

# Using Augmented Reality to Treat Phobias

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## 1. INTRODUCTION

Virtual reality is useful for treating several psychological problems, including phobias such as fear of flying, agoraphobia, claustrophobia, and phobia to insects and small animals.<sup>1-5</sup> For example, Carlin et al.,<sup>1</sup> Renaud et al.,<sup>2</sup> and Garcia et al.<sup>3</sup> used VR to treat arachnophobia. Botella et al.'s telepsychology system used VR to treat phobia to insects and small animals (cockroaches, spiders, and rats).<sup>4</sup>

We believe that augmented reality (AR) could also be used to treat some psychological disorders. AR and VR share some advantages over traditional treatments, as Table 1 shows. However, AR gives a greater feeling of presence (the sensation of being there) and reality judgment (judging an experience as real) than VR because the environment and the elements the patient uses to interact with the application are real. Moreover, in AR users see their own hands, feet, and so on, whereas VR only simulates this experience. With these differences in mind, the question arises as to the kinds of psychological treatments AR and VR are most suited for. AR could be suitable when the following two premises are met:

- when patients can use real elements to interact with the application, such as their hands and feet; and
- when it's possible to use or reproduce the real environment (with little cost or time) or to use an alternative environment.

If both premises aren't satisfied, VR might be preferable. Because neither AR nor VR are a panacea, the phobia type will determine the most appropriate technology to use.

We have developed an AR system for treating phobias to spiders and cockroaches. In our system, patients see their own hands touching a table, holding a marker with a dead spider or cockroach, and picking up a flyswatter, a can of insecticide, or a dustpan.

TABLE 1  
 ADVANTAGES OF AR AND VR WITH RESPECT TO TRADITIONAL TREATMENTS FOR PSYCHOLOGICAL DISORDERS

Traditional treatment	AR and VR treatment
The place where the treatment takes place is real, and the elements that the patient fears are also real. Therefore, these elements may not behave as the therapist desires	The elements that the patient fears are virtual, so they cannot hurt him/her
It might be necessary to actually go to the location that the patient fears, or to recreate it. Access to this place could be complicated and the therapy might require several sessions	In AR or VR scenes, the virtual elements can appear whenever the therapist wants. Access to the scene is as easy as running the program
The order that stimuli are produced in is not controlled by the therapist	Stimuli generation is controlled by the therapist, and the stimuli can be repeated as many times as necessary. The order of appearance of virtual elements can also be controlled. The therapist can start/stop the program at any time
The therapist cannot assure that the patient will be completely safe during the treatment	The virtual elements are not real, which means that there is no real danger to the patient
The real place could be public. The patient might suffer a panic attack during the treatment, and it might be embarrassing for both the therapist and the patient	The place where the program is run is chosen by the therapist, so he/she can control all the possibilities

## 2. AR SYSTEM FOR TREATING PHOBIAS TO SPIDERS AND COCKROACHES

### 2.1. HARDWARE

Our system uses a USB or FireWire camera and a marker. We used Creative NX-Ultra and Logitech QuickCam Pro 4000. The exposure sessions with patients were performed using a Creative NX-Ultra camera. We also displayed the output of the system on a HMD. The patient wears the HMD, and the therapist watches the treatment on the monitor, and has the same view as the patient has. We used 5DT HMD (5DT Inc., 800 H x 600 V, High 40° FOV). A creative NX-Ultra camera was attached to the HMD. So that, the camera focuses where the patient is looking, see Fig. 1(a).

### 2.2. DESCRIPTION OF THE AR SYSTEM

The system is programmed in C and uses Visual C++ version 6.0 as development environment. ARToolKit 2.65 with [6] VRML support has been used to incorporate AR options.

The virtual elements are the spiders and cockroaches. One cockroach and spiders in three different sizes (small, medium and large) have been modelled. Fig. 2a, 2b and 2c show these three types of spiders. We have tried to make the animals look as real as possible, by paying special attention to the structure, the movement and the texture. Both the model and the movement of a cockroach/spider were modelled using 3DStudio Max. These models were exported to VRML format, and VrmIPad was used to edit the objects and to modify some of their characteristics. Three models for the spider/cockroach were created: static, in movement, and dead. The cockroach in movement moves its feelers and its legs; the spider in movement moves its legs. Fig. 1(b) shows a wire model of the cockroach and Fig. 2(d) shows a dead cockroach. Textures were created using Adobe Photoshop 7.0 and were applied to the models.

GLUI Library was used to develop the Graphic User Interface. The Graphic User Interface can show all the actions the user can select, or it can hide them in order to show only the image captured by the camera and the overlapped spiders/cockroaches. If the menu is hidden, the user can control the application using computer keys. OpenAL Library was used to include sounds.

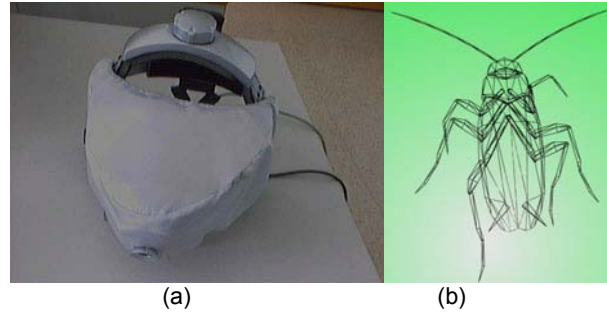


Fig. 1. (a) Capture and visualization system (Creative NX-Ultra and 5DT HMD). b) Wire model of the cockroach

The system performs the following steps:

1. It initializes the video entry, loads the files that are related to the markers and the camera, and performs all the required initializations.
2. For each frame of video:
  - 1.1. It captures a frame of the video entry.
  - 1.2. It searches for possible regions with markers and recognizes the markers in the captured frame.
  - 1.3. It obtains the transformation matrix of the camera related to the markers that are found.
  - 1.4. It draws the virtual objects on the markers.
3. It closes the video entry.

Steps 1 and 3 are executed only once, at the beginning and at the end of the program. Step 2 makes up the loop of the system. While the loop is being executed, key events are detected and treated, modifying the values of the objects to be drawn in step 2.4. The menu options also affect these values. The AR instructions related to all these steps are ARToolKit instructions, which are included in our system. Step 2.4 draws the virtual objects using a function of ARToolKit. The required transformations (translation, scale and rotation) must be executed before executing this function. There are a total of four different markers that can be identified in step 2.2, and the actions related to these markers are as follows:

- Animal marker: The system overlays one or more cockroaches/spiders in different position on the marker, depending on the selection that the user has chosen (from one to sixty).
- Insecticide killer marker (Fig. 3(a)(left)): The system identifies when this marker is close to the animal marker, then it kills one or several spiders/cockroaches. The system plays a squirting sound just like when you use a real can of insecticide.
- Flyswatter marker (Fig. 3(a)(right)): The system identifies when this marker is close to the animal marker, then it kills one or several spiders/cockroaches. The system plays a

squishing sound just like when you flatten a real spider/cockroach.

- Dustpan marker (Fig. 3(b)): The system identifies when this marker is close to the animal marker. A single dead animal appears on the animal marker and the dustpan can pick up the dead animal. This helps the patient to pick up a dead animal and throw it into the dustbin.

The system shows a different number of animals depending on the selection of the user. Five different menu options/keys have been assigned to make: 1 animal appear; 3 animals appear/disappear; 20 animals appear/disappear.

When the system recognizes the animal marker, it shows the number of selected spiders/cockroaches. If there is a single spider/cockroach, it appears in the centre of the marker. The system increases or reduces the number of animals in increments of 3 or 20 depending on the selected option. In the case of several animals, they are divided into three groups depending on the distance relative to the marker. The first group is on or near the marker, the second group is halfway between the animal marker and the established maximum distance, and the third group is at the farthest distance as possible. When animals appear, they are distributed as follows: The first animal belongs to the first group, the second belongs to the second group, and the third belongs to the third group, then, the fourth belongs to the first group and so on until the maximum number of allowed animals is reached (60). This distribution assures that there are always animals near the marker. To provide randomness, each time the system runs, a random value is assigned to the first group of animals and is used to rotate them. Therefore, these animals have a different orientation at each run. The second and third groups are always orientated towards the marker.

If the user selects one or more animals without movement, the static model of the selected animal appears. If the user chooses the movement of animals, the model in movement is shown. The movement is repetitive. If one spider/cockroach is near the marker and its orientation is towards the outside of the image, it starts the movement towards the outside of the image, moves the established distance, and goes back to its initial position (this distance is not the same for all animals). If the spider/cockroach is as far as possible, its movement is towards the marker, and the animal goes back to its initial position (the final position is not the same for all spiders/cockroaches). If the movement is stopped, the animal in movement is replaced by the static animal, which remains at the location it was stopped at. When movement is selected again, the

animals renew movement from the position they were in.

Two more actions can be added by pressing the associated keys/selecting menu options:

- The selected animals can return to their initial positions, i.e. their position and orientation are the initial values.
- The system can increase or reduce the size of the selected animals, i.e. the scale factor for each animal can be modified.

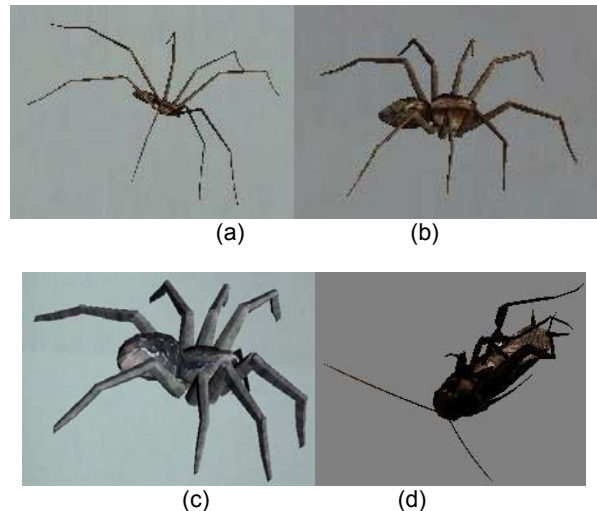


Fig. 2. (a), (b) and (c) The three different types of spiders (small, medium and large). (d) A dead cockroach

All of these options allow the therapist to make the treatment progressive. The therapist can control how many spiders/cockroaches appear, their size, whether they move or not, whether to kill a spider/cockroach when the patient is prepared, and whether to throw it into a dustbin.

Because markers are visible, the patients are able to guess when a spider/cockroach is going to appear. Therefore, surprise elements can be included. In order to simulate a search for a spider/cockroach, the therapist can incorporate several boxes under which there may or may not be markers. The patient must then pick up boxes looking for animals.

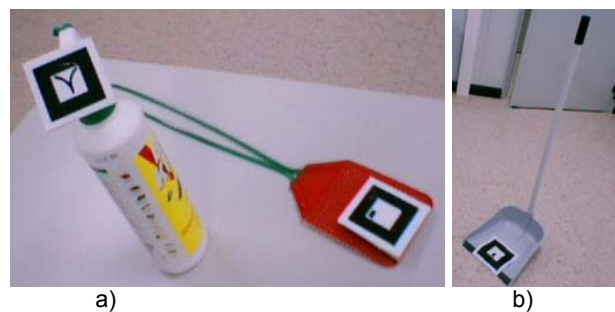


Fig. 3. (a) Elements used, from left to right, insecticide killer; flyswatter. (b) Dustpan

### 3. METHOD

#### 3.1. PARTICIPANTS

The treatment was tested on nine participants. Five of them had a phobia to cockroaches and four of them had a phobia to spiders. All of them asked for help at the Jaume I University Anxiety Disorders Clinic. They met DSM-IV (Diagnostic and Statistical Manual of Mental Disorders - Fourth Edition) [7] criteria for specific phobia, situational type (specifically, fear of cockroaches, and fear of spiders). None of them had previously received treatment for this problem.

Participant 1 (P1) was a 33-year-old, single female, who worked as a hairdresser. She had phobia of spiders. The problem began when she was 13 years old. The problem moderately interfered in her life; she had a house in the country, and she avoided going anywhere she believed that spiders could appear. She rated the severity of her problem as 7 (on a scale from 0 to 10).

Participant 2 (P2) was a 21-year-old, single female, who was a university student. She had phobia of spiders. The problem began when she was 5 years old. The problem grew worse and worse. If she saw a spider, the patient would react by crying, shouting and having nightmares for several days. She defined it as "hysterical reaction". She rated the severity of her problem as 7 (on a scale from 0 to 10).

Participant 3 (P3) was a 33-year-old, married female, who worked in administration at the university. She had phobia of spiders. Her fear began when she was a child; her mother told her that she had to wash her hair, otherwise, spiders would grow in it. She had a fear of spiders as long as she could remember. She rated the severity of her problem as 8 (on a scale from 0 to 10).

Participant 4 (P4) was a 19-year-old, single man, who was a university student. He had phobia of spiders. He manifested physical sensations like palpitation, sweating, shivers, and fear of losing control when he saw a spider. He reported having a fear of spiders since he was a child. He rated the severity of his problem as 8 (on a scale from 0 to 10).

Participant 5 (P5) was a 29-year-old, single female, who worked as doctor. She had phobia of cockroaches. She had been afraid of them since she was a child, and this fear had generalized to other insects, like butterflies, wasps or beetles. She rated

the severity of her problem as 7 (on a scale from 0 to 10).

Participant 6 (P6) was a 20-year-old, single female, who was a university student. She had phobia of cockroaches. The fear of cockroaches began when she was a child, for no apparent reason. She rated the severity of her problem as 6 (on a scale from 0 to 10).

Participant 7 (P7) was a 27-year-old, single female, who worked as a nurse in a residential home for the elderly. She had phobia of cockroaches. The problem began when she was a child and it got worse with age. She rated the severity of her problem as 10 (on a scale from 0 to 10). There are cockroaches in the residential home for the elderly where she works and, for this reason, she had decided to leave her workplace.

Participant 8 (P8) was a 31-year-old, single female, who worked in administration. She feared cockroaches. The problem began when she was younger because a lot of wasps attacked her. Her fear has expanded to other insects (bees, wasps, etc.) She rated the severity of her problem as 8 (on a scale from 0 to 10).

Participant 9 (P9) was a 35-year-old, married female and worked as a psychologist. She feared cockroaches. The problem began when she was 15 years old and there was a plague of cockroaches in the town where she was living. Her fear was increasing. She rated the severity of her problem as 6 (on a scale from 0 to 10).

#### 3.2. MEASURES

Diagnostic Interview. An adaptation of the Anxiety Disorders Interview Schedule (ADIS-IV), specific phobia section [8] was used. ADIS-IV is a semi-structured interview that is designed to carry out a differential diagnosis of the anxiety disorders included in the DSM-IV [7]. This instrument gathers clinical data such as the history of the problem, as well as cognitive and situational factors that could play a role in the phenomenology of the anxiety response.

Fear and avoidance scales. These scales were adapted from [9]. The patient and the therapist establish the target behaviors or situations that the patient avoids and that he/she would like to overcome by the end of the treatment. The patient rates the daily level of avoidance on a 0-10 scale.

Measures regarding expectations and satisfaction with the treatment. We included two questions adapted from [10] about the willingness of getting involved in a treatment program that includes: *in vivo* or AR exposure. The patients rated these questions on a 1 to 7 scale, where 1 was "I would never do it"

and 7 was "I would absolutely do it". Following [10], we also included several questions to measure the satisfaction about the AR exposure treatment.

Presence and Reality Judgment. In order to assess the degree of presence experienced in the AR session, three questions were asked to the participants after interacting with the AR system. The three questions were (on a scale from 0 to 10): "To what degree have you felt present in the situation", "To what degree have you felt that you were in a place in which spiders/cockroaches appeared", and "To what degree did you think the spiders/cockroaches were real".

Subjective units of discomfort scale (SUDS). Following [11], we asked participants to rate his/her maximum level of anxiety on a 0 to 10 scale (0=no anxiety, 10=high anxiety).

Consent form. Participants read and signed a consent form accepting the treatment they were going to receive, allowing us to videotape the sessions, and to use their data in our research.

### 3.3. THE EXPOSURE SESSION USING THE AR SYSTEM FOR TREATING PHOBIAS TO COCKROACHES/SPIDERS

The AR system was applied using the guidelines for "one-session treatment" from Öst-treatment [12]. The steps followed in the AR exposure session were as follows:

- We put the capture and visualization system on the patient. The program ran and the therapist started by showing one spider/cockroach. When the therapist considered it opportune, more spiders/cockroaches progressively appeared. During the AR session, the patients were able to see sixty animals at the same time.
- In the second step, the therapist tried to get the patient to bring his/her hand closer to the therapist's hand where spiders/cockroaches were crossing. At first, the therapist tried with only one animal; later the therapist used two animals, and then more spiders/cockroaches. The patients pulled their hands away several times when a spider/cockroach approached/crossed their hands. Fig. 4 shows an image of this part of the treatment for Participant P1.

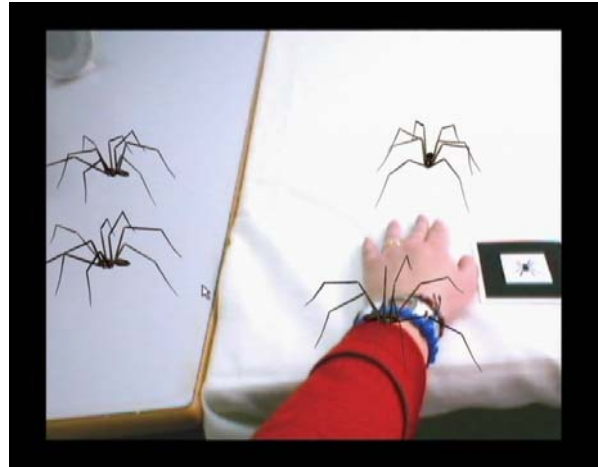


Fig. 4. Participant P1 lets spiders approach and cross over her hand

- In the third step, the therapist included a surprise box. This element was introduced to generate uncertainty in the patients. If the patient saw the marker, he/she automatically associated it with the appearance of one or more spiders/cockroaches. However, if he/she did not know if there was marker under a box or inside a cupboard, he/she did not know if one or more spiders/cockroaches were going to appear. This is to simulate when you are searching for a spider/cockroach in your house. You know there is a spider/cockroach, but you do not know exactly where it is. In the system, there can be from one to four surprise boxes. Under one or two of these surprise boxes there was a marker. When the therapist or the patient picked up the box, one or more spiders/cockroaches appeared, depending on the selection the therapist had made. Again, the therapist picked up boxes with and without markers. Later, the patient picked up boxes with or without markers, Fig. 5.
- In the fourth step, the therapist started to kill spiders/cockroaches. At first, the therapist killed one spider/cockroach. After repeating this action several times, the therapist tried to get the patient to kill animals and throw them into a box. Fig. 6 shows how participant P2 kills a spider using the flyswatter. Fig. 7 shows how the participant P5 picks up the dead cockroach to throw it into a box.

After the AR session, the therapist tried to get the patients to approach and interact with a real spider/cockroach. First, the therapist tried to get the patients to approach a bowl that contained a live spider/cockroach. After the patients touched the bowl, the therapist let the spider/cockroach out of the



bowl and it ran on the floor. All the patients were able to approach a real spider/cockroach, interact with it and kill it by themselves. Fig. 8 shows how Participant P1 kills a real spider.

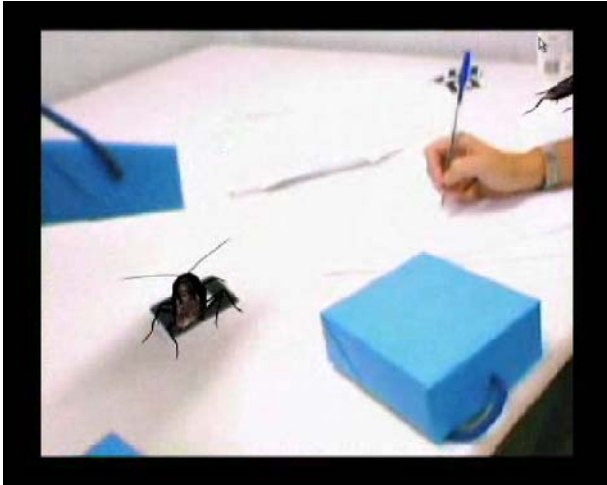


Fig. 5. Participant P5 picking up a box under which there was a marker



Fig. 6. Participant P2 killing a spider with the flyswatter



Fig. 7. Participant P5 picking up a dead cockroach



Fig. 8. Participant P1 killing a real spider

#### 4. RESULTS

In all cases, the treatment produced an important decrease in the participants' fear when they had to face their target spider/cockroach.

Results from the treatment showed an important change in the avoidance of spiders/cockroaches. Before the treatment, none of the patients were able to approach real spiders/cockroaches. After the treatment, all of them were able to kill several real, live spiders/cockroaches.

The results of the self-report measures are shown in Table 2. During the treatment, the participants' scores for anxiety were high, but they dropped by the end of the treatment. Analysis of this data indicates that, the AR system induces anxiety in people suffering from fear of spiders/cockroaches. Moreover, the system not only induced anxiety, but it also diminished it through prolonged exposure to the virtual spiders/cockroaches. Furthermore, the nine

participants were able to kill a live spider/cockroach after the treatment. We consider this fact as a very meaningful measure of improvement. Taking into account this criterion, we may consider the AR treatment for fear of spiders/cockroaches to be successful in reducing the participants' fear and avoidance.

To measure the sense of presence and the reality judgment of the participants when they were immersed in the system, we asked them three questions, whose answers are shown in Table 3. As can be observed, all the scores were very high, indicating that all the participants were able to get into the AR environment and feel really anxious, just as if they were actually confronting real spiders/cockroaches.

TABLE 2  
DEGREE OF ANXIETY DURING THE EXPOSURE SESSION AND AFTER THE TREATMENT

SUBJECTS	Anxiety during the exposure	Anxiety after the treatment
P1	9	0
P2	9	5
P3	10	3
P4	7	0
P5	9	0
P6	10	5
P7	10	2
P8	8	0
P9	8	0

TABLE 3  
SENSE OF PRESENCE AND REALITY JUDGMENT

SUBJECTS	Q1	Q2	Q3
P1	10	8	9
P2	7	5	6
P3	8	8	8
P4	10	10	9
P5	7	7	7
P6	10	10	10
P7	10	10	10
P8	8	8	8
P9	10	10	8

Q1: "To what degree have you felt present in the situation".  
Q2: "To what degree have you felt that you were in a place in which animals appeared".  
Q3: "To what degree did you think the animals were real".

## 5. CONCLUSIONS

The positive results of this first prototype suggest AR's potential in psychology. The study's main shortcoming is the small sample size. We need to apply this treatment to larger samples in a group design that includes a control

group. Such a procedure would increase the confidence in this new exposure format. We believe that AR applications can also be useful as a therapeutic tool for several other psychological disorders.

## Acknowledgments

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## REFERENCES

- [1] Carlin, A., Hoffman, H., & Weghorst, S., "Virtual reality and tactile augmentation in the treatment of spider phobia: a case report", *Behaviour Research and Therapy*, 35, pp. 153-158, 1997
- [2] Renaud, P., Bouchard, S., & Proulx, R., "Behavioral avoidance dynamics in the presence of a virtual spider", *IEEE Trans. On Information Technology in Biomedicine*, 6 (3), pp. 235-243, 2002
- [3] García-Palacios, A., Hoffman, H. G., Carlin, A., Furness, T., & Botella, C., "Virtual Reality in the treatment of spider phobia: A controlled study. *Behaviour*", *Research and Therapy*, 9, pp. 983-993, 2004
- [4] Botella, C., Baños, R., Quero, S., Perpiñá, C., & Fabregat, S., "TelePsychology and Self-Help: The treatment of phobias using the Internet", *Cybertherapy, San Diego (EEUU)*, 2004
- [5] Hodges, L., Anderson P., Burdea, G., Hoffman, H., & Rothbaum, B., "Treating Psychological and Physical Disorders with VR", *IEEE Computer Graphics and Applications*, 21(6), pp. 25-33, 2001
- [6] Kato, H., & Billinghurst, M., "Marker tracking and HMD calibration for a video-based augmented reality", *Conferencing system. 2<sup>nd</sup> IEEE and ACM International Workshop on Augmented Reality (IWAR'99)*, San Francisco (California), pp. 85-94, 1999
- [7] American Psychiatric Association, "Diagnostic and statistical manual of mental disorders DSM-IV-TR", (4<sup>th</sup> ed., text revision). Washington, DC, APA, 2000
- [8] Di Nardo, P.A., Brown, T.A., & Barlow, D.H., "Anxiety Disorders Interview Schedule for DSM-IV: Lifetime Version (ADIS-IV)", *Psychological Corp.*, San Antonio, Tex, 1994
- [9] Marks, I. M., & Mathews, A. M., "Case histories and shorter communication", *Behaviour Research and Therapy*, 17, pp. 263-267, 1979
- [10] Borkovec, T.D., & Nau, S.D., "Credibility of analogue therapy rationales", *Journal of Behaviour Therapy and Experimental Psychiatry*, 3, pp. 257-260, 1972
- [11] Wolpe, J., "The practice of behavior therapy", New York: Pergamon Press, 1969
- [12] Öst, L., Salkovskis, P., & Hellström, K., "One-session therapist directed exposure vs. self-exposure in the treatment of spider phobia", *Behavior Therapy*, 22, pp. 407-422, 1991