The Treatment of Fear of Flying: A Controlled Study of Imaginal and Virtual Reality Graded Exposure Therapy

Brenda K. Wiederhold, Dong P. Jang, Richard G. Gevirtz, Sun I. Kim, In Y. Kim, and Mark D. Wiederhold

***Abstract*—The goal of this study was to determine if virtual reality graded exposure therapy (VRGET) was equally efficacious, more efficacious, or less efficacious, than imaginal exposure therapy in the treatment of fear of flying. Thirty participants (Age $= 39.8 \pm 9.7$) with confirmed DSM-IV diagnosis of specific phobia fear of flying were randomly assigned to one of three groups: VRGET with no physiological feedback (VRGETno), VRGET with physiological feedback (VRGETpm), or systematic desensitization with imaginal exposure therapy (IET). Eight sessions were conducted once a week. During each session, physiology was measured to give an objective measurement of improvement over the course of exposure therapy. In addition, self-report questionnaires, subjective ratings of anxiety (SUDs), and behavioral observations (included here as flying behavior before beginning treatment and at a three-month posttreatment followup) were included. In the analysis of results, the Chi-square test of behavioral observations based on a three-month posttreatment followup revealed a statistically significant difference in flying behavior between the groups [$x^2(4) = 19.41$, $p < 0.001$]. Only one participant (10%) who received IET, eight of the ten participants (80%) who received VRGETno, and ten out of the ten participants (100%) who received VRGETpm reported an ability to fly without medication or alcohol at three-month followup. Although this study included small sample sizes for the three groups, the results showed VRGET was more effective than IET in the treatment of flying. It also suggests that physiological feedback may add to the efficacy of VR treatment.**

***Index Terms*—Anxiety, flying, phobias, therapy, virtual reality.**

I. Introduction

FEAR of flying is a serious problem with personal and financial repercussions. An estimated 10–20% of the general population is affected by a fear of flying, although this fear may not always reach the intensity to meet DSM-IV criteria for classification as a specific phobia [1]. Of those who do fly, approximately 20% use sedatives or alcohol to deal with their anxiety [2]. Several controlled studies have shown that exposure-based treatments are effective for fear of flying [3]–[6]. Exposure therapy involves exposing the subject to anxiety-producing stimuli while allowing the anxiety to attenuate. These stimuli are generated through a variety of modalities including imaginal (subject generates stimulus via imagination) and *in vivo* (subject is exposed to real-life situations). While effective in treating fear of flying, exposure therapies do have some deficiencies [7]. These include, in the case of imaginal exposure with some patients, an inability to feel present in the phobic situation and to reexperience the fear stimuli. Since the fear structure is not activated, it cannot be changed. In the case of *in vivo* exposure, loss of confidentiality, lack of controllability, added time, and added expense all make this treatment less desirable. *In vivo* exposure is also "too real" for some individuals to consider therapy. For example, someone with an intractable fear of flying might consider *in vivo* exposure therapy so undesirable that they may never seek treatment for their phobia. In order to overcome these difficulties, some studies have recently appeared in the literature using virtual reality graded exposure therapy (VRGET) to successfully treat fear of flying [8]–[17]. In VRGET, patients view real-life situations in an immersive virtual environment. VRGET offers several advantages over both imaginal and *in vivo* exposure therapy. Advantages of VRGET include no loss of confidentiality, therapy provided in the safety of the therapist's office, and the ability to systematically present stimuli. It also feels safer to the patient starting treatment, since the exposure is entirely under the patient's and therapist's control. VR is also more highly immersive than imaginal– all senses are stimulated during the exposure, which allows the desensitization process to progress more rapidly.

This study was designed to explore the use of VRGET in the treatment of fear of flying. No studies to date have compared VRGET with the more standard exposure therapy of "visualization" or imaginal exposure therapy (IET) to determine if VR is clinically more effective than or as effective as this traditional exposure technique. The goal of this study was to determine if VRGET was equally efficacious, more efficacious, or less efficacious, than IET in the treatment of fear of flying.

II. Method

A. Participants

Volunteers over 18 years of age with confirmed DSM-IV diagnosis of specific phobia fear of flying were chosen for this study. Participants were recruited through advertisements at the California School of Professional Psychology, San Diego, through advertisements in local newspapers, and were referred by clinicians in the San Diego area. After an initial phone screening, qualified participants were scheduled for an initial

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B. K. Wiederhold, R. G. Gevirtz, and M. D. Wiederhold are with the Virtual Reality Medical Center, San Diego, CA 92121 USA (e-mail: bwiederhold@vrphobia.com).

D. P. Jang, S. I. Kim, and I. Y., Kim are with Hanyang University, Seoul 133–605, Korea.

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TABLE I
DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS

		GROUP			
		VRGETno	VRGETpm	IET	Total
Gender	male	6	3	3	12
	female	4	7	7	18
Age	Mean	35.8	40.1	43.5	39.8
	SD	9.25	9.89	9.27	9.69
Ethnicity	caucasian	8	10	9	27
	hispanic	2		1	3
Marital Status	never married	4	2	3	9
	first marriage	5	5	4	14
	remarried		1	1	2
	separated/divorced	1	2	2	5

intake session. A participant was excluded from the study if he or she had a history of heart disease, migraines, seizures, or concurrent diagnosis of severe mental disorders such as psychosis or major depressive disorder as determined by the intake interview. The sample included 30 participants, ranging in age from 24 to 55 years, who met the DSM-IV criteria for fear of flying. Demographic characteristics of participants (age, ethnicity, gender, and marital status) are listed in Table I.

B. Procedure

Participants were randomly assigned to one of three groups when they arrived for the initial intake session, based on a previously generated random numbers table. The three groups were: Group A: VRGET with no physiological feedback (VRGETno), Group B: VRGET with physiological feedback (VRGETpm), Group C: systematic desensitization with IET. All three groups received an initial intake session, instruction in diaphragmatic breathing, and a relaxation tape to be used for home practice. In addition, all groups received a second 45-min session to answer further questions about the study and to practice breathing techniques prior to beginning desensitization training. Only participants in the VRGETpm group were given visual feedback during physiological monitoring and breathing retraining.

An "individualized" fear hierarchy was constructed with the therapist's help for each participant randomized into the IET group at this time. For the remaining six sessions, Sessions 3–8, the exposure therapy sessions, the following procedure was followed:

The participant arrived at the clinic and was escorted to the treatment room. Following alcohol swabbing, surface electrodes were attached to both the individual's wrists, and to the middle, ring, and index fingers of the left hand to measure physiology. A baseline reading was then taken for 5 min while the participant remained in a sitting position with eyes open. Only participants in the VRGETpm group received visual feedback on physiology at this time. Participants then received 20 min of desensitization training, either imaginally or in virtual reality. A recovery reading was then recorded for 5 min following the desensitization training. The above procedures were done once a week for six weeks.

Participants in the IET group and the VRGETno group did not receive information on their physiology during the sessions. Participants in these two groups were asked for a SUDS rating every 2 min during exposure therapy. Participants in the VRGETpm group received visual feedback on physiology during baseline and recovery periods of the session, and verbal feedback from the therapist concerning their skin resistance levels while in the virtual environment. Participants in this group were asked for an average SUDS rating after the conclusion of each exposure session.

C. Measures

1) Physiological Measures: An I-330 C2 computerized biofeedback system with Physiological Programming Software (PDS) manufactured by J & J Enterprises, Poulsbo, Washington was used to collect all physiological data. All three groups had the following physiological measures recorded during the six sessions of desensitization: skin resistance (SR) peripheral skin temperature, heart rate, and respiration rate. Changes in skin resistance were measured with one channel of SR. The SR electrodes were attached with velcro and placed on the pads of the first and third fingers, on the palmar side of the left hand. Peripheral skin temperature changes were collected using a thermistor attached to the palmar side of the middle finger on the participant's dominant hand. The thermistor was secured at the fingertip and base of the finger to avoid movement. Heart rate was measured with two disposable electrodes attached to the dorsal side of the participant's right and left wrists. A small amount of electrode gel was used on each electrode to improve signal conductance. Respiration rate was monitored using a pneumograph consisting of one abdominal strain gauge placed over the participant's clothing. Respiration rate was measured with a "strain gauge" consisting of a tube filled with saline solution, which was placed around the individual's abdomen to measure diaphragmatic breathing.

a) Collection of Physiological Data: Data was recorded for each exposure session as follows: a 5-min average baseline reading, a 20-min training session reading, and a 5-min average recovery period reading. The PDS software report provides 10-s

averages for all physiological data, although 256 samples/s are recorded.

2) Self-Report Measures:

a) Visual Analog Scales: After an explanation of the therapy procedure, but before receiving any actual therapy sessions, participants were asked to fill out a form adapted from [18] rating the relative efficacy of the therapy. This was done with a series of five 10-cm visual analog scales (VAS), with anchors: 1) not logical and very logical for scale 1, 2) not confident and very confident for scale 2; 3) not willing and very willing for scale 4; and 4) not successful and very successful for scale 5.

b) Demographic Information Survey: Individuals were asked to fill out a standard demographic survey that included such items as racial/ethnic background, age, and gender. In addition, items pertinent to this study included questions concerning heart problems and seizures.

Three times during the protocol—prior to any training, after two weeks of relaxation training, and after completion of six sessions of exposure therapy—participants were asked to complete five self-report measures to determine if subjective anxiety was decreasing over treatment.

These measures included the questionnaire on attitudes toward flying (QAF) [19], fear of flying inventory (FFI) [20], self-survey of stress responses (SSR) [21], state-trait anxiety inventory (STAI) [22], and VR scenarios sheet [10]. Details of these questionnaires and the change observed over treatment by each group are discussed in a previous publication [16].

c) Subjective Ratings of Anxiety: SUDs ratings, from $0 =$ no anxiety to $100 =$ maximal anxiety, were taken every 2 min during the training sessions for participants in the VRGETno group and the IET group. One 20-min SUDs rating was taken for participants in the VRGETpm group each session. Participants in the VRGETpm group were progressed through the VR scenarios based on SR levels and, therefore, were not asked for SUDs ratings during the exposure sessions.

d) Behavioral Observation: Patients were telephoned three months posttreatment and asked about their flying behavior. They were asked if they could still not fly, could now fly with the use of medication or alcohol, or could now fly without the use of medication or alcohol.

D. Virtual Environments

The virtual environment system for this study consisted of a head mounted display (MRG4, Liquid Image Inc.), electromagnetic head tracker (INSIDETRAK, Polhemus Inc.), and office chair with a subwoofer mounted underneath to deliver vibrations to participants during the flight experience. The VR software was developed by Hodges and Rothbaum of Virtually Better, Inc. (Atlanta, GA).

III. Results

The chi-square test of followup data revealed a statistically significant difference in flying behavior between the groups $[x(4) = 19.41, p < 0.001]$. Fig. 1 shows the followup data for three groups: VRGETpm, VRGETno, and IET.

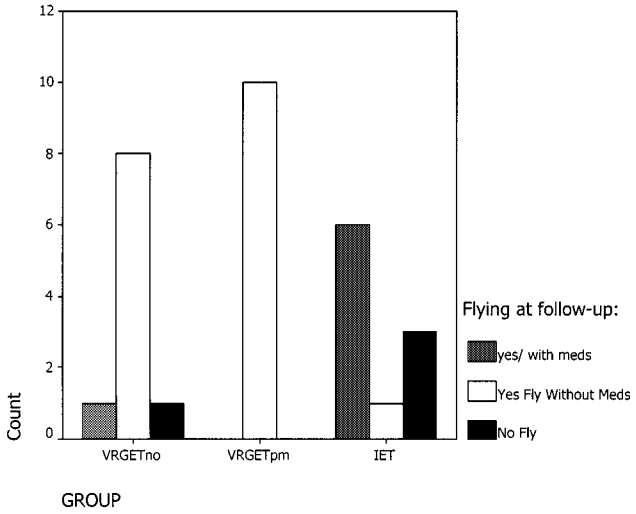

Fig. 1. Followup data for three groups: VRGETpm, VRGETno, and IET.

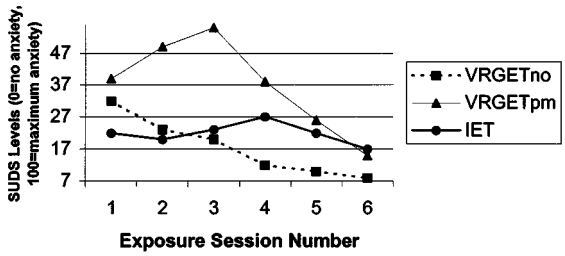

Fig. 2. SUDs data for the three treatment groups: VRGETpm, VRGETno, and IET.

A Group (3) $\times$ Time (3) analysis of variance (ANOVA) was conducted for self-report questionnaire data. There were three time periods: prior to treatment, after two sessions of relaxation training, and after six sessions of exposure therapy. For a full discussion of statistical data from these analyses, see [16]. In general, however, analyses revealed that all three groups showed a reduction in self-reported fear and anxiety over the treatment course. The analysis of SUDs scores conducted shows significant changes over time $[F(3.51, 63.14) = 7.93, P < .001, x^2 = .31]$, with the VRGETno group decreasing from an average SUDs of 32 at first exposure to an average SUDs of eight at the sixth exposure. The VRGETpm group went from 39 at first exposure to 15 at sixth exposure, and the IET group went from 22 to 17 (Fig. 2).

Because physiology levels often vary widely by individual, the percentage change from baseline was used for analysis rather than absolute values. Before comparing physiology, percentage change was calculated as follows:

$$\frac{(\text{MeanVR} - \text{MeanBaseline})}{\text{MeanBaseline}}$$

where MeanVR is the mean physiological value during the VR exposure session and MeanBaseline is the mean physiological value during the baseline recording period, prior to exposure. Physiological data; heart rate, skin resistance, peripheral skin temperature, and respiration rate; were analyzed for each exposure session, by group, using a one-way ANOVA. Results indicate the following changes:

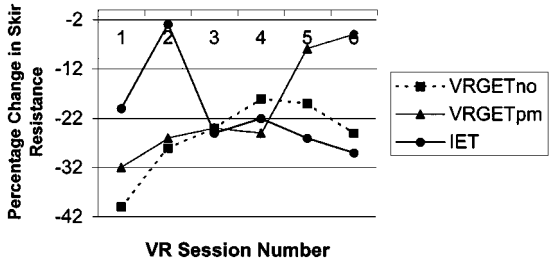

Fig. 3. Skin resistance percentage change between baseline recording and exposure session for the three treatment groups: VRGETpm, VRGETno, and IET.

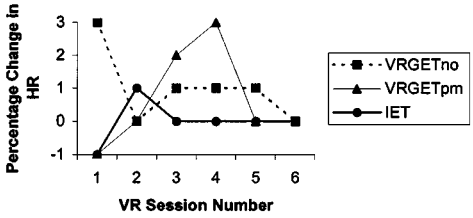

Fig. 4. Heart rate percentage change between baseline recording and exposure session for the three treatment groups: VRGETpm, VRGETno, and IET.

All groups showed a changed in skin resistance over time, however, only the first exposure session showed a statistically significant difference between groups ($F = 5.58$, $p = .009$), with two other sessions nearing significance: second exposure session ($p = .08$) and last exposure session ($p = .08$). The other changes, although not statistically significant, show clinically significant differences (Fig. 3). Heart rate changes did not show statistically significant differences either, with only the first exposure session nearing significance ($p = .06$) (Fig. 4). Other studies at our Center have included heart rate variability, which appears to be a more sensitive measure of heart rate changes during anxiety. Peripheral skin temperature and respiration also did not show statistically significant changes, nor did changes near significance.

IV. Discussion

We tested to determine if self-report questionnaire scores would change differently over treatment for the VRGETpm, VRGETno, and IET groups. Although all groups showed improvement, they did not change differentially over time based on self-report questionnaire scores. These findings do not match what we predicted. Previous studies have found that participants given IET do show a decrease in self-report questionnaire scores [19], [23]. This decrease in scores has also been found in VRGET [8], [10]. We had expected that, since VR environments are a step closer to *in vivo* exposure, VRGETpm and VRGETno would have resulted in a more significant decrease in self-report scores than would imaginal exposure.

The SUDs self-report scores for VRGET and IET both improved over time. Interesting to note, however, is that upon examination of the means, the IET group never reported as much anxiety during exposure, nor showed as much decline of anxiety during exposure as either VRGET group (Fig. 2). Since we know from previous research that in order to change the fear structure that fear must be activated during exposure, it may be thought that the fear elicited during IET was not as intense as that elicited during VRGET. This could account for the lack of behavioral change (inability to fly) in the IET Group.

Further examination revealed that only 10% (one out of ten) in the IET group could fly without medication or alcohol when contacted three months posttreatment, 80% of those in the VRGETno group (eight out of ten) could do so, and 100% of those in the VRGETpm group (ten out of ten) could do so. Although VRGETno had more favorable self-report score changes, the VRGETpm group had more favorable behavioral change, in that all could fly without medication when contacted at three months posttreatment. We can speculate that this may have been because the VRGETpm group knew we were watching their physiology during the session, and they were given feedback on their physiology. This may have caused them to be slightly more honest in their self-report of anxiety. The VRGETno group, on the other hand, was not given feedback on their physiology and may have felt compelled to self-report lower anxiety as treatment progressed.

When physiological responses to exposure were analyzed, it was found that both VR groups became much more physiologically aroused than the imaginal group and this may have helped them to then become desensitized as treatment progressed. As previously reported, the fear structure must be activated both subjectively and objectively for desensitization to occur [24]–[26]. It appears that the VR groups may have been able to desensitize because they were fully aroused during the exposure, remaining on task without cognitively drifting "off task" as can occur during imaginal exposure. It is also interesting that the group who had learned to control physiology prior to exposure became aroused initially but was able to overcome this arousal, so that by the sixth exposure session, their skin resistance remained only 5% below baseline. This is in contrast to the VR group which received no visual feedback on physiology, and who at the end of six sessions still remained 25% below baseline, and the IET group, which remained 29% below baseline at the end of exposure. The imaginal group took more sessions to evidence physiological arousal, and showed an "uneven" desensitization pattern. This again, could have been due to cognitive avoidance, or drifting "off task" during part of the exposure experience. Some participants also reported an inability to become highly aroused using imaginal images of flying. The VRGETno group showed initial arousal, since they were placed in an anxiety-provoking environment, but was not able to overcome their arousal at the end of the six exposure sessions, since they had been taught no coping skills. Some participants reported they did not feel ready to attempt a flight, which was confirmed at followup, with only 80% actually flying without medication or alcohol. The VRGETpm group, on the otherhand, had been taught a coping mechanism (diaphragmatic breathing) and had been shown visual feedback of their physiology, so were able to begin using their coping mechanism *in vivo* when anxiety increased. This group reported feeling "in control" and this translated to 100% being able to fly when contacted at three month posttreatment followup.

V. Conclusion

It is clear from the present study as well as numerous past studies that IET has some limitations in the treatment of persons with fear of flying. Persons may not always be able to hold a clear image in IET or recreate the fear when sitting in the therapist's office. Although the present study included small sample sizes for the three groups, results show that virtual reality graded exposure therapy should be considered a viable option when performing exposure therapy for fear of flying. In addition, the use of physiological feedback as a training mechanism prior to exposure and during each session may give individuals the control they need to increase self-efficacy and feel ready to perform a task in the real world. Future studies should include more sensitive physiological measures such as heart rate variability, blood pressure, and cardiac output in an effort to further understand the mechanism of change that occurs as the phobic patient becomes desensitized. This may help clinicians to predict which patients are ready to complete therapy and which may still need further sessions prior to flying.

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Brenda K. Wiederhold received the MBA, Ph.D., and BCIA degrees and the doctorate degree in clinical health psychology from the California School of Professional Psychology, San Diego. She received a Masters degree in business administration from Chapman University, Orange, CA.

She is Executive Director of The Virtual Reality Medical Center (VRMC), a professional medical corporation, San Diego, CA, and Chief Executive Officer of the Interactive Media Institute, a nonprofit organization. She is a licensed clinical psychologist. She is nationally certified in both biofeedback and neurofeedback by the Biofeedback Certification Institute of America. She serves on the editorial board of *CyberPsychology* and *Behavior Journal* and is recognized as a national and international leader in the treatment of anxiety and phobias with virtual reality exposure therapy, having completed more than 3000 VR therapy sessions. She is on the faculty at University of California San Diego, La Jolla. She has ten years experience as chief financial officer of an investment firm, and is a former government auditor. She currently is completing her third book and has more than 50 publications.

Dr. Wiederhold also serves as Chief Executive Officer of VRHealth, an international company with offices in San Diego, CA, and Milan, Italy. VRHealth develops virtual environments and clinical protocols as well as conducting clinical research studies using virtual environments and Internet-based worlds.

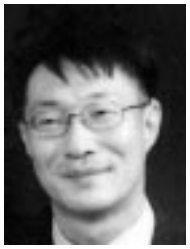
Dong P. Jang received the B.A. and M.S. degrees in electrical engineering from Hanyang University, Seoul, Korea, in 1996 and 1998, respectively, and the Ph.D. degree in biomedical engineering from Hanyang University.

He was a Research Engineer in the Virtual Reality Medical Center (VRMC), a professional medical corporation, San Diego, CA. He is a Research Engineer in biomedical engineering, Hanyang University. His work focused on virtual reality in psychotherapy, psychophysiology, and medical instruments. His current interests include electrophysiology for hearing aids and wireless healthcare.

Richard Gevirtz is a Professor in the Health Psychology Program at the California School of Professional Psychology, San Diego. He has been involved in research and clinical work in applied psychophysiology for the last 25 years. He is the author of many journal articles and chapters on these topics. In addition to his academic duties, he has maintained a part-time clinical practice for many years. His primary interests are in understanding the physiological mediators involved in disorders such as chronic muscle pain, gastrointestinal pain, fibromyalgia, chronic fatigue syndrome, panic disorder, and functional cardiac disorder.

Sun I. Kim received the B.A. and M.S. degrees in electrical engineering from Seoul University, Seoul, Korea, in 1976 and 1978, respectively, and the Ph.D. degree in biomedical engineering from Drexel University, Philadelphia, PA.

He was a Research Associate in Mayo Clinic from 1987 to 1988. Since 1988, he has been a Professor and Director of the Department of Biomedical Engineering, Hanyang University, Seoul, Korea. He is Vice-President in the Korean Society of Medical Engineering and in the Korean Society of PACS, Korea. His interests include virtual reality in medicine, 3-D graphics, and brain modeling.



In Y. Kim received the M.D. and Ph.D. degrees in 1989 and 1994, respectively, from Seoul National University, Seoul, Korea.

From 1994 to 1999, he was with the Department of Biomedical Engineering of Samsung Biomedical Research Institute of Technology, Suwon, Korea. He is currently an Assistant Professor in the Department of Biomedical Engineering, Hanyang University, Seoul, Korea. His current research interests are medical application of virtual reality, bio-signal analysis, human–machine interface, and hearing science.

Mark D. Wiederhold is a Physician Executive with a diverse background in academic health, clinical research, and product development. At Science Applications International Corporation, he invented and patented a noninvasive method for cancer diagnosis, currently in phase II testing at Tripler Army Medical Center, Honolulu, HI. He also developed a PC-based rugged portable diagnostic medical device for the US Navy and Marine Corps, currently deployed to the Pacific Fleet. This device was approved by the FDA in four months, and was funded by Congress for two years. He has eight years of experience developing telemedicine systems including wireless data transmission protocols. He was formerly Director of Clinical Research at the Scripps Clinic, La Jolla, CA, where he has been a Staff Physician for the past 15 years. He completed an internship and residency in Internal Medicine and Critical Care Medicine at the Scripps Clinic. He is on the faculty at University of California, San Diego Medical School.

Dr. Wiederhold is the Editor-in-Chief of *CyberPsychology* and *Behavior Journal* and Editor-in-Chief of IEEE TRANSACTIONS IN EXPERIMENTAL BIOLOGY AND MEDICINE. He serves on several advisory, editorial, and technical boards. He is a Certified Physician Executive, a Diplomate of the American College of Physician Executives, and a Fellow of the American College of Physicians. He has more than 150 scientific publications. He is President of the Virtual Reality Medical Center, which is developing new clinical protocols for the treatment of a variety of health-related disorders.