Virtual reality exposure therapy in the treatment of fear of flying: a case report

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Summary—The efficacy of virtual reality (VR) exposure therapy was examined for the fear of flying. Virtual reality exposure involved six sessions of graded exposure to flying in a virtual airplane. The specific contribution of anxiety management techniques (AMT) and the VR exposure was examined in a single case design. The subject was a 42-year-old female with a debilitating fear and avoidance of flying. All self-report measures of the fear and avoidance of flying decreased following AMT and decreased still further following VR exposure. A planned post-treatment flight was completed with anxiety measures indicating comfortable flight. The implications of this new medium for exposure therapy are discussed.

INTRODUCTION

Virtual reality (VR) exposure has been proposed as an alternative to standard in vivo exposure. VR integrates real-time computer graphics, body tracking devices, visual displays, and other sensory input devices to immerse a participant in a computer-generated virtual environment. The investigators conducted a case study using five sessions of VR exposure over 3 weeks to treat a subject with acrophobia, with a particular fear of elevators. VR exposure was successful in reducing fears of heights on all measures of anxiety, avoidance, attitude, distress, including a behavioral avoidance test (Rothbaum, Hodges, Opdyke, Williford & North, 1995).

The authors conducted the first published controlled study of VR exposure in the treatment of a psychological disorder (Rothbaum, Hodges, Kooper, Opdyke, Williford & North, 1995). The efficacy of computer-generated VR exposure was compared to a wait-list (WL) control in the treatment of acrophobia. In individual sessions over 8 weeks, subjects were exposed to virtual foot bridges, outdoor balconies, and a glass elevator. Significant group differences were found on all measures such that the VR exposure group was significantly improved at post-treatment but the WL group was unchanged. Anxiety, avoidance, distress, and all negative attitudes towards heights decreased significantly from PRE to POST for the VR exposure group but not for the control group. Subjects experienced a range of physical anxiety symptoms consistent with the apparent threat they encountered from virtual height situations. The average anxiety ratings decreased steadily across sessions, indicating habituation. In addition, 7 of the 10 VR exposure treatment completers exposed themselves to height situations in real life during treatment although they were not specifically instructed to do so. VR exposure was considered successful in reducing fears of heights.

It is an appeal to the sense of presence that distinguishes VR as different from merely a multimedia system or an interactive computer graphics display. A sense of presence is also essential to conducting exposure therapy since therapy is aimed at facilitating emotional processing (Hodges, Rothbaum, Kooper, Opdyke, Meyer, de Graaf, Williford & North, 1995). Discussions of emotional processing theory as applied to anxiety disorders (Foa & Kozak, 1986; Foa, Steketee & Rothbaum, 1989) purport that fear memories can be construed as structures that contain information regarding stimuli, responses, and meaning. Therapy is aimed at facilitating emotional processing. For this to occur, it has been proposed that the fear structure must be activated and modified. For virtual reality exposure therapy to be effective, it must activate the fear structure and elicit the fearful responses, requiring a sense of presence. In the studies discussed above, it is clear that the fear structures of acrophobic subjects were activated and modified by the VR exposure therapy. It is important to determine if VR exposure can be helpful for other disorders as well.

Fear of flying is a significant problem, affecting an estimated 10–25% of the population (Agras, Sylvester & Oliveaux, 1969; Deran & Whitaker, 1980). A Boeing Airplane Company survey indicated that 25 million adults in the United States are fearful about flying (Deran & Whitaker, 1980). In addition, approximately 20% of those who do fly depend on alcohol or sedatives during flights (Greist & Greist, 1981). Avoidance of flying causes sufferers serious vocational and social consequences.

Fear of flying is an ideal candidate for VR exposure therapy for many reasons. First, logistically it would be relatively easy to track subjects' head and arm movements using current tracker technology since subjects in an airplane passenger cabin naturally remain with a small area of space. With props such as actual airplane seats and sound effects of actual flights, VR flying will be very realistic. Second, we should be able to activate subjects' fears. As was demonstrated in our
VR fear of heights study, subjects experienced a sense of presence and became anxious despite realistic absence of threat (i.e. they were not actually 50 m high). Fear of flying subjects have been shown to be comprised of a mixture of specific phobics and agoraphobics. Specific phobics with a fear of flying have been shown to be fearful of crashing, whereas agoraphobics are fearful of having panic attacks (Howard, Murphy & Clarke, 1983; McNally & Louria, 1992). Both of these fears should be activated with VR and consequently anxiety should habituate with repeated exposure (Beckham, Vrana, May, Gustafson & Smith, 1990).

Third, fear of flying is a serious problem with growing financial repercussions. As mentioned above, this fear and avoidance has serious consequences, including career repercussions, social embarrassment and restrictions, as well as stigmatization (Roberts, 1989). In 1982, annual revenue loss for the U.S. air travel industry attributed to the fear of flying was estimated at 1.6 billion dollars (Roberis, 1989).

Many fear of flying programs have been described but without data as to their efficacy. These typically include a number of anxiety management techniques such as relaxation training, thought-stopping, and cognitive restructuring, provision of accurate information regarding airplanes and flying, and exposure techniques including imaginal and in vivo exposure (Cummings, 1989; Doctor, McVarish & Boone, 1990; Greco, 1989; Heller, 1993; Roberts, 1989; Waldner, McCracken, Herbert, James & Brewitt, 1987).

A controlled study investigated evidence of emotional processing using a minimal-therapist-involvement stress inoculation training (Beckham et al., 1990). A subject manual presented stress inoculation training incorporating relaxation training and cognitive coping strategies. Subjects were randomly assigned to receive treatment, including the manual and weekly telephone contact with a therapist, or to a wait-list control group. A post-treatment flight was scheduled at pretest for all subjects. The Questionnaire on Attitudes toward Flying (QAF; Howard, Mattick & Clark, 1982) was administered pre- and post-treatment and at a follow-up of 8 weeks post-flight. Heart-rate and SUDs were gathered during the flight for all subjects. Results indicated significant improvements for the treated subjects relative to the controls as indicated by QAF scores, attendance at the post-treatment flight, and subsequent flying. The pre-treatment QAF score, indicating initial levels of fear, was significantly related to heart rate at the most fearful point in the flight, 5 min after take-off. Moreover, subjects who flew subsequent to treatment showed more evidence of emotional processing during exposure than those who continued to avoid: they had higher heartrates during exposure, a greater reduction in heartrate from the beginning to end of exposure, and greater self-reported fear reduction pre-to post-flight. These results support the effectiveness of a minimal anxiety management training program combined with an exposure component. The results also highlight the importance of fear activation and extinction during exposure as important determinants of emotional processing.

Systematic desensitization, flooding, implosion, and relaxation treatments were equally superior to a no-treatment control in a controlled design (Howard et al., 1983). Other less controlled or conventional treatments have been studied. An automated audiovisual treatment using a modified systematic desensitization program administered by non-professionals was effective as measured by the number of subjects who flew (Denholtz & Mann, 1975), but this program had 30 dropouts during treatment. In a study using undergraduates as subjects, overall there were no treatment differences between four groups: preparatory information training, self-statement training, combined information and self-talk, and a control treatment viewing films on aviation history (Girodo & Roehl, 1978). In a small sample (n = 10), both stress inoculation training and applied relaxation were equally effective in enhancing actual flying on a post-treatment flight and reducing physiological arousal and subjective anxiety (Haug, Brenne, Johnson, Berntsen, Gostetam & Hugdahl, 1987).

Fear of flying studies have been criticized for not including a post-treatment flight to evaluate outcome (Haug et al., 1987). Considering the prevalence and impact of fear of flying, it is surprising that more controlled studies have not been conducted. However, the difficulty and expense of using actual airplanes and flights for exposure have daunted many researchers and therapists. Some fear of flying programs exist in large metropolitan cities, often sponsored by airlines and charging high fees to include flights, and usually are not covered by insurance. These programs have not been subjected to rigorous evaluation, and therefore their efficacy cannot be ascertained. VR exposure is potentially an efficient and cost-effective treatment of fear of flying. Treatment costs will be low compared to in vivo exposure using real airplanes, therapists can conduct treatment sessions in their office instead of accompanying their subjects to an airport, and the potential for violation of patient confidentiality will be reduced. The use of VR assisted exposure to flying is analogous to the use of flight simulators to train pilots.

**METHOD**

**Subject**

The subject was a 42-year-old female with a debilitating fear and avoidance of flying, who met DSM-IV (APA, 1994) criteria for a specific phobia. She was working gainfully in a profession that did not require travel. She was happily married with two children. In general, she was not generally anxious (pre-treatment STAI-State of 21 and STAI-Trait of 23) nor depressed (pre-treatment BDI of 0). She reported a prior history of regular but fearful flying for vacations, having grown increasingly fearful over the past 5 years, worrying about the plane crashing. During this period, she used antihistamines as preparatory information training (Howard et al., 1983). Other less controlled or conventional treatments have been studied. An automated audiovisual treatment using a modified systematic desensitization program administered by non-professionals was effective as measured by the number of subjects who flew (Denholtz & Mann, 1975), but this program had 30 dropouts during treatment. In a study using undergraduates as subjects, overall there were no treatment differences between four groups: preparatory information training, self-statement training, combined information and self-talk, and a control treatment viewing films on aviation history (Girodo & Roehl, 1978). In a small sample (n = 10), both stress inoculation training and applied relaxation were equally effective in enhancing actual flying on a post-treatment flight and reducing physiological arousal and subjective anxiety (Haug, Brenne, Johnson, Berntsen, Gostetam & Hugdahl, 1987).

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**Measures**

The Questionnaire on Attitudes toward Flying (QAF; Howard et al., 1982) assesses history of fear of flying, previous treatment, and attitudes towards flying. It includes a 36-item questionnaire rating the level of fear on a 0-11 scale in different flying situations. The possible range of scores on the QAF is 0-360. Test–retest reliability was 0.92, and split-half reliability was 0.99.

The Fear of Flying Inventory (FFI; Scott, 1987) is a 33-item scale measuring intensity of fear of flying. Items are rated on a 0-8 scale. Test–retest reliability for 15 wait-list patients was 0.92, and it has been sensitive to change with treatment. Fearful flyers mean score was 148 (n = 38), whereas controls (travelers) scored 34.7 (n = 50).

The Self-Survey of Stress Responses (SSR; Forgione & Bauer, 1980) is a 38-item measure tapping fearful responses during flying. Items are rated on a 0-5 scale and are divided into (A) Autonomic (e.g. "My heart beats very fast"), (M) Muscle (e.g. "My head aches..."), or (C) Central Process (e.g. "I bite my nails") scores. The maximum score is 70 in each subscale.
The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970) is comprised of 40 items divided evenly between state anxiety and trait anxiety. The authors reported reliability for trait anxiety was 0.81; as expected, figures were lower for state anxiety (0.40). Internal consistency ranges between 0.83 and 0.92.

The Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock & Erbaugh, 1961) is a 21-item self-report questionnaire assessing numerous symptoms of depression. The authors report excellent split-half reliability (0.93), and correlations with clinician ratings of depression range between 0.62 and 0.66.

The Clinical Global Improvement (CGI) scale is a global measure of change in severity of symptoms. The scale is bipolar with 1 = very much improved; 7 = very much worse; and 4 = no change. It has been used extensively in clinical trials for a variety of psychiatric patients (Guy, 1976).

The Flight Self-Monitoring Sheet was developed for use in this project to record subjective anxiety during the post-treatment flight. The subject was provided with a self-monitoring sheet to assess her Subjective Units of Discomfort (SUDs) level at various points prior to boarding the plane, on board, in flight, and afterwards. SUDs ratings during flights have been responsive in studies by Beckham et al. (1990), and Howard et al. (1983).

The Therapist Form was constructed for this project to record virtual reality situations presented in session, SUDs ratings during exposure, session-by-session homework, clinical global improvement, and subject self-rating of global improvement.

Procedure

The subject was referred to the first author for treatment of the fear of flying. She was administered the battery of questionnaires described above. She was seen as a paying outpatient for seven sessions during which she was taught anxiety management techniques. These included brief breathing relaxation, bibliotherapy, thought-stopping, cognitive restructuring, and preparing for a stressor. At this point, it was mutually decided that exposure would be beneficial. She was offered free treatment using virtual reality exposure and accepted. Approximately 6 weeks passed in the interim period between terminating AMT treatment and commencing VR treatment while the software for VR was in preparation.

Immediately prior to the first VR session, the subject was informed of the study procedures and the experimental nature of the treatment. At this time, the same battery of questionnaires was completed and an informed consent form was signed. The first treatment session of VR exposure followed. Immediately following the last VR exposure session, the therapist completed the same battery of questionnaires described above. Two days following the last VR exposure session, the subject completed a planned cross country flight with her family (husband and two children). During each of two legs for each of these two flights (initial and return), she completed the flight self-monitoring sheet. One month after the completion of this flight, the same battery of questionnaires was administered as a follow-up assessment.

VR exposure treatment

Sessions were conducted for approximately 35-45 min. Virtual reality exposure to sitting in an airplane, take offs and landings in an airplane and flying in both calm and stormy weather were provided. During VR exposure sessions the subject wore a head-mounted display (Virtual Research EyeGen4) with stereo earphones that provided visual and audio cues consistent with being inside the passenger compartment of an airplane while seated in a padded chair with armrests. Actual recorded sounds of takeoffs, landings, and of weather effects such as rainstorms and thunder on the outside of the airplane were used.

The therapist viewed all virtual environments to which the subject was exposed and thus was able to make appropriate comments and encourage continued exposure until anxiety decreased. The subject was allowed to progress at her own pace along the following hierarchy: sitting on plane, engines off; sitting on plane, engines on; taxiing; smooth take-off; smooth flight; close pass over the airport similar to a missed landing; landing; turbulent flight; and rough take-off. Treatment was terminated after six sessions, when the subject indicated no more anxiety associated with the exposure. All treatment sessions were videotaped for supervision by a licensed clinical psychologist (B.O.R.).

RESULTS

The pre- and post-treatment scores can be found in Table 1. As can be seen, her self-reported anxiety about flying was reduced following AMT treatment, decrees further following VR exposure, and was maintained at follow-up. Her self-reported fear decreased from “8” at pre-treatment to “4” at post-treatment on a 0–10 scale of fear of flying on the QAF, and the therapist and patient rated her as “much improved” (2" on the CGI). In addition, she was able to complete a round-trip cross-country flight with minimal anxiety immediately following treatment. Table 2 contains SUDs ratings

### Table 1. Fear of flying VR exposure case scores pre- and post-treatment and follow-up

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pre-treatment</th>
<th>Post-AMT/Pre-VR</th>
<th>Post-VR</th>
<th>Post-flight</th>
</tr>
</thead>
<tbody>
<tr>
<td>QAF</td>
<td>215</td>
<td>113</td>
<td>62</td>
<td>74</td>
</tr>
<tr>
<td>FOFI</td>
<td>93</td>
<td>88</td>
<td>50</td>
<td>53</td>
</tr>
<tr>
<td>SSSR: A</td>
<td>22</td>
<td>14</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>M</td>
<td>13</td>
<td>9</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>C</td>
<td>9</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

**Scenarios Self-Ratings**

| Off           | 10            | 10              | 5       | 10          |
| On            | 20            | 10              | 5       | 15          |
| Taxi          | 30            | 20              | 5       | 15          |
| Take-off      | 40            | 30              | 10      | 20          |
| Flight        | 50            | 30              | 10      | 15          |
| Turbulent     | 80            | 50              | 15      | 25          |
| Turb. + thunder | 100      | 70              | 20      | 40          |
| Landing       | 40            | 20              | 10      | 15          |

QAF, Questionnaire on Attitudes Toward Flying; FFI, Fear of Flying Inventory; SSSR, Self-Survey of Stress Responses; A, Autonomic; M, Muscle; and C, Central Process; turb. + thunder, turbulence and thunderstorm.
during the four legs of this post-treatment flight. As can be seen in Table 2, during these flights her highest SUDS rating was 30. Some of her comments written on the flight self-monitoring sheets include: “Still have “blips” of anxiety on turbulence, but less intense this leg”; “About 10 minutes of strong turbulence but I stayed pretty calm...Somehow it was comforting at points to remember and picture the VR”; and “Much better than in last few years but not yet perfect”.

**DISCUSSION**

Virtual reality exposure treatment was successful in reducing this subject’s fear of flying. Although the sole contribution of VR exposure to her improvement is not possible to determine given the inclusion of AMT techniques, the contribution of VR exposure to the overall outcome is considered significant for many reasons. First, her self-reported anxiety on all measures decreased further following VR exposure. Second, she was able to complete a long flight, one that she had successfully avoided for the past 2 years. Third, as mentioned above, the usual treatments for the fear of flying include a combination of AMT and exposure. Had VR exposure not been available, this therapy would have included exposure with actual airplanes, possibly with the therapist flying with the patient before she flew with her family. Instead, the treatment goals were accomplished using VR exposure in place of *in vivo* exposure, which is the significance of this report.

Although currently the cost of the hardware required to run VR applications is prohibitive for most other than large universities, and writing the software usually requires very specialized knowledge, this will not be the case for long. Particularly driven by the computer game industry, lower cost VR helmets and applications are already available. At the 1995 Winter Consumer Electronics Show, four companies presented head mounted displays for VR ranging from $400 to $1000 for use with personal computers and television sets (*Newsweek*, 1995, p. 52). It is expected that, just as personal computers (PCs) were initially available only to a select group of university-affiliated computer experts but are now commonplace, the technology of VR will soon be available and relatively inexpensive. Therefore, it is foreseeable that if VR exposure for fear of flying, or for other disorders, proves to be an effective treatment, it will be feasible for many therapists to use this technique in their offices in the near future.

In addition, VR exposure has possible applications to telemedicine, in which diagnoses are made and treatment is prescribed and administered in a site remote from the subject through the use of video cameras and monitors. Telemedicine is particularly needed in rural settings in which adequate healthcare might not be available for miles. In this case, since the therapist is not present in the virtual environments, but rather views on a monitor that with which the subject is interacting, the therapist could conceivably be miles away viewing and commenting appropriately and therapeutically.

The major shortcoming of this report is the case study approach which necessarily limits the generalizability of the findings. However, comparing this subject’s scores to those of treatment seeking samples in larger studies indicates that she appears to be representative of fearful flyers, and, in fact, seems to have responded impressively to treatment after VR exposure. Beckham et al.’s (1990) sample started with QAF scores between 160 and 180 and following treatment had scores averaging 105. Howard et al. (1983) subjects started with QAF scores between 220 and 260 and following treatment had scores between 140 and 220. The current subject started with a QAF score of 215 and last scored a 74 at follow-up. Data on the FFI indicated that fearful flyers averaged 148 and controls (travelers) averaged 35. This subject scored 93 at pre-treatment and 53 at follow-up.

Evidence has been presented here and in previous reports (Hodges et al., 1995; Rothbaum et al., 1995a, 1995b) for the potential benefit of the application of virtual reality technology to the treatment of psychological disorders. This report extends previous findings that VR exposure was helpful in reducing the fear of heights in two important ways: one, the potential efficacy for another disorder has been demonstrated, particularly one that is logistically more difficult to treat than acrophobia. And two, the use of VR exposure as a tool in therapy has been supported, a component in an otherwise “standard” treatment. Controlled outcome studies utilizing VR exposure for this and other disorders are most definitely necessary.

**REFERENCES**


Table 2. SUDS ratings during post-treatment flight

<table>
<thead>
<tr>
<th>Flight ratings</th>
<th>1st leg out</th>
<th>2nd leg out</th>
<th>1st leg back</th>
<th>2nd leg back</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-board</td>
<td>15</td>
<td>20</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>Pre-take-off</td>
<td>20</td>
<td>15</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>5 min before take-off</td>
<td>25</td>
<td>10</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Landing</td>
<td>15</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Post-landing</td>
<td>10</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

SUDS, Subjective Units of Discomfort; 0, no anxiety; 100, maximum anxiety.


