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Fear of Flying: A Case Report Using Virtual Reality Therapy with Physiological Monitoring

BRENDA K. WIEDERHOLD,[1] M.S., M.B.A., RICHARD GEVIRTZ,[2] Ph.D., and MARK D. WIEDERHOLD, M.D., Ph.D.[3]

ABSTRACT

Virtual reality therapy has been used to successfully treat specific phobias. To illustrate the physiological differences between a person suffering from a fear of flying and a person without a fear of flying, heart rate, peripheral skin temperature, respiration rate, sweat gland activity, and brain wave activity were measured during a five-minute eyes closed baseline period, a twenty-minute virtual reality flight, and a five-minute eyes closed recovery period. Clear differences were found between the two participants' physiological responses. Four sessions of virtual reality exposure therapy were successsful in reducing physiological arousal for a person with a fear of flying. Self-report measures related to fear and avoidance of flying, as well as absorption ability, hypnotizability, and stress were also given to both participants and scores reflected distinct differences.

INTRODUCTION

ANXIETY DISORDERS are a significant and costly problem in the United States. Thirty-three percent of patients presenting with chest pain, abdominal pain, or insomnia actually have an anxiety disorder, as do 25% of those with fatigue, headache, or joint pain.[1] The average person with an anxiety disorder has ten encounters with the health-care system before being correctly diagnosed, increasing health-care costs, and causing frustration on the part of both the patient and physician.[2]

In 1990, the total mental health dollars spent in the U.S. were $147.8 billion. Of this amount, 32% (or $46.6 billion) was spent on the treatment of anxiety disorders.[3] In a more recent study, $15 billion in direct costs and $50 billion in indirect costs were the amounts estimated for anxiety disorders.[4]

Anxiety disorders are the most common mental illnesses. Twenty-three million Americans will suffer from an anxiety disorder at some time in their life, with anxiety disorders being the fifth most common diagnosis in primary care and the most common psychiatric diagnosis made by primary care physicians.[5]

Specific Phobias, which are one type of anxiety disorder, are the most prevalent mental health disorder, more common than alcohol abuse, alcohol dependence, or major depression.[6] The 30-day prevalence rate is estimated at 5.5%, with lifetime prevalence estimated at 13.3%. The prevalence estimate for specific phobias is more than twice as high for women as for men (2.3:1 ratio).[7] Specific phobia occurrence is higher among Hispanics and those who are not employed. Median age of onset is

[1] Center for Advanced Multimedia Psychotherapy, California School of Professional Psychology, Research and Service Foundation, San Diego, CA 92121.
[2] California, School of Professional Psychology—San Diego, Health Psychology Program, San Diego, CA 92121.
[3] Department of Internal Medicine, Scripps Clinic Medical Group, La Jolla, CA 92037.

15 years. Most persons (83.4%) with a specific phobia also report another *DSM-IV* disorder.

Despite significant evidence of role impairment in phobias, one study found only 12.4% had sought treatment,[6] whereas another study found 30.2% of those with specific phobias had sought professional treatment. Without treatment, only 20% of cases will remit.[7]

Fear of flying is one of the specific phobias, and is characterized by an unreasonable or excessive fear cued by flying or the anticipation of flying. This is a fear that the patient realizes is unreasonable. Individuals with this fear either avoid flying or do so with intense anxiety or distress.[8] This fear affects an estimated 10–20% of persons in the U.S.[9] Those flying despite their anxiety may choose to self-medicate with alcohol or sedatives in order to endure the fear.[10]

Exposure therapy, sometimes in combination with relaxation procedures, forms the basic psychotherapeutic approach to treat specific phobias, including fear of flying. Systematic desensitization was formally introduced in 1958 by Joseph Wolpe. This technique involves pairing relaxation with imagined scenes depicting situations that the patient has indicated cause anxious feelings.[11]

In vivo exposure involves having the patient confront the actual real-life phobic situation. Imaginal exposure involves having the patient visualize the phobic situation.[11] A new approach to treating phobias involves the use of virtual reality (VR) therapy.[12–23] In VR therapy, patients view real-life situations in an immersive virtual environment. The degree of immersion is monitored subjectively, and physiological monitoring with multiple sensors provides a more objective measure of engagement. We initially are beginning studies with fear of flying, since it is the most developed system that will run on a personal computer (PC) platform.

METHOD

Participants

The participants were two females, one in her late 20's and the other in her early 30's. One subject had a fear of flying and met the *DSM-IV* criteria for a specific phobia. The other subject had no fear of flying and, in fact, reported enjoying flying.

Measures

The following questionnaires were administered to both subjects:

Questionnaire on Attitudes toward Flying (QAF) was used to assess flying history and attitudes, as well as amount of fear caused by several aspects relating to flying. Scores may range from 0 to 360. Test–retest reliability has been reported at .92.[24]

Fear of Flying Inventory (FFI) measures different aspects of flying and how much anxiety each causes, from none at all to very severe. Scores may range from 0 to 264. Test–retest reliability is reported at .92.[25]

Self Survey of Stress Responses (SSR) attempts to determine a person's pattern of physical responses to stress, whether it be autonomic, somatic motor, or central nervous system (CNS). An example of an autonomic response item is "My stomach flutters." An example of a somatic motor response item is "I tap my feet or fingers." And an example of a CNS response item is "I pick at things (lint, hair, etc.)". Items may be rated 0 to 5. There are 38 items to the scale.[26]

State–Trait Anxiety 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). The two scales contain 20 items each, which may be scored 1 (not at all) to 4 (very much so). Trait anxiety has a reliability of .81 and state of .40, with internal consistency of between .83 and .92.[27]

The Tellegen Absorption Scale (TAS) assesses a person's ability to become deeply absorbed into what one is doing or one's environment. Scores on the 34 item True/False inventory may range from 0–34.[28]

The Hypnotic Induction Profile (HIP) determines hypnotic responsivity or how easily a person might become hypnotized.[29] The HIP scores may range from 0–16, with 0–5 meaning low hypnotizability, 6–10 being mid-range hypnotizability, and 11–16 meaning a person is likely to be highly hypnotizable.

Physiological Measures. The following physiological parameters were measured: Skin resistance, which changes in relation to change in sweat gland activity; heart rate, measured by electrocardiography; peripheral skin temperature, measured with a thermistor; and respiration rate, measured with a pneumograph. An I-330 C-2 computerized biofeedback system manufactured by J&J Engineering (Poulsbo, WA) was used to collect physiological data.

Virtual reality exposure therapy procedure

After signing an informed consent and being given a brief intake to assess for seizure history, heart problems, and medication usage (which might affect physiology), a 5-min eyes-closed baseline was taken. The subject sat quietly in a chair and was instructed to remain as still as possible so that movement artifact would be lessened. The subject then was placed in a MRG4 head-mounted display (HMD) by Liquid Image (Canada) and allowed to look around the virtual plane to become oriented. During the 20-min VR treatment, the patient wears an HMD and views a three-dimensional (3D) computer-generated image of several flying scenes, including sitting in a plane with the engines off, sitting in a plane with the engines on, pushing back to taxi, taxiing down the runway, taking off, flying in good weather, flying in turbulent weather, and landing. The therapist views the same image on a computer monitor that the patient is viewing in the HMD. The patient is able to change location in the virtual world and look around the airplane or out the window by turning her head. The current fear of flying system being used was designed by Drs. Rothbaum and Hodges of Virtually Better, Inc. (Atlanta, GA) who have previously performed VR treatment for acrophobia and fear of flying. The system is run on a high-end Intel Processor-based PC and contains advanced audio and Diamond Monster-3D graphics cards, external multimedia speakers and subwoofer, a Polhemus INSIDETRAK position Tracker, and customized software.

For each therapy session, a 5-min baseline was taken, then a 20-min VR exposure session was conducted, followed by a 5-min recovery period. The HMD was removed for both the baseline and recovery period and the patient sat upright, eyes closed. During VR sessions, the patient received audio and visual stimuli through the HMD. A subwoofer mounted under the patient's chair gave some vibratory and motion stimuli. Virtual scenes, which showed movement outside the airplane during taxi, takeoff, and landing, provided vestibular stimuli.

The participant with no fear of flying was seen for one session which included the 5-min baseline, 20-min VR flight, and 5-min recovery period. The patient with a fear of flying was seen for four sessions following the same 30-min protocol.

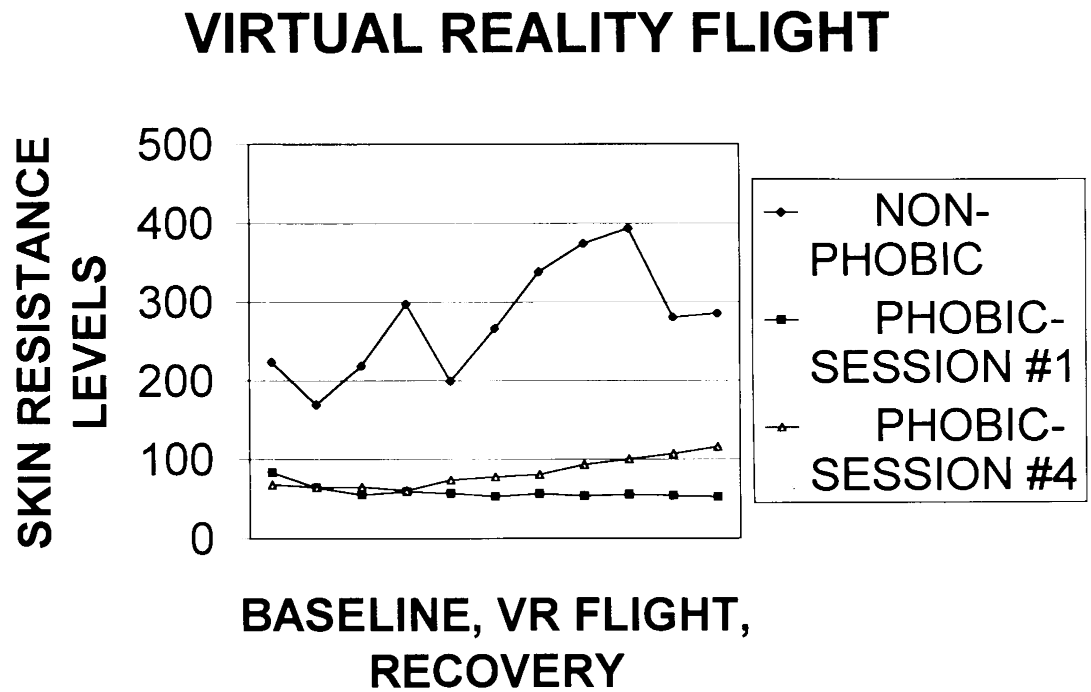
RESULTS

Non-phobic results

Some clear differences between a non-phobic's physiological response and a phobic's response when placed in the virtual environment (VE) have been noted so far. Since the VE is a new and novel stimulus, it is expected that some physiological arousal would occur. However, after orientation, one would be expected to relax to baseline physiological levels. The research participant without a fear of flying was placed in the VE. During a 5-min eyes-closed baseline, skin resistance levels were 223.97. When placed in the VE, a relatively new and novel stimulus, skin resistance dropped to 169.22 (a decrease of 24%), indicating some physiological arousal. Then, as orientation to the stimulus occurred, physiological arousal decreased and skin resistance increased to baseline levels. As the 20-min virtual flight continued, increased physiological relaxation and increased levels of skin resistance (338.51 during flying at altitude flight—51% above baseline) occurred. Subjectively, relaxation also continued to occur as the participant realized the new and novel stimulus was not dangerous (Figure 1).

Results for participant with fear of flying

In contrast, the physiological response of a participant with a fear of flying in the virtual world appears to be much different. The par-



SKIN RESISTANCE LEVELS DURING BASELINE, VR FLIGHT, & RECOVERY	BASELINE	ENGINES OFF	ENGINES ON	TAXI TO TAKEOFF	TAXI	TAKEOFF	GOOD WEATHER	BAD WEATHER	GOOD WEATHER	LAND	RECOVERY
NON-PHOBIC	223.97	169.22	218.63	297.73	199.59	266.56	338.51	374.09	393.59	280.92	285.80
PHOBIC-SESSION #1	83.08	63.88	55.01	59.04	57.14	53.06	56.50	53.67	55.20	53.98	52.32
PHOBIC-SESSION #4	67.69	64.45	65.02	60.47	73.57	77.51	80.87	93.07	99.92	106.77	115.62

FIG. 1. Skin resistance levels over baseline, 20-minute VR flight, and recovery period.

ticipant was referred to our center after having been successfully treated for other phobias over the past year with imaginal exposure and biofeedback. She had been unable to overcome the fear of flying using these standard procedures. During the first VR session, skin resistance decreased from baseline levels of 83.08 to 55.01 (a decrease of 34%) when the airplane engines were turned on. Skin resistance then decreased another 04% (to 53.06) during takeoff. The patient could not stabilize physiology even during recovery periods. The patient was exposed to the VR world progressively until the physiological response was attenuated. Initially, subjective units of discomfort (SUDs) were used while the patient was in the virtual world, but periodic questioning of the patient was found to be too intrusive. The patient reported difficulty maintaining the immersive feeling of being in a real airplane. It was therefore decided to advance the sequence of the flight only when the patient was able to control arousal by relaxation. In this way the patient learned relaxation skills in an unpredictable and changing environment. In the fourth VR session, skin resistance decreased by only 5% (from 67.69 to 64.45) when the VR flight began. Skin resistance then began to stabilize, so that it was actually at 57% above baseline (106.77) at the end of the VR flight, indicating a lowering of physiological arousal. The patient also reported subjectively feeling more relaxed at the end of the flight, and now has

TABLE 1. SELF-REPORT SCORES RELATING TO FEAR OF FLYING, ATTITUDES TOWARD FLYING, ANXIETY, STRESS RESPONSES, ABSORPTION ABILITY, AND HYPNOTIZABILITY

Scores on Questionnaires	*Phobic*	*Non-phobic*
QAF	301	20
FFI	128	20
STAI		
State	31	23
Trait	48	27
SSR		
A	34	28
M	32	17
C	33	12
TAS	25	23
HIP	11	10.5

indicated a readiness to try a real-life airplane flight (Figure 1).

Results of Self-Report Questionnaires

As shown in Table 1, the self-report scores for questionnaires relating to fear of flying and attitudes toward flying are dramatically different for the participant with a fear of flying and the participant without a fear of flying. Interesting to note also is the difference in both State and Trait anxiety for our two participants, with both being higher for the phobic participant. She also appears to respond to stress with all three systems (autonomic, somatic motor, and CNS) whereas the non-phobic participant is primarily an autonomic responder. Scores on the TAS and HIP were almost the same for both participants, and both participants subjectively reported being able to become deeply immersed in the virtual experience.

DISCUSSION

Studies have reported that when the phobic's fear structure is activated, autonomic arousal (such as increased sweat gland activity) occurs.[30] Emotional processing theory states that in order to change a patient's fear structure, the structure must be activated.[31] Real-time physiological monitoring will help to determine when the patient's fear structure is activated and open to change. Monitoring is useful and indicates when the patient is becoming too aroused and needs to be placed back at a lower level of their fear hierarchy or taken out of the phobic scenario altogether. It can also reveal if the patient has become desensitized to a certain aspect of the phobic scenario and should actually be encouraged to move on to the next level of the fear hierarchy.

In 1907, Carl Jung discovered that skin resistance (which decreases as sweat gland activity increases) was a means to objectivy emotional tones previously thought to be invisible. Skin resistance, unlike electromyography (EMG) and skin temperature, tends to reflect mental events more rapidly and with more resolution than the other physiological measures.[30] Baseline levels vary widely by individual so the percentage change from baseline is normally measured rather than the absolute value.

Although this report describes only two study participants in detail, many others have now been exposed and studied in the VR system. Many useful comments related to system use, degree of comfort, immersiveness (believability) and other reactions are being utilized to improve and redesign the system. Some participants comment on the weight of the HMD causing some discomfort in the neck and shoulders. Some have also complained that the graphics are too cartoonish and not realistic enough, while others are able to become fully immersed in the treatment. We are working to elucidate any differences between these two groups, which could help differentiate those who may be treated in VEs from those who may require an actual airplane ride. Interestingly, some patients who complain of a lack of realism still have noticeable physiological responses in the VE.

Some advantages of VR therapy as compared to *in vivo* include confidentiality, safety, control, and flexibility. Since the treatment is done in the therapist's office, there is no loss of confidentiality. Because the treatment is in the office and can be terminated at any moment, it should be "safer" than being trapped on a plane and having severe anxiety or a possible panic attack. Since there is more control of the scenario, with the patient able to, at any time, remove the HMD or ask the therapist to stop the VR scenario, more patients may be willing to seek treatment. Also, the therapy may be just "unreal" enough that many patients who have resisted therapy due to in vivo approaches are willing to try it. If the patient's main fear centers on airplane landings, one can practice landings over and over in the virtual world. This flexibility allows for more directed treatment and hopefully will require less treatment time, thus reducing costs. Compared to Imaginal, the VR system is more highly immersive due to the stimulation of several sensory modalities, including audio, visual, and vestibular. Multiple sensory modalities may better prepare patients for an actual airplane trip. Also, since the therapist is seeing exactly what the patient is seeing, and can more easily determine the stimuli eliciting the fear response, therapy can be directed more toward only those parts of the environment causing anxiety.

Virtual environments are still costly for the individual therapist, difficult to operate for those who are not computer literate, and cannot be changed to suit individual patient's fear and phobia hierarchies. They may also cause psychological or physiological side effects in a small percentage of patients. They may also not be realistic enough for some persons.

In conclusion, it is clear that some patients do respond well to VR therapy. At first glance, the number of sessions to overcome the fear of flying seems to be reduced, when compared to imaginal therapy. Physiological monitoring appears to be a helpful adjunct when working with patients in virtual worlds, providing objective evidence that desensitization is occurring. And, finally, important differences between responders and non-responders need to be investigated further so that VR treatment may continue to be refined.

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Address reprint requests to:
Brenda K. Wiederhold, M.S., M.B.A.
Director
Center for Advanced Multimedia Psychotherapy
CSPP Research and Service Foundation
6160 Cornerstone Court East
San Diego, CA 92121

E-mail: Brendawied@aol.com

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