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Virtual Reality in the Treatment of Claustrophobic Fear: A Controlled, Multiple-Baseline Design

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The aim of this study was to determine the effectiveness of virtual reality (VR) exposure in the treatment of claustrophobic fear. We evaluated the intervention following a controlled, multiple-baseline design across 4 participants with claustrophobic fear who sought psychological help in our anxiety disorders clinic. The treatment consisted of 8 individual VR graded exposure sessions. Data were obtained at pretreatment, posttreatment, and 3-month follow-up on several clinical measures: Behavioral Avoidance Test, Self-Efficacy Toward Closed Spaces, Problem-Related Impairment Questionnaire, Beck Depression Inventory (Beck, 1978), and Anxiety Sensitivity Index (Peterson & Reiss, 1992). Results support the effectiveness of the VR procedure for the treatment of claustrophobic fear. An important change appeared in all measures after treatment completion. It can be concluded that VR exposure was effective in reducing fear and avoidance in closed spaces and in increasing self-efficacy in claustrophobic situations. Moreover, changes were maintained at 3-month follow-up.

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The second wave of virtual reality (VR) applications to the field of health has just started (Wiederhold, 1998), and this technology is beginning to demonstrate enormous potential. In the past years, several papers have been published pointing out the utility of VR techniques for the treatment of different psychological problems. In the specific field of anxiety disorders, there is research work on the treatment of acrophobia (North & North, 1994; North & North, 1996; Rothbaum et al., 1995a, 1995b), spider phobia (Carlin, Hoffman, & Weghorst, 1997), flying phobia (Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996), agoraphobia (Rothbaum et al., 1995a), and claustrophobia (Botella, Baños, Perpiñá, Villa, et al., 1998). As Wiederhold points out, numerous publications from at least 15 centers around the world state that the treatment of specific phobias using VR is not only effective, but it also has a number of advantages if we compare it to traditional treatments.

Traditionally, the treatment of choice for specific phobias has been in vivo exposure (Marks, 1987; Öst, 1987); however, not all patients benefit from this treatment, since some are too afraid of facing the threatening object or context, and either reject an exposure program or drop out (Marks & O'Sullivan, 1992). Even for patients who accept treatment, it can be very aversive. Patients may not feel safe, as there is no certainty for them that something may not go wrong (e.g., elevator stopping, technical problems in the airplane, etc.).

An important advantage of VR is the safety that it provides to the patients; they can control the context generated by the computer at will and with no risks, because it can be absolutely graded. Therefore, VR can be an intermediate step between the therapist's consulting room (where the patients feel safe and protected) and the real environment (which can be so threatening for some patients that they decide not to face it). Another advantage of VR is that it becomes a very useful tool in some cases where the feared situation is not easily accessible (e.g., an airplane). Finally, it has been pointed out that some patients who follow an exposure program continue to show "residual fears" in the feared situation (Marks & O'Sullivan, 1992). The control that VR environments provide and the possibility of going beyond what a "real" situation would allow are factors that could promote the patients' feelings of self-efficacy and help to eliminate residual fears. VR "fits" the patient very well: The virtual environment can be graded in regard to the suitable degree of difficulty for the patient, who can practice as long as he or she wants or needs to. Moreover, VR makes it possible to go beyond the limits of time, and past times can be re-created or future situations created.

Claustrophobic fear has a number of special features that makes this psychological problem eligible for its treatment with VR. Functionally equivalent to agoraphobia, but with more limited avoidance (Barlow, 1988; Booth & Rachman, 1992; Öst, 1987), claustrophobia also shares some features with panic disorder (PD; Curtis, Hill, & Lewis, 1990): The bodily sensations reported by claustrophobic participants are very similar to those reported by participants with PD (Booth & Rachman). Moreover, participants with claustrophobic fear reported more physiological and cognitive symptoms than did

the participants with other specific phobias (Craske & Sipsas, 1992). Finally, claustrophobic fear, in itself, may also be limiting and cause a notable impairment in an individual's life.

As concluded in the works published to date, evidence exists on the utility of VR for the treatment of different psychological disorders. However, the studies carried out so far have a limited accuracy from a methodological point of view given that most are case studies. Therefore, for VR techniques to be widely accepted, it may be necessary to carry out studies with a higher experimental control, which will increase the confidence in the efficacy of VR as a therapeutic tool. The primary purpose of the present study was to carry out a controlled, multiple-baseline design across 4 participants (who sought psychological assistance) to determine the effectiveness of VR exposure in the treatment of claustrophobic fear. We hypothesized that the virtual claustrophobic context would activate a high degree of anxiety in the patients, and that they would be able to overcome their claustrophobic fear through virtual exposure. The effectiveness of VR treatment was evaluated mainly by means of the reported fear of closed spaces in four participants (three suffering from panic disorder with agoraphobia and one from claustrophobia). If VR exposure was effective, reports of expected danger and fear, behavioral avoidance scores, and degree of impairment of the problem in the person's life would decrease and self-efficacy scores would increase. Lastly, it was also hypothesized that, because of the similarity between claustrophobia and PD with agoraphobia, scores in the Anxiety Sensitivity Index would decrease due to treatment effectiveness. Maintenance of the results at 3-month follow-up was evaluated, as well.

Method

Participants

Four persons who asked for help to overcome their fear of closed spaces at the Psychological Assistance Service (PAS) of the Jaume I University took part in the study. One participant (P4) met *DSM-IV* criteria (American Psychiatric Association, 1994) for specific phobia, situational type (claustrophobia), and the remaining 3 met *DSM-IV* criteria for PD with agoraphobia. Within this disorder they were also experiencing impairing fear and avoidance of closed spaces. None had received prior treatment for their psychological problem.

Two participants (P1 and P3) were taking medication (SSRIs and benzodiazepines, respectively) that improved mood but not anxiety symptoms. To take part in the study, they were asked to discontinue their pharmacological treatment under psychiatrist guidelines to avoid symptom rebound. When the study was initiated (including baseline period), none was taking medication.

Participant 1 (P1) was a 22-year-old white female, single, working as a modiste. For the past 2.5 years (following a car accident without victims), she began to experience anxiety symptoms (dizziness, feelings of unsteadiness,

palpitations, and fear of being alone and fainting because nobody would be there to help her). Her main fear was of fainting. She avoided crowds, public transportation, and closed spaces (mainly banks, movie theaters, and elevators). She lived in a small town, an environment in which she could take a walk unaccompanied. If she had to leave town, she only went accompanied, to places she considered safe. She was afraid of traveling and only got in a car with her father or her boyfriend because she knew she could exit the car whenever she wanted to. Her problems fit criteria for PD with agoraphobia.

P2 was a 24-year-old white female, single, undergraduate psychology student. She reported a sudden onset of her fear of closed spaces. She avoided elevators, crowds, and traveling by bus. She also avoided sitting in the middle seats of the classroom at university (she always sat at the desks next to the exit). There was no prior history of fear of closed spaces, although she had always feared crowds because of the thought that something bad would happen to her and she would not be able to escape. Her problems fit criteria for PD with agoraphobia.

P3 was a 37-year-old white female, married with two children, working in a laundry shop. She experienced fear of closed spaces (elevators, buses, crowds, and planes). The onset of her problem occurred when a crowd surged toward her in a shopping mall 12 years ago. As a consequence, she also developed a specific phobia, natural environment type (storms), because it was a big storm what caused the people seeking shelter in the mall. One year after the incident, she began to fear crowds, being enclosed in an elevator or in reduced spaces, tunnels, traffic jams, and airplanes. She suffered a panic attack while on vacation (she came to the emergency room of a hospital). Since then, she has not traveled to unknown places and she has not gone shopping alone. Her problems fit criteria for PD with agoraphobia.

P4 was a 26-year-old white male, married, psychologist. He experienced intense fear in small and crowded elevators and when traveling in the backseat of a two-door car. The onset of his fear occurred 18 years ago when, playing with some friends, they surged toward him and he felt he could not breathe. The problem became worse when he was trapped in an elevator for 10 minutes. Once again, he felt short of breath. He has since avoided going into elevators with other people, fearing losing control. He also feared situations in which help might not be available if something wrong happened, but he did not avoid those situations. He disliked crowds and avoided parties where there were many people. His problems fit criteria only for specific phobia (claustrophobia).

Measures

Admission interview. This semistructured interview, designed by the clinical and research team at the PAS, includes screening questions for each one of the *DSM-IV* diagnostic criteria for the anxiety disorders. To fulfill the purpose of the current study, questions tracing fear and avoidance of closed spaces were added. The interview also gathers information regarding main

complain, problem duration, problem severity as perceived by the participant, former treatments, alcohol and substance use, and presence of organic diseases.

Behavioral Avoidance Test (BAT). Avoidance of closed spaces was assessed using a behavioral avoidance test. A closet measuring 75 cm (width) × 1 m (length) × 2 m (height) was built for this purpose. Participants were asked to enter the closet and stay there for 5 minutes with the door locked. They could terminate the test at any moment and could also refuse to enter the closet if they felt that the anxiety would be more than they could bear. The test lasted 5 minutes, unless the participants stopped it before this time. Prior to taking the BAT, participants answered questions about what they thought was going to happen during the test, specifically measuring expected danger, expected fear, expected self-efficacy, and subjective fear. The participants rated these variables using a 10-point scale for each. The BAT also measures participants' avoidance of closed spaces. The scores here ranged from 0 to 13 and were obtained as follows: 0 = *refused to enter*; 1 = *went into the closet*; 2 = *closed the door but did not lock it*; 3 = *closed the door and locked it*. Thereafter, 0.25 points were added for each period of 30 seconds that the participant stayed inside the closet with the door open; 0.50 points for each period of 30 seconds that the participant stayed inside with the door closed but unlocked; and 1 point for each period of 30 seconds that the participant stayed inside with the door locked.

Subjective Units of Discomfort Scale (SUDS; Wolpe, 1969). Participants rated their highest level of anxiety on a 10-point scale (1 = *no anxiety*, 10 = *high anxiety*) before the BAT, while they were in the closet, and after the BAT. This measure was also used during the exposure sessions.

Fear Record (FR). The target behavior (fear of closed places) was rated daily by participants according to their degree of fear, ranging from 0 (*no fear*) to 10 (*extreme fear*).

Problem-Related Impairment Questionnaire. This instrument by Echeburúa and De Corral (as cited in Borda & Echeburúa, 1991) evaluates the impairment the disorder causes in several areas of the participant's life and the degree of change obtained in this aspect after the VR exposure. As suggested by Nathan and Gorman (1998), it is convenient to assess the problem-related impairment to validate empirically the psychological treatments. Only global impairment was analyzed in this study, and it was rated on a 10-point scale with scores ranging from 0 (*not at all*) to 10 (*completely*).

Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1992). This is a self-report measure of anxiety sensitivity, which Reiss, Peterson, Gursky, and McNally (1986) described as an individual difference variable defined by the belief that experiencing fear/anxiety causes illness, embarrassment, or additional anxiety. This measure is considered very relevant in the assessment of panic disorder (Shear & Maser, 1994), and it may be hypothesized as relevant for claustrophobia as well, because both disorders share the same features regarding anxiety sensitivity (Booth & Rachman, 1992; Craske & Sipsas, 1992). The Spanish version of the ASI, adapted by Sandín, Chorot, and McNally

(1996), was used. This version includes 16 items ranging from 0 (*very little*) to 4 (*very much*). Cronbach's alpha coefficients for the Spanish version of the ASI were 0.91 for clinical participants and 0.80 for normal controls. There is also evidence of adequate construct validity and concurrent validity of this version (Sandín et al.)

Apparatus

Hardware to create Virtual Environments (VEs) consisted of a Silicon Graphics Indigo High Impact computer graphics workstation, a high-quality head-mounted display (FS5 from Virtual Research) and an electromagnetic sensor that was used to track the participant's head and right hand (Fastrak system from Polhemus). Modeling was done with Autocad v.13 software (Autodesk, Inc). To obtain realistic VEs, a special technique of texture-mapping generation was used. VEs were rendered with radiosity techniques using Lightscape v.3.0 software (Lightscape Technologies). Once VE radiosity solutions had been calculated, the Dvise v.3.0 (Division Inc.) was used to create VE from the models. On this model, the texture generated from radiosity solutions was mapped on the geometry models, thus obtaining a highly realistic VE.

Virtual Environments

To graduate the levels of difficulty of the "claustrophobic" environment, two different settings were created: a house and an elevator. Each had different scenarios that allowed the design of exposure hierarchies with degrees of increasing difficulty. In both environments, participants could see their virtual hand (which served to manipulate virtual objects), but they could not see their virtual bodies or faces.

Setting 1: House. The first room, with a large window with a blind, was 4×5 meters and had a door that exited to a small garden. When the door or the window were open, a blue sky could be seen and sounds of birds could be heard. The door, the window, and the blind could be opened and closed in three stages. The second room measured 3×3 meters and had no furniture or windows. Its ceiling and floor were of a darker wood texture to give a higher sensation of closure. In the center of this room was a lectern with several buttons that permitted the participant to interact with the VE. The participant could also close the door to this room in three stages and, once closed, it could be blocked if he or she decided to do so by means of one of the buttons on the lectern. Moreover, one of the door's walls could be displaced at the participant's will (producing a loud noise) by means of one of the buttons on the lectern. The wall also had different possibilities of advance, reducing the room to a minimum space of 1 square meter.

Setting 2: Elevator. This setting depicts a wide entry with a large window. From this entry the participant can access the elevator by pressing a button. The elevator was designed to offer the following four different possibilities regarding the claustrophobic threat, taking into account various parameters (size, position, and possibility of blocking the elevator):

1. The elevator, located on the ground floor, measured 1 × 2 meters. The participant could be inside the elevator with the door open and looking at the entry. He or she could get in and out at will;
2. The elevator was closed and operating. The participant pressed a button, the elevator doors closed, and it started functioning. The elevator could go up to different floors and once it arrived the participant could get out at his or her will;
3. The elevator was blocked. The participant could block the elevator by pressing a button and, from that moment, he or she would not be able to get out in any way during a random period of time predetermined by the system. The aim was to simulate a failure;
4. A small-sized elevator in which one of its walls could move with a loud noise, enclosing the participant in a 1 square meter space. This elevator also offered all the possibilities that the larger elevator offered.

Design

A multiple-baseline design across subjects (Hersen & Barlow, 1984) was used to demonstrate the effects of treatment on fear of the target behaviors (elevators, buses, banks, movie theaters, the back seat of a two-door car, etc.). Given the fact that not all participants were available when the study started, we decided to apply the nonconcurrent multiple baseline between-subjects design proposed by Watson and Workman (1981). The length of the baselines was decided as 9, 12, or 15 days, so that as long as participants were asking for help at the Anxiety Disorders Clinic, they could be randomly assigned to one of the three possibilities. The rationale was to have observation periods of at least 8 days before starting the treatment and also to have very detailed observation periods throughout the entire process. With this purpose in mind, it was considered appropriate to group data every 3 days. The baselines were established at three, four, and five possible observation periods. P1 was assigned to a baseline of three periods, P2 to one of four periods, and P3 and P4 to a baseline of five periods.

Procedure

To establish the participant's diagnostic status, an experienced clinical psychologist applied the admission interview. An independent assessor, who was an experienced psychologist and blind to the study, reviewed the assessment and confirmed the presence or absence of claustrophobia, panic disorder, and other anxiety diagnoses. During the same session, the self-report instruments described above were also administered. All participants signed a consent form stating their knowledge of being taking part in an experimental study. During the second assessment session, participants were asked to provide self-efficacy ratings of coping with a closed space created especially for the BAT. They were asked to rate from 0 to 10 how sure they were that they would be able to stay in a closet for at least 5 minutes. The therapist rated the degree of avoidance in the BAT. At the end of the second session, participants

were provided with an FR and instructed to monitor their fear of their claustrophobic target behavior. They were asked to keep the record on a daily basis throughout the entire process. The FR was reviewed at the beginning of each subsequent session, and difficulties in monitoring were addressed. The same self-report scales fulfilled at the beginning of treatment were administered again immediately after the last VR exposure session (posttreatment assessment) and 3 months after they had finished the VR treatment (follow-up assessment).

Treatment

A total of eight VR graded exposure sessions was carried out for all participants over two sessions per week (except for P2, who interrupted her sessions due to her Christmas vacation). VR exposure lasted approximately 35 to 45 minutes each session. A video monitor allowed the therapist to observe the VEs to which the participants were being exposed. The therapist's instructions in the VR sessions were similar to those used in regular in vivo exposures. The therapist encouraged the participant to interact with the environments long enough for his or her anxiety to decrease. Anxiety level (SUDS) was assessed every 5 minutes. The only focus of treatment for all participants was claustrophobic fear, using the exposure to the two VEs described above.

Results

Regarding the FR, Figure 1 shows the means of daily fear ratings for closed places along 3-day periods. Due to the demands of the design, treatment started for each participant according to the order established by the random assignment of participants to baseline conditions. A decrease of fear during baseline is observed for P1 and P4. Although it would have been desirable to gather more data on the stability of their fear, it was decided to comply with the design guidelines. Nonetheless, fear stability can be inferred from the duration of their problems (2.5 and 18 years, respectively). In all cases, the treatment brought about an important decreases in participants' fear when they had to face their target behaviors. The fear of target behaviors decreased upon completion of treatment for each participant. The important increase experienced by P4 in Observation Period 14 corresponded to a panic attack suffered when he became enclosed in an elevator for 10 minutes. Improvement was maintained in all participants at the 3-month follow-up assessment.

Results from the BAT (see Table 1) showed an important change in the avoidance of closed spaces for all participants. They changed from not being able to complete the BAT before treatment to completely achieving the demands of the test after treatment completion. A clear improvement in all BAT measures was obtained: expected danger and expected fear decreased, and self-efficacy in the feared situation increased. Degree of fear reported during the BAT decreased as well, and behavioral performance increased. These results were also maintained in all participants at follow-up.

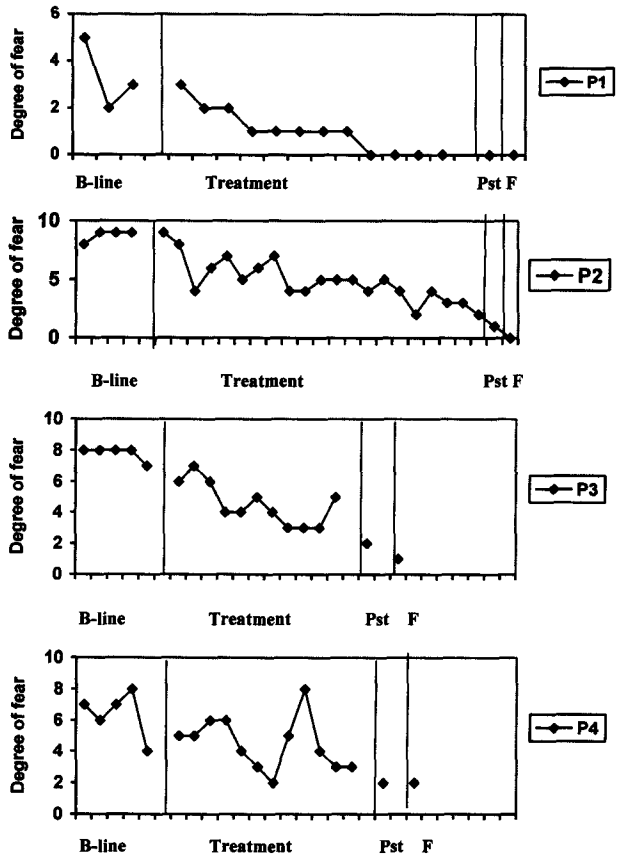

FIG. 1. Fear Records for target behavior. Note: Every point corresponds to a 3-day period.

Results on self-report measures are shown in Table 2. Before treatment, participants' scores in the ASI were high, but they dropped upon completion of treatment, and continued dropping at follow-up. There was a decrease in the variable of global impairment, which was maintained at follow-up.

Discussion

The results of this study support the clinical effectiveness of VR exposure for treating claustrophobic fear. A decrease on all measures was observed, and moreover, data support the results of our previous case study (Botella, Baños, Perpiñá, Villa, et al., 1998), where it was shown that the virtual claustrophobic context activated a high degree of anxiety in the participants, and that they were able to overcome the phobia by means of virtual exposure. VR, used alone as the sole technique, with no combination of other psychological

TABLE 1
SCORES IN THE BEHAVIOR AVOIDANCE TEST (BAT)

Participant	BAT	Pretreatment	Posttreatment	Follow-up
P1	Expected Danger	10	1	0
	Expected Fear	10	1	0
	Expected Self-efficacy	0	9	10
	Subjective Fear	5	0	0
	Behavioral Avoidance	3	13	13
P2	Expected Danger	10	0	0
	Expected Fear	10	0	0
	Expected Self-efficacy	0	10	10
	Subjective Fear	8	0	0
	Behavioral Avoidance	7	13	13
P3	Expected Danger	10	3	1
	Expected Fear	10	3	1
	Expected Self-efficacy	0	7	8
	Subjective Fear	9	0	0
	Behavioral Avoidance	4	13	13
P4	Expected Danger	5	2	2
	Expected Fear	10	2	2
	Expected Self-efficacy	2	9	9
	Subjective Fear	6	0	0
	Behavioral Avoidance	8	13	13

treatment techniques. Therefore, it appears to be very useful from a therapeutic perspective (Botella, Baños, Perpiñá, & Ballester, 1998; Botella, Baños, Perpiñá, & García-Palacios, 1998). Furthermore, because this study used a multiple baseline design across participants, and a 3-month follow-up was included, the results obtained in this study have increased the confidence in this treatment. Nonetheless, due to the decrease of fear in P1 and P4 during baseline, it is not possible to rule out the possibility of a response to nonspecific factors different from treatment. Therefore, it would be necessary to apply this treatment to larger samples in a group design, including a control group. Such a procedure would increase the confidence in this exposure format.

According to the results, an improvement was obtained in daily FRs for closed places and in the measures on BAT (Expected Danger, Expected Fear, Expected Self-Efficacy, Subjective Fear, and Behavioral Avoidance). Regarding self-efficacy measures, data also support the premise that VR may be an excellent source of information in the field of performance outcomes (Bandura, 1977; Botella, Baños, Perpiñá, & Ballester, 1998; Botella, Baños, Perpiñá, & Garcia-Palacios, 1998; Botella, Baños, Perpiñá, Villa, et al., 1998) because all participants showed an important change in their self-efficacy regarding coping with closed spaces. However, it remains unclear whether this measure reflects willingness to confront feared situations or a self-evaluated skill.

TABLE 2
SCORES IN THE SELF-REPORT MEASURES

Participant	Measures	Pretreatment	Posttreatment	Follow-up
P1	ASI	43	33	24
	Interference	8	6	4
P2	ASI	33	15	10
	Interference	5	0	0
P3	ASI	34	25	18
	Interference	8	7	5
P4	ASI	15	12	8
	Interference	2	1	1

With respect to ASI data, some comments should be emphasized. On one hand, the scores of the participants before treatment were very high. According to data from Spanish samples (panic disorder: $X = 32.8$; $SD = 10.7$; simple phobia: $X = 14.6$; $SD = 7.4$; normal control: $X = 8.2$; $SD = 5.1$; Sandín et al., 1996), P1, P2, and P3 are situated in the range of scores of people with a diagnosis of panic disorder or even higher, and P4 obtained scores in the range of the diagnosis of specific phobia (Sandín et al.). These data indirectly support the current approach on the construct of anxiety sensitivity, that is, this construct is more strongly associated to panic disorder than to other anxiety disorders (McNally, 1991, 1994), since the higher scores belonged to the participants who had diagnoses of panic disorder with agoraphobia. On the other hand, upon completion of treatment, there were important decreases in the scores of all participants, and in two of them (P2 and P4) scores were similar to those of normal controls.[1] These findings are encouraging because the condition of those three participants could be considered as severe and the only treatment they received was VR exposure to claustrophobic scenarios. However, results in the ASI are less consistent than results in the BAT; thus, change on the former during follow-up cannot be attributed to VR exposure exclusively because other noncontrolled factors might have had an influence on it.

On the other hand, although the main purpose of this study was limited to test the effectiveness of VE for claustrophobic fear, the reports that participants provided after treatment and at follow-up indicated that all generalized improvement to other behaviors that were not specifically treated. P1 began to go out alone, to take the bus, to travel (she sent to her therapist pictures of each city she visited). P2 generalized the improvement in regards to her fear

[1] In regard to this, we would like to point out that the Spanish scores from a control group are higher than the scores found in former studies (Peterson & Reiss, 1992). The authors' explanation (Sandín et al., 1996) is that, when selecting the sample, they rejected any participant who had a history of panic attacks with the exception of the panic disorder group, and that this fact could have been responsible for the reduced mean scores they found in the ASI.

of crowds as she began to go to pubs and clubs, and to sit in the middle seats of the classroom at university. P3 achieved an important improvement in her fear of storms, a problem which, apparently, had nothing to do with claustrophobic fear. She also began to go alone to places that she had previously avoided because of her agoraphobia (picking up her children from school, going shopping alone, and taking the bus to work). Her fear of getting trapped in a traffic jam decreased significantly. P4 generalized improvement to riding in the back seat of a two-door car. Nonetheless, it should be stressed that these were self-reported accounts that related to other feared situations and were not the focus of the VR exposure. Because no specific measures were taken in this respect, it is not possible to state convincingly that changes in follow-up were due to the VR treatment per se.

In summary, data indicate that VR exposure is a useful procedure in the treatment of claustrophobic fear. However, any statement regarding the effectiveness of VR must be taken with caution since most of the work in this field is still to be done. As mentioned previously, it is necessary to carry out studies with larger samples, using group designs that include control groups, and to analyze the usefulness of VR in the treatment of other psychological disorders.

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