sensor. The hardware and software have been described in greater detail elsewhere (5).

Originally, 31 students were randomly assigned to a treatment condition (virtual reality or waiting list) following screening for acrophobia. Twenty students (12 who had been assigned to virtual reality treatment and eight who had been assigned to the waiting list) attended the group pretreatment assessment. During the group pretreatment assessment the study was explained, informed consent was obtained, and baseline self-report scales were completed.

After the group pretreatment assessment, the 12 students in the treatment group received their first treatment session. At that time they were familiarized with the virtual reality equipment. After seven weekly sessions of virtual reality graded exposure (8 weeks after the group pretreatment assessment), they completed the same measures. The students in the waiting list condition completed the same measures after 8 weeks with no treatment. Treatment and assessments were provided free of charge.

Individual virtual reality graded exposure treatment was conducted in seven weekly 35–45-minute sessions by an advanced clinical psychology graduate student (D.O.). The students spent as much time in each situation as they needed for their anxiety to decrease; each progressed at his or her own pace. The therapist simultaneously viewed on a video monitor all of the virtual environments in which the students were interacting and commented appropriately, as would be expected for conventional exposure.

The following virtual environments were encountered: 1) three footbridges that were 7, 50, and 80 meters above water; the two lower bridges could be viewed from the highest bridge and added to the sensation of height, 2) four outdoor balconies with railings that were on the ground, second, 10th, and 20th floors, and 3) one glass elevator simulating the elevator at the Atlanta Marriott Marquis convention hotel, rising 49 floors, up to 147 meters at the top; the subject controlled the movement of the elevator by using three "buttons."

The effect of virtual reality treatment on the measures was tested by using the change by treatment interaction term from a repeated measures analysis of variance computed with the BMDP 5V computer program (6) by using the REML algorithm and compound symmetry covariance structure. The maximum likelihood estimation procedure used by the computer program results in a chi-square statistic rather than the usual F statistic. This procedure was chosen because it did not require the exclusion of subjects for whom values were missing. The chi-square for the interaction of change by group assesses differences in the amount of improvement between groups.

RESULTS

No pretreatment differences were detected between the group of students given treatment and those in the waiting list condition on any measure or demographic variable. The results and analyses of the assessments before and after treatment are presented in table 1. As can be seen, measures of anxiety, avoidance, distress (Rating of Fear Questionnaire), and all attitudes toward heights decreased significantly from the pretreatment assessment to the posttreatment assessment for the virtual reality graded exposure treatment group but not for the waiting list comparison group. Examination of the individual attitude ratings revealed that the means on all items were below 4.0 at posttreatment assessment for the treatment group, indicating positive attitudes on the semantic differential scale. In contrast, all attitudes were negative for the waiting list comparison group at posttreatment assessment. The mean rating of subjective discomfort in each session decreased steadily across sessions, indicating habituation.

Seven of the 10 students who completed the virtual reality graded exposure treatment exposed themselves to height situations in vivo between treatment sessions, although they were not specifically instructed to do so. These exposures appeared to be meaningful, including riding 72 floors in a glass elevator and intentionally parking on the top floor of a parking deck close to the edge rather than in the center of the ground floor.

CONCLUSIONS

In this controlled study of the application of virtual reality to the treatment of a psychological disorder, we found that students treated with virtual reality graded exposure experienced reductions in self-reported anxiety and avoidance of heights and improvements in atti-

tudes toward heights and that students in a waiting list comparison group did not evidence any change. Although the students in the current study group were not patients seeking treatment, our results are comparable to those of Cohen (4). The pretreatment anxiety and avoidance scores for Cohen's subjects, who were acrophobic patients seeking treatment, were 60.64 and 13.83, respectively, which are comparable to the pretreatment scores of the students in the present study. The anxiety and avoidance raw scores of Cohen's subjects decreased by 28.6 and 6.7, respectively, after treatment with systematic desensitization; the scores of our students treated with virtual reality graded exposure decreased by 37.3 and 13.3, respectively.

In addition to our selected study group, other limitations of this study include the absence of a treatment comparison group, especially subjects given standard exposure treatment, the absence of follow-up data, and no formal assessment of phobic avoidance. Despite these limitations, our findings provide support for the use of virtual reality graded exposure in the treatment of height phobias. Virtual reality also appears applicable in the treatment of other anxiety disorders in which

exposure-based treatments are recommended. The reasonable applications and limits of therapy assisted by virtual reality must be established.

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