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14 Virtual Reality Exposure Therapy vs. Imagery Desensitization Therapy in the Treatment of Flying Phobia

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Abstract: This study examined the value of virtual reality graded exposure therapy (VRGET) compared to standard graded exposure therapy using imagery alone for patients with flying phobia. Thirty subjects were randomized into either VRGET with physiological feedback of skin resistance, peripheral skin temperature, heart rate, and respiration; VRGET with no physiological feedback, or imagery conditions. Patients in all conditions were first taught to relax (for two sessions) and then exposed in six subsequent sessions to flying stimuli (either through a virtual airplane with visual and somatic stimuli, or through producing mental images). Results showed that subjects in all three conditions were equally physiologically and subjectively aroused throughout the exposure series. However while only 20% of imagery patients flew after 8 weeks of therapy, 80% of VR patients receiving no physiological feedback and 100% of VR patients receiving physiological feedback were able to fly without using medications ($p<.001$). This is the first study to compare the benefit of virtual reality graded exposure therapy to graded exposure using imagery alone.

Contents

14.1 Introduction

An estimated 10-20% of the general population are affected by a fear of flying, although this fear may not always reach the intensity to meet Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for classification as a specific phobia [1,2]. Of those who do fly, approximately 20% use sedatives or alcohol to deal with their anxiety [3]. Fear of flying not only results in social stigmatization for some, but may result in lost job opportunities due to an inability to travel. The cost to the airline industry alone has been estimated at $1.6 billion per year [4], while the costs to individuals for lost productivity and opportunities is incalculable.

Although fear of flying has been shown to be quite prevalent in the general population, few controlled studies exploring treatment for this disorder have been conducted. The first controlled study of fear of flying with a civilian population was by Solyom, Shugar, Bryntwick, and Solyom in 1973 [5]. Subjects were treated with one of four treatments: 1) habituation, 2) systematic desensitization, 3) aversion relief , 4) or group therapy. All three behavior therapies were forms of "exposure therapy" and proved equally effective in reducing fear of flying. Group therapy, however, proved ineffective.

Several controlled studies have shown that exposure-based treatments are effective for fear of flying [5-8]. In fact, since Solyom et al's 1973 study, all other fear of flying studies found in the literature have included an exposure-based technique, either used alone or as part of a comprehensive treatment package intended to manage arousal, such as cognitive restructuring, thought stopping, and relaxation training [9-14]. Systematic desensitization has been the most common clinical method for treating fear of flying. Systematic desensitization consists of pairing relaxation skills with imaginal exposure to the phobic stimuli [15]. In a study by Howard, Murphy, and Clarke (1983), fifty-six subjects were treated in groups of two or three with seven sessions of systematic desensitization, flooding, implosion, or relaxation alone. Forty-four subjects completed the flight. All treatments proved equally effective in reducing anticipatory fears. Fear of the actual flight – takeoff, being in the air, and landing – was not reduced. The authors hypothesized that in vivo exposure might work better at helping overcome actual in-flight fears [8].

In Solyom, Shugar, Bryntwick, and Solyom's 1973 study mentioned earlier, behavior therapy techniques including systematic desensitization, aversion relief, and habituation worked equally well in decreasing fear of flying compared to group psychotherapy, which employed discussion only and proved ineffective in reducing fear. Since aversion relief and habituation worked as well as systematic desensitization, the need for the relaxation component unique only to systematic desensitization was questioned [5]. However, a 1979 study done by Borkovec and Sides found that heart rate data provided evidence for the hypothesis that relaxation used in desensitization with speech phobics increased imagery vividness, increased physiological arousal to imagery, produced a decline in arousal over repeated exposures, and resulted in the most positive outcome for subjects in their study. Thus, vividness of imagery and not relaxation per se may be a critical element of laboratory exposure therapy [16].

Other studies have attempted to approximate laboratory flight experiences through advanced audio-visual sensations. Enholtz & Mann (1975), used a combination of techniques (desensitization, modeling, and positive reinforcement) as part of an automated audiovisual program to treat flight phobics. Phobics were allowed to complete up to twenty-four sessions of treatment. Results of the study revealed that sixty-five percent of those in a relaxation group with progressive audio-visual exposure were able to fly alone on a free post-treatment flight, compared to only 15% of a relaxation group with full exposure, 27% of a group with no relaxation but progressive exposure, and 0% of a relaxation-only group. However, there were significant problems with dropouts in this study (37%), compromising its generalization. It is also

not known if patients were selected based on ability to visualize, so the group chosen may have only been those with good imagery abilities [6].

At 3 1/2-year follow-up, Denholtz, Hall, & Mann (1978) ascertained subjects continued ability to fly alone. Forty-three of the fifty-one subjects from the 1975 study were contacted. Of those who had taken the post-treatment flight, eighty-eight percent had maintained their ability to fly as measured by a telephone interview, although forty-three percent still continued to use alcohol or tranquilizers before flying [7].

14.2 Virtual Reality Graded Exposure Therapy

Recent case studies have appeared in the literature using virtual reality graded exposure to successfully treat fear of flying [17-24]. It has long been known that individuals vary in their imagery ability. A major benefit of VRGET over visualization is that the patient need not rely on internal imagery or their abilities to visualize well [25]. Immersive virtual reality consists of a computer-generated real-time graphical display accessed by the subject through the use of some type of head-mount display, tracking mechanism, and other sensory input devices [26]. In an immersive virtual reality system, the headset worn by the user allows projection of the virtual world through liquid crystal displays mounted in the headset.

This presents the illusion of actually being in the virtual world and allows the brain to combine the images into a three-dimensional picture [27]. Virtual reality graded exposure was used to successfully treat ten undergraduate students suffering from acrophobia [28, 29]. This study compared computer-generated (virtual reality) graded exposure (n=10) to a waiting-list control group (n=7). Seven of the 10 students who completed the virtual reality graded exposure treatment exposed themselves to actual height situations during treatment though not specifically asked to do so. No behavioral change was reported for those in the wait-list control group. Other studies have also shown VRGET to be efficacious in the treatment of fear of heights [30, 31].

Other phobias that have responded well to VRGET include claustrophobia [32-35]; arachnophobia [36]; agoraphobia [37]; public speaking [38, 39]; driving [23, 40]; and social phobia [23].

Virtual reality exposure therapy offers several advantages over both imaginal and in vivo exposure therapies. In comparison to in vivo, VR is safer since the exposure is entirely under the patient's and therapist's control and can be "switched off" any time it becomes intolerable. With virtual reality, there is also an added benefit of being able to expose a patient over and over to the specific part of a scenario that causes fear. For example, a patient who only fears airplane landings, but is comfortable with all other aspects of air travel, would be able to practice landings over and over as many times as necessary in the virtual world.

In comparison to imaginal exposure, VR may be more realistic. It offers an advantage over imaginal exposure of bringing in several different sensory modalities, such as sight and sound. Vestibular clues such as motion and vibration can also be included to allow the patient to feel more present in the experience. VR is also interactive and provides constant stimuli versus the patient perhaps "drifting" from the imaginal scene. VR offers the advantage of allowing the therapist to see exactly what the client is seeing so that therapy can be tailored to what is activating the fear structure for the client. This flexibility should allow therapy to proceed more efficiently [41]. VR, versus something like television, provides a more immersed and richer experience.

This study was designed to explore the use of virtual reality graded exposure therapy in the treatment of fear of flying. When this study was undertaken, no studies had compared virtual reality graded exposure to more standard exposure. The only fear of flying studies using virtual reality exposure had been case studies lacking empirical rigor. Since that time, however, a

controlled study by Rothbaum, et al [42] has shown VR to be equally effective to in vivo exposure for fear of flying when compared at six month post-treatment follow-up.

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. 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 post treatment follow-up) were included to provide several different measurement techniques, from subjective to objective. This was based on emotional processing theory which indicates that treatment success depends on the occurrence of both physiological and subjective activation of fear during exposure [43, 44].

14.3 Method

14.3.1 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 CSPP-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 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.

14.3.2 Demographics

The sample included thirty participants, ranging in age from 24 to 55, who met the DSM-IV criteria for fear of flying. Means, standard deviations and percentages are listed in Table 14.1 for age, ethnicity, gender, occupational status, and marital status.

14.3.3 Group Assignment

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: virtual reality graded exposure therapy with no physiological feedback (VRGETno); Group B: virtual reality graded exposure therapy with physiological feedback (VRGETpm); and Group C: systematic desensitization with imaginal exposure therapy (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 forty-five minute session to answer further questions about the study and to practice breathing techniques prior to beginning desensitization training.

Table 14.1 (a) Demographic Characteristics of the Study Sample

Participants N.	30	*Occupational Status*	%
Age, mean years (s.d.)	39.80 (9.69)	Blue Collar Workers	3

Demographic Variables	%	Retirees	7
Ethnicity		Students	10
Caucasian	93	Unemployed	7
Hispanic	7	White Collar/Professional	73
Gender		*Marital Status*	
Female	60	Never Married	30
Male	40	First Marriage	47

Table 14.1 (b) Demographic Characteristics by Experimental Groups.

	VRGETno	*VRGETpm*	*IET*
Age, mean years (s.d.)	35.8 (9.26)	40.1 (9.89)	43.5 (9.28)
By Percentage	*VRGETno*	*VRGETpm*	*IET*
Ethnicity			
Caucasian	30%	33%	30%
Hispanic	3%	0%	3%
Gender			
Female	13%	23%	23%
Male	20%	10%	10%
Marital Status			
Never Married	13%	7%	10%
First Marriage	17%	17%	13%
Remarried	0%	3%	3%
Separated/Divorced	3%	7%	7%
Widowed	0%	0%	0%
Occupational Status			
Blue Collar Workers	3%	0%	0%
Retirees	3%	3%	0%
Students	3%	3%	3%
Unemployed	0%	0%	7%
White Collar/Professional	23%	27%	23%

IET = imaginal exposure therapy without physiological feedback; VRGETno = virtual reality graded exposure therapy without physiological feedback; VRGETpm = virtual reality graded exposure therapy with physiological feedback

14.4 Measures

14.4.1 Physiological Measures

All three groups had the following physiological measures recorded during the six sessions of desensitization: SR Skin Resistance (SR), Heart Rate (HR), Peripheral Skin Temperature (ST), Respiration Rate (RR), and electroencephalogram (EEG) at both 01 and CZ.

14.4.2 Self-Report Measures

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 [45] rating the relative efficacy of the therapy. This was done with a series of five ten-centimeter Visual Analog Scales (VAS), with anchors: 1) not logical and very logical for scale 1, 2) not confident and very confident for scales 2 and 3 3) not willing and very willing for scale 4, and 4) not successful and very successful for scale 5.

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 the following self-report measures:

Questionnaire on Attitudes toward Flying (QAF) [46]. This questionnaire was used to assess the participants' flying histories and attitudes, as well as to ascertain how much fear different aspects of the flying experience caused. Scores may range from 0 to 360, with 36 scoreable items on the scale. Test-retest reliability has been reported at .92.

Fear of Flying Inventory (FFI) [47]. This 33-item questionnaire was used to measure how much anxiety various aspects of flying such as landing and taking off cause, from no anxiety at all to very severe anxiety. Scores on the questionnaire may range from 0 to 264. Test-retest reliability is reported at .92.

Self-Survey of Stress Responses (SSR) [48]. This questionnaire was used to determine a person's pattern of physiological responses to stress, whether it is autonomic (A), somatic motor(M), or central nervous system (CNS). An example of an autonomic response item would be, "I feel nausea." An example of a somatic motor response item would be, "My hands tremble or my head quivers". And an example of a CNS response item would be, "I continuously have the same or many thoughts running through my head." Each item is rated from 0 to 5, with a maximum score of 70 for each sub-scale, and there are 38 items to the scale.

State-Trait Anxiety Inventory (STAI) [49]. This inventory measures a person's situational (or state) anxiety, as well as the amount of anxiety a person generally feels most of the time (trait) anxiety. Individuals were instructed to answer the "state" questions as how their anxiety was currently about flying and to answer the "trait" questions as how their anxiety was generally about every day life and situations. Trait anxiety has a test-retest reliability of .81 and state of .40, with internal consistency of between .83 and .92.

VR Scenarios Sheet. A checklist of the different scenarios used in the VR environment was given to participants to determine the subjective anxiety caused by "sitting on the plane, engines off; sitting on the plane, engines on; taxiing; takeoff; smooth flight; turbulent flight and thunderstorm; and landing". This self-rating scale, developed by Rothbaum & Hodges [19] is scored from 0 to 100 for each item. Maximum and minimum scores were assessed to determine if these changed over treatment.

14.4.3 Subjective Ratings of Anxiety

Subjective Units of Distress. Subjective Units of Distress (SUDs) ratings, from 0 = no anxiety to 100 = maximal anxiety, were taken every two minutes during the training sessions for participants in the VRGETno group and the IET group. One SUDs rating was taken after twenty minutes for participants in the VRGETpm group. 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.

14.4.4 Behavioral Observation

Patients were telephoned three-months post treatment 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.

14.5 Procedure

Participants were recruited from CSPP-San Diego, newspaper advertisements, and San Diego area clinicians. Potential participants who inquired about the study were contacted by telephone. At this time, the purpose of the study was indicated, as well as an initial assessment to see if any exclusion criteria were met. Those who met the research criteria and agreed to participate were given an individual initial appointment time. Each participant was called the night before his or her appointment and asked to refrain from exercise for two hours prior to the appointment, and caffeine for four hours prior to the appointment. This was done so that no participant's physiology would be affected by either stimulant. At the initial appointment, the purpose of the study was again explained to each participant who was asked to read and sign an informed consent form indicating that they had voluntarily agreed to participate in this investigation. The consent form also acknowledged that they were able to withdraw from the study at any time if they so chose.

Session 1 was comprised of consenting to participate and history taking to ascertain comorbid mental disorders, physical illnesses, and specificity of fear (whether relating to a fear of crashing or a fear of panic attacks and inability to escape from an enclosed place). This session was also used to convey instructions on diaphragmatic breathing, along with the making of a relaxation tape for home use by all participants. Only participants in the VRGETpm group were allowed to view the physiological data on the computer monitor with instructions to try and reduce their arousal and were given an explanation of what each numerical value and graph meant. Following standard protocol, Skin Resistance electrodes were attached with velcro, and were placed on the pads of the first and third fingers, on the palmer surface of the left hand. The pneumograph strain gauge was placed over the participant's clothing around the abdomen. The thermistor was placed on the palmer surface of the participant's middle finger and attached with cloth tape at the fingertip and just above where the finger attaches to the hand. A positive electrode was placed on the left wrist, and a negative electrode was placed on the right wrist to measure heart rate.

An individualized fear hierarchy was constructed for each participant randomized into the IET group during the first meeting. Participants in the IET group were told that they would be in the IET group and that IET had been used successfully for the treatment of phobias for over forty years. They were also told that an "individualized" hierarchy would be constructed for them with the therapist's help. The participants in the IET group were told that the VR therapy, which had not been proven effective in a controlled study, would be offered to them at the end of their treatment and a three-month follow-up period for free if they so desired.

Persons in both VRGET groups were told that the VR therapy was still considered experimental and had not been proven effective in a controlled study. They were told that they would be given IET for free at the end of treatment and a three-month follow-up period if they so desired.

Immediately following the first session, each participant filled out the first set of self-report questionnaires. Although the participants were shown diaphragmatic breathing procedures during session 1, questionnaires were filled out before leaving the office, so no practice in the procedures had occurred. Questionnaires were collected and the participants were instructed to practice breathing each day for fifteen to twenty minutes using the relaxation tape made in session 1 as a guide.

During Session Two, a five-minute eyes open and a five-minutes eyes closed baseline physiology recording were taken. This was done to allow participants the chance to further become comfortable with having non-invasive sensors attached to their fingers and wrists, and a strain gauge placed around their abdomen. This session also allowed participants the opportunity to ask any questions that they might have as well as a chance for the therapist to further review breathing techniques with them. Participants were then instructed on the format for desensitization training, whether imaginal or virtual, and an appointment time to begin desensitization training the following week was secured.

Thirty minutes prior to Session 3, each participant was asked to again fill out the self-report questionnaires. This allowed each participant to have experienced two weeks of relaxation training. 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 five minutes while the participant remained in a sitting position with eyes open. Participants only in the VRGETpm group received visual feedback on physiology at this time. Participants then received twenty minutes of desensitization training, either imaginally or in virtual reality. A recovery reading was then recorded for five minutes 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 minutes 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.

Three-months post-treatment, all participants were contacted by phone to assess number of flights taken, number of flights avoided, and flight opportunities experienced since completion of treatment.

14.6 Results

14.6.1 Group Equivalence at Baseline

14.6.1.1 Demographics: The three groups were compared on demographic characteristics. Chi-square analyses showed no statistically significant differences in age, [$F(2,27) = 1.66$, $p = .21$], gender, [$\chi^2(2) = 2.5$, $p = .29$], ethnicity, [$\chi^2(2) = 2.22$, $p = .33$], marital status, [$\chi^2(6) = 2.21$, $p = .90$], occupation, [$\chi^2(8) = 7.36$, $p = .50$], or flying behavior at intake [$\chi^2(2) = .27$, $p = .87$].

14.6.1.2 Baseline Distress Level: A one-way ANOVA was used to compare the three groups at baseline across self-report questionnaire scores. In this and all subsequent ANOVAs, to correct for the Type I error created by violation of the sphericity assumption, the Huynh-Feldt correction was used. The degrees of freedom associated with this correction are reported as appropriate [50].

To correct for Type I error due to multiple dependent variables, a modified Bonferroni correction was used. Therefore, group differences were considered significant if $< .02$ [50,51]. There were no statistically significant differences between the scores on the Fear of Flying Inventory [$F(2,27) = 1.01$, $p = .38$], Self-Survey of Stress Responses Total Score [$F(2,27) = .10$, $p = .91$], Self-Survey of Stress Responses Autonomic Score [$F(2,27) = .86$, $p = .43$], Self-Survey of Stress Responses Motor Score [$F(2,27) = .02$, $p = .98$], Self-Survey of Stress Responses Central Nervous System Score [$F(2,27) = .17$, $p = .84$], State-Trait Anxiety Inventory, State Score [$F(2,27) = 1.21$, $p = .31$], State-Trait Anxiety Inventory, Trait Score [$F(2,27) = .56$, $p = .58$], Questionnaire on Attitudes Towards Flying [$F(2,27) = .28$, $p = .76$], VR Scenario Sheet Low Score [$F(2,27) = 1.31$, $p = .29$], and VR Scenario Sheet High Score [$F(2,27) = .80$, $p = .46$] (See Table 14.2).

14.6.2 Manipulation Checks

14.6.2.1 Objective Arousal

In order to verify that participants became aroused during each exposure session, skin resistance was used as a measure of sympathetic arousal [52]. Change scores were computed by subtracting skin resistance average for the 20-minute exposure session from a 5-minute baseline skin resistance level. A Group (3) x Time (6) ANOVA revealed no significant effect of Time ($p = .47$), and no significant Group x Time Interaction ($p = .50$). Since there was no difference in arousal by Group, individual t-tests were conducted to determine increases in arousal level at each time session. Paired samples t-tests were computed for baseline vs. the first exposure session, [$t(29) = 5.25$, $p < .001$]; second exposure session, [$t(29) = 3.37$, $p = .002$]; third exposure session, [$t(25) = 4.47$, $p < .001$]; fourth exposure session, [$t(22) = 2.556$, $p = .018$]; fifth exposure session , [$t(22) = 1.863$, $p = .076$]; and sixth exposure session, [$t(22) = 2.74$, $p = .012$]. Although during the fifth exposure session significance was not reached, it did approach significance (see Table 14.3).

Table 14.3 (a) Skin Resistance Averages for 5-minute baseline compared to 20-minute flight. Skin Resistance is measured in microohms

	Mean	*S.D.*	*t*	*p*	*df*
Session 3	85,72	89,42	5,25	< .001	29
Session 4	70,04	113,94	3,37	0,002	29
Session 5	87,78	100,23	4,47	< .001	25
Session 6	81,87	153,59	2,56	0,018	22
Session 7	43,24	111,32	1,86	0,076	22
Session 8	72,32	126,67	2,74	0,012	22

Table 14.3 (b) SUDS Average for 5-minute baseline compared to 20-minute flight (baseline = 1)

	Mean	*S.D.*	*t*	*p*	*df*
Session 3	27,58	21,33	7,08	< .001	29
Session 4	28,89	22,24	7,12	< .001	29
Session 5	29,19	25,90	5,85	< .001	26
Session 6	24,40	22,54	5,19	< .001	22
Session 7	18,85	13,51	6,39	< .001	20
Session 8	12,25	9,55	6,15	< .001	22

SUDS = subjective units of discomfort, from 0 = no anxiety to 100 = maximum anxiety

Table 14.3 (c) Pre-treatment scores on self-report questionnaires

Questionnaire	Group	*N*	*Mean*	*S.D.*
FOF	VRGETno	10	128,20	50,21
	VRGETpm	10	106,55	37,81
	IET	10	133,40	45,26
	Total	30	122,72	44,74
SSR-Tot	VRGETno	10	74,10	34,68
	VRGETpm	10	73,50	23,03
	IET	10	78,60	25,07
	Total	30	75,40	27,17
SSR-A	VRGETno	10	26,50	13,18
	VRGETpm	10	25,10	10,62
	IET	10	31,40	9,67
	Total	30	27,67	11,20
SSR-M	VRGETno	10	20,90	12,67
	VRGETpm	10	20,70	9,99
	IET	10	21,70	11,61
	Total	30	21,10	11,08
SSR-CNS	VRGETno	10	26,70	10,89
	VRGETpm	10	27,70	6,80
	IET	10	25,50	6,69
	Total	30	26,63	8,12
STAI-S	VRGETno	10	46,00	18,12
	VRGETpm	10	42,00	14,39
	IET	10	52,40	12,00
	Total	30	46,80	15,16
STAI-T	VRGETno	10	43,20	16,43
	VRGETpm	10	38,00	7,72
	IET	10	39,10	8,61
	Total	30	40,10	11,42
QAF	VRGETno	10	213,80	71,27
	VRGETpm	10	193,50	73,57
	IET	10	211,90	54,81
	Total	30	206,40	65,38
VR-Low	VRGETno	10	15,00	12,47
	VRGETpm	10	24,60	23,39
	IET	10	28,60	20,40
	Total	30	22,73	19,52
VR-High	VRGETno	10	97,40	4,20
	VRGETpm	10	93,50	6,26
	IET	10	95,00	9,43
	Total	30	95,30	6,92

STAI-T = state-trait anxiety inventory (trait); QAF = Questionnaire on attitudes toward flying; VR-Low = VR scenario sheet low score; VR-High = VR scenario sheet high score; VRGETno = virtual reality graded exposure therapy without physiological feedback; VRGETpm = virtual reality graded exposure therapy with physiological feedback; IET = imaginal exposure therapy without physiological feedback; FOF = Fear of Flying Inventory; SSR-Tot = self-survey of stress responses – total; SSR-A = self-survey of stress responses – autonomic; SSR-M = self-survey of stress responses – motor; SSR-CNS = Self-survey of stress responses – CNS; STAI-S = state-trait anxiety inventory (state)

14.6.2.2 Subjective Arousal

In order to verify if there was subjective arousal during exposure, subjective units of discomfort

(SUDs) scores were computed by subtracting SUDs average for the 20-minute exposure session from a 5-minute baseline SUDs level (with all subjects reporting they felt "very relaxed," SUDS = 1 by the end of the baseline). A Group (3) x Time (6) ANOVA revealed a significant effect of Time ($p<.001$), and a significant Group x Time Interaction ($p = .008$), however, no significant main effect for group was found ($p = .05$). The VR group receiving physiological feedback reported the highest level of subjective arousal, however, all groups showed arousal during all six exposure sessions. Single sample t-tests (vs. 1) were computed for the first exposure session, [$t(29) = 7.08$, $p < .001$]; second exposure session, [$t(29)=7.12, p<.001$]; third exposure session, [$t(26)=5.85, p<.001$]; fourth exposure session, [$t(22)=5.19, p<.001$]; fifth exposure session, [$t(20)=6.39, p<.001$]; and sixth exposure session, [$t(22)=6.15, p<.001$]. Means and standard deviations for SUDS scores across Sessions are shown in Table 14.3. Based on skin resistance and SUDS data, it was concluded that arousal, both subjective and objective, was achieved using the stimulus at hand.

14.6.2.3 Treatment Expectancy

Groups rated the treatments as being efficacious after having heard a description of the proposed treatment, but prior to the beginning of treatment. As several prior research studies have demonstrated, patient expectancy for improvement is thought to be a significant variable that may affect treatment outcome [45]. It was predicted that VRGETno, VRGETpm, and IET would be rated as potentially equally efficacious by participants on a series of five 10-centimeter line visual analog scales (VAS) adapted from Borkovec and Nau [45]. As in Borkovec's study, scores were summed over the five items. A one-way ANOVA compared the three groups at baseline. No significant differences were found, indicating that all three groups felt treatment would be equally efficacious in any of the groups they participated in [$F(2,24) = .29$, $p = .75$]. It was; therefore, a significant finding to know that participants in all treatment groups showed no difference in their expectancy for improvement based on the explanation of the treatment they received.

14.7 Clinical Outcomes

14.7.1 Subjective Ratings

Group (3) x Time (3) ANOVAs were used to test whether self-report questionnaire scores (QAF, FFI, SSR, STAI, VR Scenarios) varied due to intervention condition (VRGETpm, VRGETno,or IET) over three time periods (prior to treatment, after two sessions of relaxation training, and after six sessions of exposure therapy). All self-report questionnaires showed decreases in distress scores over Time (see Table 14.6). However, no main effect for Group or Group x Time interaction was found among any of the self-report questionnaires (see Table 14.4).

A Group (3) x Time (6) ANOVA was performed to assess Subjective Units of Distress (SUDs - with 0 indicating no anxiety and 100 indicating maximum anxiety) during exposure sessions 1, 2, 3, 4, 5, and 6. No significant main effect for group was found [$F(2,18) = 3.69$, $p = .05$]. However, there was a significant main effect for Time [$F(3.51,63.14) = 7.93$, $p < .001$]. Group x Time Interaction was also found to be significant [$F(7.02, 63.14) = 3.06$, $p = .008$] (see Table 14.5). Planned comparisons revealed that both the VRGETno group and the VRGETpm group were significantly improved on SUDS ratings compared to the IET group over the course of the six exposure sessions (VRGETno vs. IET $p = .009$; VRGETpm vs. IET $p = .04$). The two VR groups also differed from each other over time ($p = .03$).

14.7.2 Behavioral Outcome

Flying behavior was assessed three months post treatment. Chi-square analysis compared the groups at three-months post-treatment to determine how many participants could fly with medication, without medication, or could not fly.

Prior to training, there was no difference between subjects' ability to fly with or without medications between the three groups (see Table 14.6).

Participants were telephoned to determine how many flights they had taken since the end of treatment, how many flight opportunities they had since treatment ended, and how many flights they had avoided since treatment ended. They were also asked if they had taken medication prior to or during the flights to control anxiety.

The chi-square revealed a statistically significant difference in flying behavior between the groups [$\chi^2(4) = 19.41$, $p < .001$].

14.8 Discussion

The goal of this study was to determine if Virtual Reality Graded Exposure Therapy (VRGET) was equally efficacious, more efficacious, or less efficacious, than IET in the treatment of fear of flying. Physiology was measured to give an objective measurement of degree of arousal caused by 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 post treatment follow-up) were included to provide both subjective to objective measurements.

Table 14.4 (a) Questionnaire scores at Session 1, 3, and 8.

	Group	*Mean*	*S.D.*	*N*
VR-High	VRGETno	97.38	4.57	8
	VRGETpm	93.89	6.51	9
Session 1	IET	94.44	9.82	9
	Total	95.15	7.25	26
VR-High	VRGETno	85.63	20.26	8
	VRGETpm	93.33	8.66	9
Session 3	IET	96.00	5.39	9
	Total	91.88	12.94	26
VR-High	VRGETno	47.50	22.36	8
	VRGETpm	81.11	21.47	9
Session 8	IET	75.56	31.77	9
	Total	68.85	28.75	26

VR-High = VR scenario sheet high score; VRGET = Virtual reality graded exposure therapy; IET = Imaginal exposure therapy; Sess 1 = Session 1; Sess 3 = Session 3; Sess 8 = Session 8

First examined was whether self-report questionnaires scores would change differently over treatment for the Virtual Reality Graded Exposure Therapy with physiological feedback (VRGETpm) group, Virtual Reality Graded Exposure Therapy with no physiological feedback (VRGETno) group, and Imaginal Exposure Therapy (IET) groups. Although all groups showed improvement, they did not change differentially over time based on self-report questionnaire scores. Previous studies have found that participants given IET do show a decrease in self-report questionnaire scores [46, 21].

Table 14.4 (b) Questionnaire scores at Session 1, 3, and 8.

	Group	*Mean*	*S.D.*	*N*

FOF: Sess 1	VRGETno	115,38	37,27	8
	VRGETpm	108,72	39,44	9
	IET	132,44	47,89	9
	Total	118,98	41,57	26
FOF: Sess 3	VRGETno	119,50	29,83	8
	VRGETpm	112,78	38,93	9
	IET	141,61	46,82	9
	Total	124,83	39,98	26
FOF: Sess 8	VRGETno	83,38	32,95	8
	VRGETpm	91,44	35,00	9
	IET	111,44	57,49	9
	Total	95,88	43,57	26
SSR-Tot: Sess 1	VRGETno	77,13	35,17	8
	VRGETpm	71,56	23,54	9
	IET	80,11	26,10	9
	Total	76,23	27,48	26
SSR-Tot: Sess 3	VRGETno	64,75	40,58	8
	VRGETpm	76,56	31,88	9
	IET	74,56	31,35	9
	Total	72,23	33,58	26
SSR-Tot: Sess 8	VRGETno	59,88	36,36	8
	VRGETpm	72,83	22,77	9
	IET	68,67	34,11	9
	Total	67,40	30,62	26
SSR-A: Sess 1	VRGETno	27,50	12,87	8
	VRGETpm	23,89	10,51	9
	IET	32,00	10,06	9
	Total	27,81	11,23	26
SSR-A: Sess 3	VRGETno	21,13	13,90	8
	VRGETpm	24,11	13,62	9
	IET	29,67	9,31	9
	Total	25,12	12,42	26
SSR-A: Sess 8	VRGETno	18,13	10,40	8
	VRGETpm	22,67	9,89	9
	IET	27,22	11,39	9
	Total	22,85	10,82	26

FOF = Fear of Flying Inventory; SSR-Tot = self-survey of stress responses – total; SSR-A = self-survey of stress responses – autonomic; VRGET = Virtual reality graded exposure therapy; IET = Imaginal exposure therapy; Sess 1 = Session 1; Sess 3 = Session 3; Sess 8 = Session 8

Table 14.4 (c) Questionnaire scores at Session 1, 3, and 8.

	Group	*Mean*	*S.D.*	*N*

SSR-M: Sess 1	VRGETno	22,50	12,88	8
	VRGETpm	20,89	10,58	9
	IET	21,89	12,29	9
	Total	21,73	11,45	26
SSR-M: Sess 3	VRGETno	21,13	13,53	8
	VRGETpm	24,78	13,18	9
	IET	20,56	12,27	9
	Total	22,19	12,60	26
SSR-M: Sess 8	VRGETno	21,00	13,29	8
	VRGETpm	22,33	9,26	9
	IET	19,11	12,35	9
	Total	20,81	11,30	26
SSR-CNS: Sess 1	VRGETno	27,13	11,73	8
	VRGETpm	26,78	6,51	9
	IET	26,22	6,67	9
	Total	26,69	8,15	26
SSR-CNS: Sess 3	VRGETno	22,50	15,07	8
	VRGETpm	27,67	8,11	9
	IET	24,56	10,58	9
	Total	25,00	11,19	26
SSR-CNS: Sess 8	VRGETno	20,75	15,23	8
	VRGETpm	27,83	6,23	9
	IET	22,33	12,02	9
	Total	23,75	11,54	26
STAI-S: Sess 1	VRGETno	46,88	20,29	8
	VRGETpm	42,44	15,19	9
	IET	52,78	12,67	9
	Total	47,38	16,12	26
STAI-S: Sess 3	VRGETno	48,38	17,01	8
	VRGETpm	40,33	15,07	9
	IET	42,22	12,29	9
	Total	43,46	14,62	26
STAI-S: Sess 8	VRGETno	42,75	14,65	8
	VRGETpm	35,33	6,71	9
	IET	39,33	11,48	9
	Total	39,00	11,22	26

SSR-M = self-survey of stress responses – motor; SSR-CNS = Self-survey of stress responses; CNSSTAI-S = state-trait anxiety inventory (state); VRGET = Virtual reality graded exposure therapy; IET = Imaginal exposure therapy; Sess 1 = Session 1; Sess 3 = Session 3; Sess 8 = Session 8

Table 14.4 (d) Questionnaire scores at Session 1, 3, and 8.

	Group	*Mean*	*S.D.*	*N*

STAI-T : Sess 1	VRGETno	41,50	17,90	8
	VRGETpm	38,22	8,15	9
	IET	40,44	7,94	9
	Total	40,00	11,53	26
STAI-T : Sess 3	VRGETno	42,25	18,20	8
	VRGETpm	36,67	7,52	9
	IET	38,56	7,50	9
	Total	39,04	11,58	26
STAI-T : Sess 8	VRGETno	40,38	17,71	8
	VRGETpm	36,11	8,13	9
	IET	38,11	7,18	9
	Total	38,12	11,34	26
QAF: Sess 1	VRGETno	204,25	72,77	8
	VRGETpm	200,56	74,35	9
	IET	208,67	57,11	9
	Total	204,50	65,63	26
QAF: Sess 3	VRGETno	195,38	50,29	8
	VRGETpm	190,39	77,80	9
	IET	197,22	52,98	9
	Total	194,29	59,60	26
QAF: Sess 8	VRGETno	140,50	45,83	8
	VRGETpm	156,61	63,46	9
	IET	171,44	59,37	9
	Total	156,79	56,28	26
VR-Low	VRGETno	12,50	10,00	8
	VRGETpm	25,11	24,75	9
Session 1	IET	28,44	21,63	9
	Total	22,38	20,52	26
VR-Low	VRGETno	16,25	16,42	8
	VRGETpm	19,56	18,66	9
Session 3	IET	20,67	23,93	9
	Total	18,92	19,33	26
VR-Low	VRGETno	5,75	6,52	8
	VRGETpm	17,44	24,46	9
Session 8	IET	9,44	13,24	9
	Total	11,08	16,86	26

STAI-T = state-trait anxiety inventory (trait); QAF = Questionnaire on attitudes toward flying; VR-Low = VR scenario sheet low score; VRGET = Virtual reality graded exposure therapy; IET = Imaginal exposure therapy; Sess 1 = Session 1; Sess 3 = Session 3; Sess 8 = Session 8

This decrease in scores has also been found in VRGET [17-19]. We had expected that, since virtual reality environments are a step closer to in vivo exposure, VRGETpm and VRGETno would have resulted in a more significant decrease in scores than would IET.

However, this hypothesis was not supported. Of interest was the fact that all three groups showed an increase in some questionnaire scores from pre-treatment levels to the second testing,

which followed relaxation sessions. We attribute this to participants confronting their fears instead of avoiding them, and had begun to become more aware of their anxiety. That both VRGET groups and the IET group showed a decrease in fear as evidenced by the questionnaire scores may mean that all treatments did provide some therapeutic benefit for the individual participants in terms of subjective experience. The scores on the Trait portion of the STAI did not change significantly however. This helps support the fact that answers to self-report questionnaires may not have been influenced by social desirability, since if they had, we might have expected both state and trait scores to have decreased.

Table 14.5 (a) Means and standard deviations for suds scores

Source	*Group*	*Mean*	*S.D.*	*N*
SUDS AVERAGE FOR SESSION 3	VRGETno	31,56	20,37	8
	VRGETpm	38,75	27,35	8
	IET	22,00	6,44	5
	Total	32,02	21,42	21
SUDS AVERAGE FOR SESSION 4	VRGETno	23,13	13,85	8
	VRGETpm	48,75	30,09	8
	IET	20,15	3,82	5
	Total	32,18	23,79	21
SUDS AVERAGE FOR SESSION 5	VRGETno	19,97	13,61	8
	VRGETpm	55,38	31,84	8
	IET	22,75	12,79	5
	Total	34,12	27,30	21
SUDS AVERAGE FOR SESSION 6	VRGETno	12,47	12,36	8
	VRGETpm	38,13	28,82	8
	IET	26,65	17,83	5
	Total	25,62	23,23	21
SUDS AVERAGE FOR SESSION 7	VRGETno	10,00	10,16	8
	VRGETpm	26,00	15,24	8
	IET	21,55	7,58	5
	Total	18,85	13,51	21
SUDS AVERAGE FOR SESSION 8	VRGETno	7,70	7,82	8
	VRGETpm	15,00	11,88	8
	IET	17,42	5,08	5
	Total	12,79	9,68	21

SUDS = Subjective Units of Discomfort 0 = no anxiety, 100 = maximum anxiety; IET = imaginal exposure therapy without physiological feedback; VRGETno = virtual reality graded exposure therapy without physiological feedback; VRGETpm = virtual reality graded exposure therapy with physiological feedback.

Table 14.5 (b) Two-way ANOVAs for SUDS scores by treatment group.

Source	*SS*	*df*	*MS*	*F*	*p*
TIME (MAIN EFFECT)	5.867,19	3,51	1.672,77	7,93	<,001
GROUP (MAIN EFFECT)	9840,59	2	4.920,30	3,69	0,05
TIME * GROUP2 (INTERACTION)	4.529,83	7,02	645,74	3,06	0,08

SUDs self-report scores for VRGET and IET both improved over time, but did not differ significantly by group. 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. 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 in the IET group. A greater percentage of those in both VRGET groups were able to fly without medication at three-months post-treatment follow-up, as compared to the IET group as had been predicted. Only one participant (10%) who received IET reported an ability to fly without

medication or alcohol at three-month follow-up. Eight of the ten participants (80%) who received VRGETno reported an ability to fly without medication or alcohol at three-month follow-up, and ten out of the ten participants (100%) who received VRGETpm reported an ability to fly without medication or alcohol at three-month follow-up. However, this difference was not statistically significant, possibly due to sample size.

Although all three groups self-report scores showed a decrease when measured after Session 8, the participants in the imaginal group did not translate this change in attitudes towards flying to a behavioral change, i.e., ninety percent of the group still could not fly without medication or alcohol. Thus, although the IET treatment was effective in reducing subjective anxiety, it was not effective in altering flying behavior.

Even though subjective improvement occurred across all groups, self-efficacy improved much more for the VR groups and this further translated into actual flight behavior. The VRGET groups had an increase in belief that they could fly without drugs or alcohol, whereas the IET had a decrease in their belief that they could fly. In addition, the VRGET groups were more accurate in their assessment of their true ability to fly compared to the IET group.

Table 14.6 Flying behavior at follow-up

GROUP	*Flying w/meds*	*Flying w/o meds*	*Not flying*
VRGETno	1	8	1
VRGETpm	0	10	0
IET	6	1	3
Chi-square (4) = 19.41, p < .001			

GROUP	*Change*	*No Change*
VRGETno	8	2
VRGETpm	10	0
IET	2	8
Chi-square (2) = 15.60, p < .001		

14.9 Treatment Maintenance

Of those who called and were accepted for the study, only sixty-three percent (10 out of 16) in the IET group went beyond the 1st intake session when told they would be in the IET group. None of these patients had previously attempted IET prior to the study. And only 38% of imaginals who originally sought treatment (6 out of 16) completed all eight treatment sessions. None of these participants had a positive change in flying behavior after discontinuance of treatment. Two of those six who dropped out after intake chose to pay for virtual reality therapy as patients and the remaining four chose not to seek further treatment at our Center. No one in the virtual reality therapy groups dropped out of the study. Two participants in the VRGETpm group chose to quit treatment after five sessions because they were able to successfully fly without medication and with decreased anxiety. One participant in the VRGETno group chose to quit treatment after five sessions because of an ability to fly without medication and with decreased anxiety. Based on these experiences, it appears that VRGET is a more "attractive" treatment to the public seeking help with fear of flying. So, from a marketing standpoint, VRGET is much easier to get people to come in for than IET.

14.10 Clinical Implications

It is clear from the present study as well as numerous past studies that imaginal exposure therapy 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. It is also clear from past studies that in vivo exposure suffers from some limitations including cost, uncontrollability, and lack of confidentiality. Given that the results of this preliminary study were quite positive, it would seem that virtual reality graded exposure therapy should be considered a viable option when performing exposure therapy for fear of flying. The fact that virtual reality exposure allows for audio, visual, vestibular, and vibratory stimuli to be presented simultaneously to the participant may account for its success in alleviating fears. These multiple stimuli taken simultaneously constitute a form of "augmented reality" which represents the next step in the evolution of VR systems. It is important to emphasize that VRGET is just a technique-not a therapy. Exposure therapy, formally introduced by Joseph Wolpe in 1958 [53], and the newer technique of VRGET is but a powerful tool to be used as part of a well conceptualized therapeutic intervention.

Although the present study included small sample sizes for the three groups, results were rather dramatic and certainly warrant further investigation. Although the treating therapists were not blinded to the three therapy groups, we feel the explanation given for imaginal therapy provided a positive loading in favor of imaginal therapy and the lack of blinding should therefore not be considered a weakness. The methods used were standardized and reviewed for quality, ant therefore therapist bias if it exists at all should have minimal impact. To determine recidivism, a two year post treatment follow-up is underway.

Obviously as computer hardware and software power advances, more sophisticated VR environments will become available, perhaps with more flexibility and adaptability to individual patients as well as more scenarios. Participants in the current study overall were impressed with the audio and vibratory realness of the simulation, but some commented on the cartoonish nature of the visual environment. This should be solved in the future with advanced computing.

Future studies may help strengthen the case that virtual reality graded exposure therapy may be a more efficient and effective alternative to more traditional techniques of exposure therapy when treating specific phobias.

Notwithstanding the problems with the Denholz 1978 study [6], in which he found an 82% success rate after up to 48 sessions of treatment, it may be that VR is a more efficient treatment but not necessarily a more effective treatment.

14.11 References

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