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Treating Cockroach Phobia With Augmented Reality

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In vivo exposure is the recommended treatment of choice for specific phobias; however, it demonstrates a high attrition rate and is not effective in all instances. The use of virtual reality (VR) has improved the acceptance of exposure treatments to some individuals. Augmented reality (AR) is a variation of VR wherein the user sees the real world augmented by virtual elements. The present study tests an AR system in the short (posttreatment) and long term (3, 6, and 12 months) for the treatment of cockroach phobia using a multiple baseline design across individuals (with 6 participants). The AR exposure therapy was applied using the "one-session treatment" guidelines developed by Öst, Salkovskis, and Hellström (1991). Results showed that AR was effective at treating cockroach phobia. All participants improved significantly in all outcome measures after treatment; furthermore, the treatment gains were maintained at 3, 6, and 12-month follow-up periods. This study discusses the advantages of AR as well as its potential applications.

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To date, empirically supported treatments, including in vivo exposure therapy, have been shown to be efficacious in treating specific phobias. However, some aspects of their application remain unknown. Choy, Fyer, and Lipsitz (2007) have posed the following question: "Exactly how effective are the available treatments, and how long does treatment last?" In their review, the authors point out that although in vivo exposure has proven its efficacy in treating phobias, researchers have yet to assess its overall effectiveness regarding aspects such as treatment motivation and adherence.

Most people who suffer phobias (approximately 60% to 80%) never seek treatment (Agras, Sylvester, & Oliveau, 1969; Boyd et al., 1990; Essau, Conradt, & Petermann, 2000; Magee, Eaton, Wittchen, McGonagle, & Kessler, 1996). Furthermore, of those who do seek treatment, approximately 25% either refuse exposure therapy after learning what it entails or terminate the therapy (García-Palacios, Botella, Hoffman, & Fabregat, 2007; García-Palacios, Hoffman, See, Tsay, & Botella, 2001; Marks, 1978, 1992). Choy et al. (2007) report a dropout rate ranging from 0% to 45% for in vivo exposure used to treat specific phobias in adults. Although there have been no systematic studies on the causes of attrition (Choy et al., 2007), one possible explanation for the high rates is that in vivo exposure therapy entails actually confronting the feared stimuli, which some people may find too frightening. Further advances are necessary in order to increase the number of phobia sufferers who benefit from exposure therapy (García-Palacios et al., 2007) by improving the acceptance of the treatment and reducing attrition.

Newer technologies such as virtual reality (VR) are demonstrating their usefulness in this area, and are proving to be effective for exposure in phobia treatment (e.g., Botella, Baños, Villa, Perpiñá & García-Palacios, 2000; Choy et al.; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Rothbaum et al., 2006) as well as in increasing the participants' acceptance of VR exposure over in vivo exposure (García-Palacios et al., 2007).

Augmented reality (AR) is a newer technology that could also improve acceptance and therapy duration. AR is a variation of VR in which the user sees the real world augmented by various virtual elements; it complements reality rather than replacing it completely (Azuma, 1997; Azuma et al., 2001). The most significant aspect of AR is that the virtual elements add relevant and helpful information to the physical information available in the real world. The user can see images that blend both "real-world elements" and "virtual elements" that have been introduced by the system. For instance, in a museum setting, AR systems can display information about objects and places as they appeared in the past. Of course, the combination of real and virtual elements should fit perfectly (that is, the virtual object should be embedded in the real world giving the impression of a unique world), and must remain so during the entire length of exposure. If an error is perceived, users will not be able to maintain their impression that the two worlds are one. Whereas VR systems immerse the user in a totally synthetic environment, AR permits the user to see the real world, with the important difference that virtual objects merge with actual ones in a composite image. Milgram and Kishino (1994) define the qualities of both systems along a continuum from real to virtual environments; the surrounding environment of VR is virtual, while the surrounding environment of AR is real.

AR has many possible applications; however, as a novel technology, relatively little is currently known about its utility in various areas. The literature shows various AR applications in the areas of education (Arvanitis et al., 2007; Kerawalla, Luckin, Seljeflot & Woolard, 2006; Squire & Klopfer, 2007; Squire & Mingfong, 2007) and medicine (mainly for neurosurgery, otolaryngology and maxillofacial surgeries; De Buck et al., 2005; Shuhaiber, 2004; Wörn, Aschke & Kahrs, 2005).

In clinical psychology, preliminary data show the utility of the system for the treatment of insect phobia (Botella et al., 2005; Juan et al., 2005). A study by Juan et al. offers a detailed description of the AR system and data concerning the ability of the system to activate anxiety in a series of participants suffering cockroach or spider phobia, and the extent to which they considered the experience as real. The Botella et al. (2005) work is a case study of a cockroach phobia patient, with no follow-up data. In the exposure treatment, we combined the use of our AR system with the "one-session treatment" guidelines developed by Öst (Öst, 1985, 1987, 1989, 1997; Öst & Ollendick, 2001). Results of these studies were very encouraging, and indicated that the system was capable of evoking fear in the participants. Furthermore, their levels of fear and avoidance of the feared insect after interacting with the system decreased. The aim of the present work was to test the efficacy of an AR system in the short (posttreatment) and long term (3, 6 and 12 months) for the treatment of cockroach phobia using a multiple baseline design.

Method

PARTICIPANTS

Six females participated in the study. Their mean age was 29 ($SD=7.49$), ranging from 21 to 41 years. All came to seek help at the Emotional Disorders Clinic at Jaume I University of Castellon (Spain) and met *DSM-IV-TR* (APA, 2000) criteria for Specific Phobia animal type, specifically Cockroach Phobia. They had received no prior treatment for fear of cockroaches. The diagnosis and assessment phase was carried out by an expert clinician who was the therapist for all participants. An independent diagnosis was also obtained by a second interviewer. We included an independent assessor but not a blind one. In order to be included in the study, the following inclusion criteria were considered: having scores over 4 in phobic avoidance (on a scale of 0 to 8), having no current alcohol or drug dependency, having no diagnosis of major depression or psychosis, not having been or being treated with a similar program and having a minimum of 1 year of duration for the problem. None of the participants was taking anti-anxiety medication for the duration of the study.

Participant 1 (P1) was a 41-year-old divorced woman with two children. She had finished secondary school and worked as a clerk in an office. Her fear of cockroaches began when she was a child and intensified with age, although she was not able to identify its exact source. During the first interview, she exhibited extreme fear of these insects. For example, she wanted to sell her apartment because she sometimes found cockroaches; in addition, she became very nervous and would sit with her feet off the floor in places where she expected to find cockroaches. She rated the interference of the problem in her life as a 7 on a scale of 0 to 8 (ADIS-IV; DiNardo, Brown, & Barlow, 1994). In the clinical interview, other psychological problems were detected. Specifically, she suffered from other phobias including fear of driving and fear of public speaking; she had received no prior psychological treatment for these problems.

Participant 2 (P2) was a 33-year-old single woman who worked in a prison as a psychologist. Her fear of cockroaches began when she was 7 years old, when her family moved to a rural house that had cockroaches. During the initial screening, she reported extreme irritability and a loss of self-control when she saw cockroaches. For example, she reported being very angry with a friend when he tried to frighten her by throwing a fake cockroach at her. In addition, her anxiety regarding cockroaches interfered with her ability to be alert in the prison. She rated the interference of her problem as a 7 (ADIS-IV) and did not report suffering other psychological problems.

Participant 3 (P3) was a 34-year-old single female psychologist. She reported having a fear of various insects, mainly moths and cockroaches. Her fear of cockroaches began when she was a child, and she did not remember any particular cause. During the assessment, the participant stated that she had never killed a cockroach, although she had occasionally found them in her house. Her fear was so severe that if she saw a cockroach, she would call some friends or wait for her boyfriend to help her get rid of it. She felt unable to enter her home alone if she suspected that she might encounter one. She rated the interference of her problem as a 5 (ADIS-IV). In addition, during the clinical interview, the participant reported a fear of enclosed spaces (mainly elevators) and high places, but she had never received help for these problems.

Participant 4 (P4) was a 21-year-old single female engineering student. Her fear of cockroaches began when she was a child, with no specific cause. She reported a high level of anxiety and a total loss of control when she saw a cockroach. One day, while driving with her father and brother, she found a cockroach in the car and became very nervous and began to cry uncontrollably. Another time, she waited for her roommates on top of a table for 2 hours because she had seen a cockroach in the apartment. She rated the interference of her problem as a 6 (ADIS-IV; DiNardo et al., 1994). P4 had received prior psychological treatment for claustrophobia 1 year prior with good results.

Participant 5 (P5) was a 27-year-old single woman who was a Ph.D. student in psychology. She estimated that her fear began 10 years prior, when she was 17 and moved into a new house which had cockroaches. Since then, she had had a severe fear of cockroaches that increased when she found a cockroach in her food. She felt extreme disgust, and afterwards she experienced high anxiety when she had to face cockroaches. She reported being unable to kill cockroaches and becoming withdrawn if she were in a place where she might find them. For example, if she were relaxing with friends and saw a cockroach in the area, she would have to leave. She believed that the fear had become worse, and she rated the interference of her problem as a 6 (ADIS-IV). She did not report any other psychological problems.

Participant 6 (P6) was a 21-year-old single female psychology student. She reported extreme repugnance and fear of insects in general and of moths and cockroaches specifically. Her fear of cockroaches began when she was a child and had become progressively worse. She was unable to kill cockroaches and experienced a high level of anxiety when she encountered them. She refused to visit her grandmother's house because of this fear. In addition, this participant had a parrot whose cage she could not clean due to her fear of encountering cockroaches. She rated the interference of her problem as a 6 (ADIS-IV). She had received previous psychological treatment for depression 2 years prior with positive results.

MEASURES

Diagnostic Measure

The Anxiety Disorders Interview Schedule (ADIS-IV; DiNardo et al., 1994) specific phobia section was used to carry out the differential diagnosis of the anxiety disorders included in the *DSM*. This instrument also includes other relevant clinical measures such as *interference and distress as perceived by the participant* on a scale from 0 to 8 (wherein 0 = "Not at all" and 8 = "Very severe"), and the *clinician's severity rating* (wherein the clinician rates the severity and interference of the problem on a scale from 0 to 8 where 0 = "Absent/none" and 8 = "Very severely disturbing/disabling"). We included these two ratings as outcome measures in our study.

This instrument has demonstrated interrater reliability from satisfactory to excellent when administered by expert clinicians who are familiar with the *DSM* diagnostic criteria (DiNardo, Moras, Barlow, Rapee, & Brown, 1993). To assess reliability of the diagnosis, a second interviewer also administered this interview. Diagnosis agreement was obtained for all 6 cases.

Target Behaviors (adapted from Marks & Mathews, 1979)

Participants assessed their fear and avoidance on a scale ranging from 0 ("No fear at all," "I never avoid") to 10 ("Severe fear," "I always avoid") for situations in which they had to confront small insects (e.g., to approach to a cockroach). For this work, the most significant target behavior chosen by each participant was used. In all cases the target behavior involved the ability to stay in a place where a cockroach was present without being able to escape. The degree of belief in catastrophic thought was also assessed on a scale of 0 to 10.

Behavioral Avoidance Test (BAT)

An adaptation of Öst, Salkovskis, and Hellström's (1991) BAT was used. This kind of test is considered to be the cornerstone for objective assessment of phobias (Meng, Kirkby, Martin, Gilroy, & Daniels, 2004; Mineka, Mystkowski, Hladek, & Rodriguez, 1999). The BAT assesses the severity of the fear and the level of avoidance and beliefs. For this study, a container with a live cockroach in it was placed 5 meters from the entrance to a room. Then, participants were asked to enter the room and approach the insect as closely as possible. They were told that they could terminate the behavioral test at any point if their anxiety became too strong. Their performances in the test were scored, taking into account their final proximity to the insect. The distance measurement was converted to a behavioral score wherein 0 = "The participant refuses to enter the room"; 1 = "The participant stops 5 meters away from the cockroach"; 2 = "The participant stops 4 meters away from the cockroach"; 3 = "The participant stops 3 meters away from the cockroach"; 4 = "The participant stops 2 meters away from the cockroach"; 5 = "The participant stops 1 meter away from the cockroach"; 6 = "The participant stops near the cockroach"; 7 = "The participant touches the container"; and 8 = "The participant opens the container and interacts with the cockroach." In addition, participants rated their level of subjective fear, avoidance, and belief in their catastrophic thoughts on a scale of 0 to 10 before they entered the room with the feared insect, as well as their fear level for the last step completed during the BAT. Results of this BAT for Spanish participants with various small animal phobias (cockroaches, spiders, and mice) can be found in Botella et al. (2008).

Fear of Spiders Questionnaire (FSQ; adapted from Szymanski & O'Donohue, 1995)

This questionnaire assesses the severity of spider phobia and consists of 18 items rated on an 8-point Likert scale ranging from 0 ("I totally disagree") to 8 ("I totally agree") for situations related to the fear of these creatures (e.g., "If I found a spider now, I would ask someone to help me to get rid of it"). The total score ranges from 0 to 126. The mean score for a group of individuals suffering from spider phobia was 89.1 ($SD = 19.6$) before treatment and 39.9 ($SD = 25.4$) after treatment; the mean score for nonphobic controls was 3.0 ($SD = 7.8$) (Muris & Merckelbach, 1996). This measure has excellent internal consistency, with Cronbach's alphas ranging from .88 to .97 (Muris & Merckelbach, 1996; Szymanski & O'Donohue, 1995), as well as good test-retest reliability (Muris & Merckelbach, 1996). For the assessment of cockroach phobia, an adaptation of this questionnaire (in which all items were referred to as cockroaches) was made. This adaptation for cockroaches has been used in previous studies (Botella et al., 2008; García-Palacios, Hoffman, Carlin, Furness, & Botella, 2002).

Spider Phobia Beliefs Questionnaire (SPBQ; adapted from Arntz, Lavy, Van der Berg, & Van Rijsoort, 1993)

This is a self-report scale composed of 78 items. It includes two subscales: items from 1 to 42 assess the strength of fearful beliefs about spiders (e.g., "It will attack me"); items from 43 to 78 measure the strength of fearful beliefs about one's reaction to encountering spiders (e.g., "I will lose control"). All items are rated on a scale from 0 ("I do not believe it at all") to 100 ("I absolutely believe it"). Good internal consistency has been reported by Artnz et al. (1993) for both the spider-related ($\alpha = .94$) and self-related ($\alpha = .94$) subscales; acceptable test-retest reliability for both subscales has also been found ($r = .68$ for the spider-related and $r = .71$ for the self-related one). The authors reported mean scores for the spider-related belief subscale in spider phobic individuals ($M = 48.76$; $SD = 17.74$ before treatment and $M = 10.15$, $SD = 13.69$ after treatment); and for the self-related beliefs subscale ($M = 49.79$; $SD = 18.72$ before treatment and $M = 8.00$, $SD = 13.15$ after treatment). Again, an adaptation of this questionnaire was made by our research team in order to assess fearful beliefs about cockroaches. This adaptation has been used for cockroaches and mice in other studies (Botella et al., 2008).

Subjective Units of Discomfort Scale (Wolpe, 1969) During the exposure sessions, participants rated their levels of anxiety on a scale from 0 (“No anxiety”) to 10 (“Extreme anxiety”).

AUGMENTED REALITY SYSTEM

A full technical description of the system can be found in Botella et al. (2005) and Juan et al. (2005, 2007). A Creative NX-Ultra camera and a Logitech QuickCam Pro 4000 were used for the exposure sessions. The camera was attached to the participant's head-mounted display (HMD); it focused in the direction in which the participant looked. The HMD was a 5DT with 800 × 600 resolution and a high (40 degrees) field of view.

Participants could see the actual world through the HMD; everything that they saw was real except the feared stimuli (in this case, cockroaches). The application used markers consisting of white squares with black borders that contained symbols or letters.

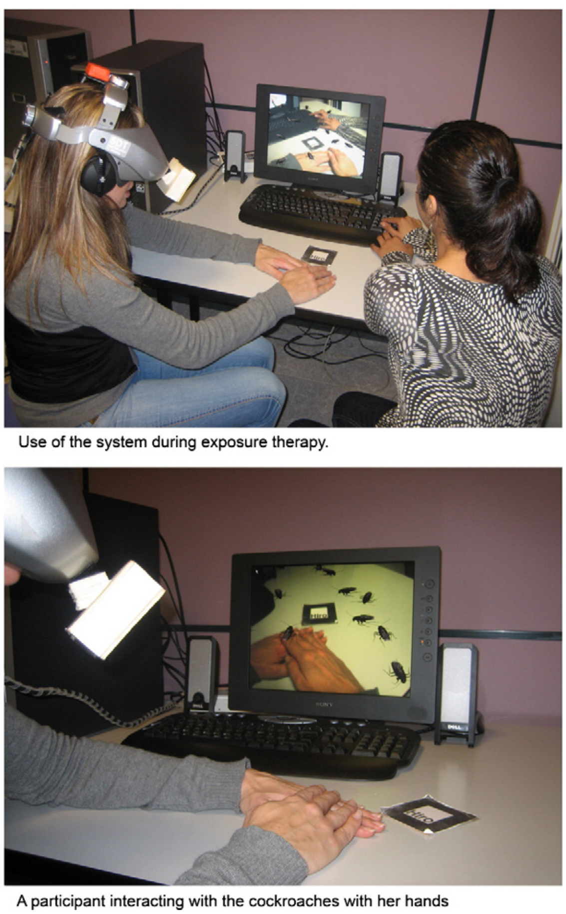

FIGURE 1 Screen shots of the AR system for treating cockroach phobia.

When the camera found a marker in the real world, the program recognized it and activated the feared virtual elements (cockroaches). The virtual insects have similar structure, movements and texture to real cockroaches. Both the body and the basic movement of the cockroaches were modelled using 3DStudio and exported in VRML format. The virtual insects can move their feelers and legs (Botella et al., 2005). The therapist can watch the virtual stimuli presented to participants during the exposure session on the monitor, and can control the application using computer keys. The system includes the following menu options: (a) number of cockroaches (with 60 as the maximum number of allowed insects), (b) movement of cockroaches (static or moving), and (c) size of cockroaches (small, medium, or large). The system also allows participants to “kill” cockroaches.[1] All of these combined options enable the therapist to apply the treatment progressively. Figure 1 shows the use of the system during exposure therapy and a participant interacting with the cockroaches with her hands.

DESIGN

A nonconcurrent multiple baseline design across-individuals was used (Hersen & Barlow, 1984). This specific design was chosen because the participants did not come to the clinic simultaneously, and not all participants were available when the study began. This kind of design involves the observation of individuals at various times; therefore, baselines and interventions are not contemporaneous for the six study participants (Watson & Workman, 1981). A priori, three baseline periods were established: 6, 9, and 12 days. We chose these short duration baseline periods so that the patients would not have to wait very long to receive treatment. Assignment orders ranged from 6-, 9-, and 12-day periods, and the participants were assigned as they arrived at the clinic. They recorded their degree of fear, avoidance and belief in catastrophic thoughts regarding the main target-behavior of their cockroach phobia on a daily basis during the baseline period.

STATISTICAL PROCEDURES

Time series analysis methods are some of the most frequently used procedures in single-case research because they take serially dependent data into consideration (Tyron, 1982). C-statistic is a simple statistical method used to evaluate the effects to treatment interventions in serially dependent time-series data and does not require a large number of data points per phase (Gorman & Allison, 1996). A nonsignificant C-statistic shows horizontally stable data. A significant C-statistic establishes that change has occurred from one phase of the experiment to another and the independent variable could be responsible for change (Tyron, 1982). The significant trends ($p<.05$) have two possible directions. One positive direction indicates change toward improved outcome. One negative direction indicates change toward worse outcome (Gorman & Allison, 1996). In this study, statistic C was used in order to examine the stability of the baseline data. In addition, C statistic was used in order to obtain quantitative information on trends for the fear, avoidance, and degree of belief scores in the target behaviors between two assessments, baseline, and postassessment periods (including posttreatment, 3-, 6-, and 8-days 12-month follow-up).

PROCEDURE

Participants were recruited through advertisements posted at Jaume I University for treatment of cockroach phobia with new technologies. After an initial screening assessment conducted at the Emotional Disorders Clinic, participants who fulfilled the inclusion criteria were invited to participate in the research and signed a consent form. The pretreatment assessment consisted of two 60-minute sessions. In the first session, the ADIS-IV for specific phobia was administered. In the second assessment session, the target behaviors and the exposure hierarchy were established, and the participants completed other self-report measures. The baseline periods were conducted after this second assessment session. Before starting the treatment, the BAT was applied to measure the degree of overt avoidance of cockroaches. Then, participants received an intensive AR exposure session. During these sessions, anxiety levels (SUDs) were assessed every 5 minutes. After completing the one-session treatment, all participants were assessed later the same day in order to obtain posttreatment data. The assessment protocol was also applied at 3-, 6- and 12-month follow-up periods. Finally, after the last follow-up period, all participants again recorded their levels of fear, avoidance, and belief in negative beliefs over the course of 8 days.

TREATMENT

The AR system was applied using "one-session treatment" guidelines developed by Öst et al. (1991) that involve intensive exposure. Exposure is conducted in a single extended session lasting up to 3 hours and implemented individually. Following Öst (1997), the treatment includes participant modelling, AR exposure (in this case), reinforced practice and cognitive challenge. The purpose of this exposure treatment is for patients to confront their phobic situation in a controlled manner, thereby allowing them to accept that the negative consequences they fear do not actually occur. In addition, according to Öst (1989) and Zlomke and Davis (2008), this intensive exposure involves "overlearning," a feature that maximizes the exposure's efficacy. Overlearning refers to repeated interaction with the feared stimuli at levels not experienced in the natural environment. For instance, AR exposure allows the participants to interact with many cockroaches repeatedly, to enlarge them or even kill them if they are able to do so. However, treatment in a single session is just a starting point; it is recommended that the participants continue to be exposed to the phobic situations after therapy in their daily lives in order to fully surmount their problems.

Regarding the treatment specifically applied in this study, during the AR "one-session treatment" the therapist could see the treatment on a monitor and observe the same stimuli as the participant. Each participant confronted various scenarios, progressing from the easiest to the most difficult situations. The goal was for the participants to remain in the situations until they experienced a notable decrease in anxiety. Specifically, a reduction of at least 2 to 3 SUDs in each step of the hierarchy was expected in order to advance to the next situation. For example, a participant could confront a moving cockroach for a few minutes until she experienced a significant decrease in her anxiety level. Then, she could progress to the next step in the hierarchy.

Throughout the treatment, the therapist's instructions to the participants were similar to those used in traditional in vivo exposures. Nevertheless, following the instructions recommended by Öst et al. (1991) (adapted for the AR system), participants were informed that the treatment required close collaboration between themselves and the therapist. They were also informed that the therapist would never take an action that was not previously planned; on the contrary, any possible event would have been previously described to the participant and permission from the participant would have been granted. That is, the exposure session would be completed in a gradual, planned, and controlled way.

The treatment application proceeded as follows. The program displayed one cockroach to the participants, and more insects were added progressively. In order to encourage interaction with the cockroaches, the therapist asked participants to bring their hands closer to the therapist's hand, which was positioned where cockroaches were traveling. Other situations included insects appearing on the floor or near personal belongings, introduced in a gradual way. The size of the cockroaches was modified as well. In the final step of the program, the therapist asked the participants to kill the virtual cockroaches, as would be expected in Spain. The therapist encouraged the participants to interact in the environment long enough for their anxiety to decrease; this exposure technique was combined with modelling throughout the whole treatment session and promoting cognitive challenging. In other words, following Öst's guidelines, during the exposure the therapist completed all of the actions before she asked the participants to confront them. The exposure sessions were carried out by an experienced doctoral-level clinical psychologist.

Results

The AR system was able to stimulate anxiety in all participants during the exposure session. Specifically, the anxiety levels of 4 of the

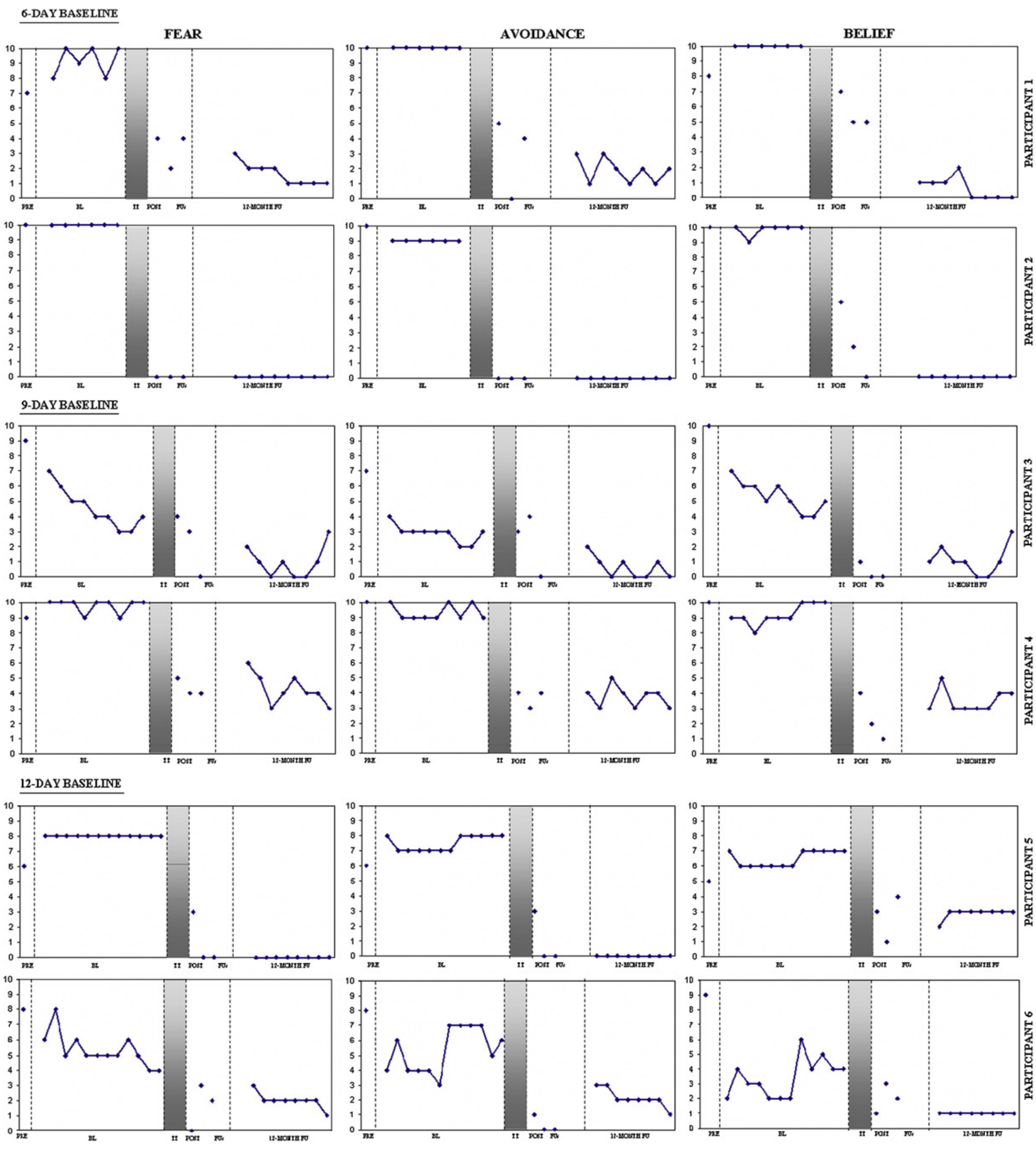

FIGURE 2 Mean Scores obtained by Participant assigned to 6-, 9-, 12-day baseline period.

participants reached the maximum level of the SUDs scale (10), while the remaining 2 reported a maximum score of 9. The mean duration of the exposure session was 1 hour and 49 minutes (*SD* = 25.49 minutes). The specific period for each participant was 1 hour and 55 minutes for P1; 2 hours for P2; 1 hour and 30 minutes for P3; 2 hours and 22 minutes for P4; 1 hour and 10 minutes for P5; and 2 hours for P6. The session duration varied according to the time each participant required to be able to "handle" cockroaches with a low level of anxiety (SUDs less than 3).

TARGET BEHAVIORS

Mean ratings for the degree of fear, avoidance and belief in negative thoughts related to the main target behavior are presented in Figure 2. In general, a reduction of all clinical variables was achieved at posttreatment, and these outcomes were maintained at 3-, 6-, and 12-month follow-up periods. Furthermore, an additional reduction was observed at follow-up periods for some participants.

OTHER OUTCOME MEASURES

Means and standard deviations for other outcome measures are shown in Table 1. Regarding the BAT, no participant could interact with the cockroach before treatment. After AR treatment, all participants could complete the 8 steps included in the BAT used in this study, obtaining the maximum score in performance (8). They were able to go inside the room, approach the container with the cockroach inside, open it, and keep their hands inside the container for a few seconds. In addition, three participants were able to kill a real cockroach with a fly swatter or their feet. At all three follow-up periods (3-, 6- and 12-month), all participants maintained a high score in their performance (they opened the container and put their hands inside). Only one participant at 3-month follow-up (P1), two participants at 6-month follow-up (P1 and P4), and one participant at 12-month follow-up (P1) could not open the container; however, they could touch it with notably reduced fear compared to pretreatment. Likewise, all participants notably improved in the BAT measures for their level of fear, avoidance and belief in their negative thoughts related to the task they were asked to complete after treatment. Similar results were observed at follow-up periods (see Table 1).

As for the specific questionnaires, a significant reduction in the FSQ was observed from pretest to 12-month follow-up. Mean scores at pretest were similar to the mean scores reported for spider-phobic individuals before treatment (Muris & Merckelbach, 1996). As for the mean scores at 12-month follow-up, the scores were even lower than those reported by the same authors for phobic individuals after the treatment. Regarding the two subscales included in the SPBQ, a significant reduction was also observed after treatment, and these outcomes were maintained at 3-, 6-, and 12-month follow-ups. Mean scores in both subscales at pretest were similar to the mean scores reported by the authors of the questionnaire for spider phobic

Table 1
Means and standard deviations obtained for outcome measures

	Pre-treatment	Post-treatment	3-Month Follow-up	6-Month Follow-up	12-Month Follow-up
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Target Behavior					
Fear	8.17 (1.47)	2.67 (2.16)	2.00 (1.67)	1.67 (1.97)	2.00 (3.03)
Avoidance	8.50 (1.76)	2.67 (1.86)	1.17 (1.84)	1.33 (2.07)	1.33 (2.42)
Belief	8.67 (1.97)	3.50 (2.35)	2.17 (1.72)	2.00 (2.10)	1.83 (2.23)
BAT					
Performance	3.50 (3.02)	8.00 (.00)	7.83 (.41)	7.67 (.52)	7.83 (.41)
Fear	8.33 (1.63)	4.33 (2.07)	.33 (.82)	.67 (1.63)	1.33 (1.75)
Avoidance	8.17 (2.23)	1.83 (2.23)	.00 (.00)	.00 (.00)	.17 (.41)
Belief	7.17 (2.32)	3.33 (2.51)	1.17 (2.40)	1.17 (.98)	1.83 (2.23)
FSQ	73.17 (36.66)	21.33 (16.12)	15.50 (14.35)	16.83 (15.97)	21.83 (31.29)
SPBQ	44.89 (18.06)	14.28 (11.42)	10.57 (9.57)	10.05 (6.01)	11.21 (9.55)
Cockroach-related beliefs					
SPBQ	39.08 (34.08)	5.33 (6.69)	5.19 (8.05)	4.02 (7.98)	5.09 (11.48)
Self-related beliefs					
Clinician's ratings	6.17 (1.47)	2.17 (1.47)	1.67 (1.37)	1.67 (1.21)	1.67 (1.97)
Interference by participant	6.17 (.75)	1.17 (1.60)	.67 (1.03)	.67 (1.63)	.83 (2.04)

Note. BAT: Behavioral Avoidance Test; FSQ: Fear Spider Questionnaire; SPBQ: Spider Phobia Beliefs Questionnaire; 3M: 3-month follow-up; 6M: 6-month follow-up; 12M: 12-month follow-up.

sufferers before treatment. Our participants' scores at 12-month follow-up were also similar to those reported by the authors for phobic individuals after the treatment (Arntz et al., 1993).

Finally, as shown in Table 1, both the clinician's rating and the interference of the problem perceived by the participants decreased notably at posttreatment, and these gains were also maintained at the three follow-up periods.

In summary, all participants improved significantly after treatment in all of the self-report measures; treatment gains were maintained at the various follow-up periods.

C-STATISTIC

C-statistic was used to obtain quantitative information about the baseline daily register in order to examine the stability of the baseline data. In addition, C-statistic was used to analyze the change trends between the baseline period, posttreatment, and follow-up assessments with the aim of establishing improvement that was attributable to the treatment. C-statistics results are presented in Table 2. As shown in Table 2, the data obtained along baseline scores were horizontally stable for all measures in half of the participants (P1, P2 and P6). In the case of P3, baseline data obtained for fear and belief in negative thoughts indicated a statistically significant trend ($p<.01$ for fear; $p<.05$ for belief) in the positive direction (indicating symptom improvement). In the case of P5, the baseline data indicated a statistically significant trend in avoidance ($p<.01$) and belief measures ($p<.01$) but in the negative direction (indicating a trend towards worse outcomes). Also, the baseline data obtained by P4 showed a significant trend towards worse outcomes for belief in negative thoughts ($p<.05$).

On the other hand, C-statistical results obtained considering baseline, posttreatment, and follow-up assessments revealed statistically significant trends in the positive direction for fear, avoidance and belief ($p<.01$) between these periods for all participants (indicating improved outcome).

Discussion

Results obtained in this study offer data concerning the efficacy of the AR system for the treatment of cockroach phobia and support the findings of previous research (Botella et al., 2005; Juan et al., 2005). Firstly, by following the "one-session treatment" guidelines stated by Öst et al. (1991), the AR system was proven capable of inducing anxiety in the participants and produced a notable reduction in the level fear, avoidance and belief in negative thoughts related to the main target-behavior in all of the participants. Secondly, whereas none of the participants could interact in the BAT with a real cockroach in the container

Table 2
C-Statistic results for target-behaviors at baseline, and between baseline and post-assessment periods (post-treatment and follow-ups)

Participant	Measures	C-Statistic BL	Trend	Direction	C-Statistic BL - Post-assessment	Trend	Direction
P1	Fear	-0.07	Horizontally stable		0.86**	Trend evident	Positive
	Avoidance	0.00	Horizontally stable		0.87**	Trend evident	Positive
	Belief	0.43	Horizontally stable		0.94**	Trend evident	Positive
P2	Fear	0.00	Horizontally stable		0.89**	Trend evident	Positive
	Avoidance	0.43	Horizontally stable		0.89**	Trend evident	Positive
	Belief	-0.14	Horizontally stable		0.95**	Trend evident	Positive
P3	Fear	0.82**	Trend evident	Positive	0.84**	Trend evident	Positive
	Avoidance	0.48	Horizontally stable		0.60**	Trend evident	Positive
	Belief	0.63*	Trend evident	Positive	0.86**	Trend evident	Positive
P4	Fear	-0.29	Horizontally stable		0.87**	Trend evident	Positive
	Avoidance	-0.25	Horizontally stable		0.87**	Trend evident	Positive
	Belief	0.58*	Trend evident	Negative	0.85**	Trend evident	Positive
P5	Fear	0.00	Horizontally stable		0.95**	Trend evident	Positive
	Avoidance	0.67**	Trend evident	Negative	0.94**	Trend evident	Positive
	Belief	0.67**	Trend evident	Negative	0.79**	Trend evident	Positive
P6	Fear	0.29	Horizontally stable		0.74**	Trend evident	Positive
	Avoidance	0.39	Horizontally stable		0.71**	Trend evident	Positive
	Belief	0.26	Horizontally stable		0.57**	Trend evident	Positive

Note. Trend in the positive direction: indicated data improvement in fear, avoidance or degree of belief punctuation from baseline phase to follow-up assessment.

Trend in the negative direction: indicated data worsening in fear, avoidance or degree of belief punctuation from baseline phase to follow-up assessment.

BL: Baseline; Post-assessment: Post-treatment and Follow-up periods; P: participant; *$p<.05$; **$p<.01$.

before treatment, after treatment all participants could enter the room, approach the container, open it, and put their hands into the container with the live cockroach. Thirdly, self-report scores (FSQ, SBQ, clinician's rating and interference of the problem perceived by the participants) also improved significantly after treatment and were similar to results obtained in other studies using VR (García-Palacios et al., 2002). In addition, the mean score obtained for the six participants in the FSQ at 12-month follow-up ($M = 21.83$; $SD = 31.29$) was lower than the mean score of phobic individuals after treatment reported by Muris and Merckelbach (1996) ($M = 39.9$, $SD = 25.4$). Regarding the cockroach-related beliefs subscale of the SBQ, means obtained at 12-month follow-up ($M = 11.28$; $SD = 9.55$) were similar to those found by Arntz et al. (1993) in a group of spider phobics after treatment ($M = 10.15$; $SD = 13.69$). For the self-related beliefs subscale of the SBQ, similar results were found, as the mean scores obtained ($M = 5.09$; $SD = 11.48$) were slightly lower than the ones found in spider phobics by Arntz et al. (1993) after treatment ($M = 8.00$; $SD = 13.15$).

The long duration of the problem for all participants (over 7 years), together with the symptoms improvement that occurred at posttreatment and in the follow-up assessment (indicated by the C-statistic), strengthens the case for the utility of the AR system. However, these results should be viewed with caution, especially in the case of P3, who showed a trend in the positive direction in the baseline data for fear and belief in catastrophic thoughts. One possible explanation is that P3 did not adequately understand how to record the data during the baseline; all other assessment measures of this participant, including the initial interview with the clinician at pretreatment, indicated high levels of fear and belief as well as notable disturbance and interference in her life attributable to the problem. As for P4 and P5, their results were the contrary: a negative trend for avoidance and belief (P5) and for belief alone (P4).

Moreover, all gains observed in the outcome measures were maintained at 3-, 6-, and 12-month follow-up periods. All participants were advised to continue exposing themselves to cockroach-related phobic situations after therapy in order to completely surmount the problem. Only one participant (P4) reported a slight decline at 12-month follow-up regarding the posttreatment scores. This participant reported having a bad experience on a trip shortly after treatment wherein she encountered a significant number of cockroaches in a house where she was staying. Despite this experience, the scores did not return to the pretreatment levels and they improved in the 8-day monitoring period after the 12-month follow-up assessment. Significantly, none of the participants received any other psychological treatment from posttreatment to follow-up periods.

Exposure times in studies with positive results generally range between 2 to 4 hours (Gotestam & Hokstad, 2002; Öst, Alm, Brandberg & Breitholtz, 2001). In this study, patients required a similar amount of time (a mean of 1 hour and 49 minutes, ranging from 1 hour and 10 minutes to 2 hours and 22 minutes) to participants mentioned by Öst et al. (1991) using in vivo exposure, and less time than in other VR studies for cockroach phobia (Carlin, Hoffman & Weghorst, 1997; García-Palacios et al., 2002). Our data confirm the good efficacy rates obtained with the 1-session treatment developed by Öst in adults, ranging from 85% to 90%. However, because the present work comprised a limited sample of 6 participants, the results should be considered with caution.

The use of new technologies can improve some aspects of available treatments. VR has already shown positive results for the treatment of fear of small animals (e.g., Botella, Baños, Quero, Perpiñá & Fabregat, 2004; Botella et al., 1998; Carlin et al., 1997; García-Palacios et al., 2002; Riva, 1997; Riva, 2002). AR shares some advantages when combined with VR over traditional treatments. First, with AR and VR the therapist has total control over the virtual situations and elements in the computer program, such as the generation of stimuli, including their order of appearance and their quantity. Second, they can make patients feel more secure during therapy because outcomes that they fear will happen in the real world cannot happen in AR and VR (without consent and planning). For example, the therapist can expose a patient to a virtual elevator and assure him/her that it will not break down, or can expose a patient to a flight with no turbulence. As the patient progresses, the therapist can plan more difficult exposure tasks. Thirdly, AR and VR enable easier access to threatening stimuli. This efficiency is significant because it is not always easy to obtain real cockroaches or spiders as needed for therapy; the AR system, on the other hand, enables constant easy access to realistic representations of the insects.

AR offers additional advantages over VR. First, AR can provoke a greater feeling of presence and reality than VR because the environment and the tools the patient uses to interact with the application are real. Second, in AR the users can see their own bodies in context, interacting with the feared stimuli; the system allows patients to use real elements and their own hands and bodies to interact with the insects. Finally, AR is cheaper than VR, as it is only necessary to design and simulate the feared elements rather than an entire immersive environment.

As mentioned previously, earlier studies have emphasized the importance of overlearning when applying exposure following the guidelines developed by Öst (Öst, 1989; Zlomke & Davis, 2008). AR applications can promote overlearning because they enable significant variations in exposure to the feared element. In this particular AR system, one can simulate 60 cockroaches of different sizes, which can be adjusted according to the patients' needs. It is also possible to ensure that the elements of the feared situation are modified only with the patient's consent; this element of predictability reduces rejection from the participants. This is an important feature from an ethical point of view, especially for treatment of children.

The present study has some limitations, the most significant being the limited number of participants included in the study. More studies using larger numbers of participants and control groups are needed to draw firmer conclusions about the efficacy and efficiency of using AR for specific phobias. Also, a measure for cybersickness was not included in this study. However, participants were carefully screened for possible cybersickness side effects during the one-session AR exposure treatment (e.g., unsteady feelings, dizziness, nausea, etc.); we were assured that they would not participate in any activities that could be dangerous to sufferers of cybersickness. Regardless, none of the participants included in this work exhibited symptoms of cybersickness. Indeed, in our clinical experience with over 200 patients treated with VR, we have found a very low rate of cybersickness (approximately 1%).

Another issue of interest is the role of disgust in insect phobias and in exposure therapy. As McNally (2002) stated: "Disgust has been the most understudied of all emotions" (pp. 561). Recently, there has been growing interest in the study of disgust in anxiety disorders (Cisler, Olatunji, & Lohr, 2009; Sandín, Chorot, Santed, Valiente, & Olmedo, 2008). VR and AR might be effective tools for studying different emotional responses to various stimuli and the different effects of exposure to certain stimuli regarding fear and disgust. Furthermore, VR and AR could promote the acceptability of exposure therapy for those patients who experience a high level of disgust, given that the feared object is merely virtual. Patients might be more willing to interact with virtual cockroaches than real ones because their levels of disgust might be lower.

In conclusion, AR is a very promising treatment alternative for phobias and might be useful for other psychological disorders. Future studies should address a comparison of the AR application with the current treatment of choice for specific phobias: in vivo exposure. A study of the efficacy of these procedures and the preferences of these treatment modalities by therapists and patients would also be enlightening. It is equally necessary to compare the efficacy and preferences for VR versus AR.

In summary, this work provides further support for the efficacy of AR as a tool for phobia therapy and adds an additional study to those that prove the efficacy of the "one-session treatment" developed by Öst for the treatment of specific phobias. It is important to highlight that AR is a tool that may have some additional value for treating some types of specific phobias. Traditional in vivo exposure is proven to be useful for specific phobias, while the use of VR, AR, or other similar procedures might prove to have additional value for some types of specific phobias. Ultimately, the choice of a treatment procedure must be made according to its proven efficacy and the patient's preferences or particular situation. In medicine, both diagnoses and treatments have been improved over time through the integration of new technologies. In the same way, these achievements are occurring in psychology, and there is no doubt that this discipline will continue to benefit from such technological advances.

References

Agras, S., Sylvester, D., & Oliveau, D. (1969). The epidemiology of common fears and phobia. *Comprehensive Psychiatry*, *10*, 151–156.

American Psychiatric Association. (2000). *Diagnostic and statistical manual for mental disorders* (4th ed.). Washington, DC: Author.

Arntz, A., Lavy, E., Van der Berg, G., & Van Rijsoort, S. (1993). Negative beliefs of spider phobics: A psychometric evaluation of the Spider Phobia Beliefs Questionnaire. *Advances in Behaviour Research and Therapy*, *15*, 257–277.

Arvanitis, T. N., Petrou, A., Knight, J. F., Savas, S., Sotiriou, S., Gargalakos, M., et al. (2007). Human factors and qualities pedagogical evaluation of a mobile augmented reality system for science education used by learners with physical disabilities. *Personal and Ubiquitous Computing*, *11*, 1–8.

Azuma, R. T. (1997). A survey of augmented reality. *Presence: Teleoperators and Virtual Environments*, *6*, 355–385.

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent advaces in augmented reality. *Computers & Graphics*, *25*, 1–15.

Botella, C., Baños, R., Perpiñá, C., Villa, H., Alcañiz, M., & Rey, A. (1998). Virtual reality treatment of claustrophobia: A case report. *Behaviour Research and Therapy*, *36*, 239–246.

Botella, C., Baños, R., Quero, S., Perpiñá, C., & Fabregat, S. (2004). Telepsychology and self-help: The treatment of phobias using the internet. *CyberPsychology & Behavior*, *7*, 272–273.

Botella, C., Baños, R., Villa, H., Perpiñá, C., & García-Palacios, A. (2000). Virtual reality in the treatment of claustrophobic fear: A controlled multiple baseline design. *Behavior Therapy*, *31*, 583–595.

Botella, C., Juan, M. C., Baños, R., Alcañiz, M., Guillén, V., & Rey, B. (2005). Mixing realities? An application of augmented reality for the treatment of cockroach phobia. *CyberPsychology & Behavior*, *8*, 162–171.

Botella, C., Quero, S., Baños, R. M., García-Palacios, A., Bretón-López, J., Alcañiz, M., et al. (2008). Telepsychology and self-help: The treatment of phobias using the internet. *CyberPsychology & Behavior*, *11*, 659–664.

Boyd, J. H., Rae, D. S., Thompson, J. W., Burns, B. J., Bourdon, K., Locke, B. Z., et al. (1990). Phobia: Prevalence and risk factors. *Social Psychiatrica and Psychiatric Epidemiology*, *25*, 314–323.

Carlin, A., Hoffman, H., & Weghorst, S. (1997). Virtual reality in the treatment of spider phobia: A controlled study. *Behaviour Research and Therapy*, *35*, 153–158.

Choy, Y., Fyer, A. J., & Lipsitz, J. D. (2007). Treatment of specific phobia in adults. *Clinical Psychology Review*, *27*, 266–286.

Cisler, J. M., Olatunji, B. O., & Lohr, J. M. (2009). Disgust, fear, and the anxiety disorders: A critical review. *Clinical Psychology Review*, *29*, 34–46.

De Buck, S., Maes, F., Ector, J., Bogaert, J., Dymarkowski, S., Heidbüchel, H., et al. (2005). An augmented reality system for patient-specific guidance of cardiac catheter ablation procedures. *IEEE Transactions on Medical Imaging*, *24*, 1512–1524.

DiNardo, P. A., Brown, T. A., & Barlow, D. H. (1994). *Anxiety disorders interview schedule for DSM-IV: Lifetime version (ADIS-IV-L)*. New York: Graywind Publications.

DiNardo, P. A., Moras, K., Barlow, D. H., Rapee, R. M., & Brown, T. A. (1993). Reliability of DSM-III-R anxiety disorder categories using the Anxiety Disorders Interview Schedule-Revised (ADIS-R). *Archives of General Psychiatry*, *50*, 251–256.

Essau, C. A., Conradt, J., & Petermann, F. (2000). Frequency, comorbidity and psychosocial impairment of specific phobia in adolescents. *Journal of Clinical Child Psychology*, *29*, 221–231.

García-Palacios, A., Botella, C., Hoffman, H., & Fabregat, S. (2007). Comparing acceptance and refusal rates of virtual reality exposure vs. in vivo exposure by patients with specific phobias. *CyberPsychology & Behavior*, *10*, 722–724.

García-Palacios, A., Hoffman, H. G., Carlin, A., Furness, T., & Botella, C. (2002). Virtual reality in the treatment of spider phobia: A controlled study. *Behaviour Research and Therapy*, *40*, 983–993.

García-Palacios, A., Hoffman, H. G., See, S. K., Tsay, A., & Botella, C. (2001). Redefining therapeutic success with virtual reality exposure therapy. *CyberPsychology & Behavior*, *4*, 341–348.

Gorman, B. S., & Allison, D. B. (1996). Statistical alternatives for single-case designs. In R. D. Franklin, D. B. Allison, & B. S. Gorman (Eds.), *Design and analysis of single-case research* (pp. 159–214). Mahwah, NJ: Lawrence Erlbaum.

Gotestam, K. G., & Hokstad, A. (2002). One session treatment of spider phobia in a group setting with rotating active exposure. *European Journal of Psychiatry*, *16*, 129–134.

Hersen, M., & Barlow, D. H. (1984). *Single case experimental designs*. New York: Pergamon.

Juan, M. C., Alcañiz, M., Calatrava, J., Zaragozá, I., Baños, R., & Botella, C. (2007). An optical see-through augmented reality system for the treatment of phobia to small animals. *Virtual Reality*, *14*, 651–659.

Juan, M. C., Alcañiz, M., Monserrat, C., Botella, C., Baños, R., & Guerrero, B. (2005). Using augmented reality to treat phobias. *IEEE Computer Graphics and Applications*, *25*, 31–37.

Kerawalla, L., Luckin, R., Seljeflot, S., & Woolard, A. (2006). "Making it real": exploring the potential of augmented reality for teaching primary school science. *Virtual Reality*, *10*, 163–174.

Magee, W., Eaton, W. W., Wittchen, H. U., McGonagle, K. A., & Kessler, R. C. (1996). Agoraphobia, simple phobia, and social phobia in the national comorbidity survey. *Archives of General Psychiatry*, *53*, 159–168.

Marks, I. M. (1978). Behavioral psychotherapy of adult neurosis. In S. L. Gardfield, & A. E. Bergin (Eds.), *Handbook of psychotherapy and behaviour change* (pp. 493–598). New York: Wiley.

Marks, I. M. (1992). Tratamiento de exposición en la agorafobia y el pánico. In E. Echeburúa (Ed.), *Avances en el tratamiento psicológico de los trastornos de ansiedad* (pp. 35–55). Pirámide: Madrid.

Marks, I. M., & Mathews, A. M. (1979). Brief standard self-rating for phobic patients. *Behaviour Research and Therapy*, *17*, 263–267.

McNally, R. J. (2002). Disgust has arrived. *Anxiety Disorders*, *16*, 561–566.

Meng, Ch. T. T., Kirkby, K. C., Martin, F., Gilroy, L. J., & Daniels, B. A. (2004). Computer-delivered behavioural avoidance tests for spider phobia. *Behaviour Change*, *21*, 173–185.

Milgram, P., & Kishino, F. (1994). A taxonomy of mixed reality visual displays. *IEICE Transaction on Information Systems*, *E77-D*, 1321–1329.

Mineka, S., Mystkowski, J. L., Hladek, D., & Rodriguez, B. I. (1999). The effects of changing contexts on return of fear following exposure treatment for spider fear. *Journal of Consulting and Clinical Psychology*, *67*, 599–604.

Muris, P., & Merckelbach, H. (1996). A comparison of two spider phobia questionnaires. *Journal of Behavior Therapy and Experimental Psychiatry*, *27*, 241–244.

Öst, L. G. (1985). Single-session exposure treatment of injection phobia: A case study with continuous heart rate measurement. *Scandinavian Journal of Behavior Therapy*, *14*, 125–131.

Öst, L. G. (1987). One-session treatments for a case of multiple simple phobias. *Scandinavian Journal of Behavior Therapy*, *16*, 175–184.

Öst, L. G. (1989). One-session treatment for specific phobias. *Behaviour Research and Therapy*, *27*, 1–7.

Öst, L. G. (1997). Rapid treatment of specific phobias. In G. C. L. Davey (Ed.), *Phobias: A handbook of theory, research, and treatment* (pp. 227–247). New York: Wiley.

Öst, L. G., Alm, T., Brandberg, M., & Breitholz, E. (2001). One vs. five sessions of exposure and five sessions of cognitive therapy in the treatment of claustrophobia. *Behaviour Research & Therapy*, *39*, 167–183.

Öst, L.G., & Ollendick, T.H. (2001). *Manual for the one-session treatment of specific phobias in children and adolescents*. Unpublished manual.

Öst, L. G., Salkovskis, P., & Hellström, K. (1991). One-session therapist directed exposure vs. self-exposure in the treatment of spider phobia. *Behavior Therapy*, *22*, 407–422.

Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy & Experimental Psychiatry*, *39*, 250–261.

Powers, M. B., & Emmelkamp, P. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of Anxiety Disorders*, *22*, 561–569.

Riva, G. (Ed.). (1997). *Virtual reality in neuro-psycho-physiology: Cognitive, clinical and methodological issues in assessment and rehabilitation*. Amsterdam: IOS Press. Retrieved from http://www.cybertherapy.info/pages/book1.htm.

Riva, G. (2002). Virtual reality for health care: The status of research. *Cyberpsychology & Behavior*, *5*, 219–225.

Rothbaum, B. O., Anderson, P., Zimand, E., Hodges, L., Lang, D., & Wilson, J. (2006). Virtual reality exposure therapy and standard (in vivo) exposure therapy in the treatment of fear of flying. *Behavior Therapy*, *37*, 80–90.

Sandín, B., Chorot, P., Santed, M. A., Valiente, R. M., & Olmedo, M. (2008). Sensibilidad al asco: concepto y relación con los miedos y los trastornos de ansiedad. *Revista de Psicopatología y Psicología Clínica*, *13*, 137–158.

Shuhaiber, M. D. (2004). Augmented reality in surgery. *Archives of Surgery*, *139*, 170–174.

Squire, K., & Klopfer, E. (2007). Augmented reality simulations on handheld computers. *Journal of the Learning Sciences*, *16*, 371–413.

Squire, K., & Mingfong, J. (2007). Mad city mystery: Developing scientific argumentation skills with a place-based augmented reality game on handheld computers. *Journal of Science Education and Technology*, *16*, 5–29.

Szymanski, J., & O'Donohue, W. (1995). Fear of spiders questionnaire. *Journal of Behavior Therapy and Experimental Psychiatry*, *26*, 31–34.

Tyron, W. W. (1982). A simplified time-series analysis for evaluating treatment interventions. *Journal of Applied Behavior Analysis*, *15*, 423–429.

Watson, P. J., & Workman, E. A. (1981). The non-concurrent multiple baseline across-individuals design: An extension of the traditional multiple baseline design. *Journal of Behavior Therapy and Experimental Psychiatry*, *12*, 257–259.

Wolpe, J. (1969). *The practice of behavior therapy*. New York: Pergamon Press.

Wörn, H., Aschke, M., & Kahrs, L. A. (2005). New augmented reality and robotic based methods for head-surgery. *International Journal of Medical Robotics and Computer Assisted Surgery*, *1*, 49–56.

Zlomke, K., & Davis, T. E. (2008). One-session treatment of specific phobia: A detailed description and review of treatment efficacy. *Behavior Therapy*, *39*, 207–223.

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