



The Therapeutic Lamp: Treating Small-Animal Phobias

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Approximately 5 percent of people suffer from animal phobias such as arachnophobia (fear of spiders). Although phobias can be managed and cured, between 60 and 80 percent of phobia sufferers don't seek treatment, and the treatment itself has low acceptance and high dropout rates. Because untreated disorders incur high economic and social costs, increasing access to and motivation for therapy is an important goal.

We believe that introducing innovative technologies can help provide effective therapeutic tools that enable therapists to reach this goal. Toward that end, we created the Therapeutic Lamp (TL), an interactive projection-based augmented reality (AR) system for treating small-animal phobias.

Treating Phobias in the 21st Century

In vivo exposure is a standard therapy that exposes phobia sufferers to live animals. Although it's effective, it presents some drawbacks. It's time-consuming and has logistics problems, therapists can't fully control the animal or situation, and, as we mentioned before, it has low acceptance and a high dropout rates.

To eliminate these drawbacks, researchers have proposed VR and AR technology that offers both

full control of the phobic object or situation and an immediate, safe environment in which therapists and clients can work. VR has demonstrated great potential in mental health (MH) applications,^{1,2} and researchers have effectively applied AR systems to treat phobias (see Figure 1).³

VR and AR bring numerous advantages to small-animal phobia treatment but still pose challenges. We developed TL to meet three of those challenges: increasing patient-therapist communication, promoting more natural interaction, and improving the patient's engagement in the therapy.

Increasing Patient-Therapist Communication

VR and AR applications typically use displays such as head-mounted displays (HMDs) to visualize a virtual environment or virtual objects. Such displays can limit visual awareness, which plays an important role in all types of face-to-face communication and demonstrates engagement, attention, and liking.

During in situ analyses of HMD-based AR exposure therapy and in vivo exposure therapy for small-animal phobias, we compared the frequency of visual contact between the patient and the therapist.⁴ The visual contact was significantly lower for the HMD-based therapy. Even though

the lower frequency didn't affect the clinical outcome, we believe that alternative visual displays such as projection-based systems could help eliminate this issue.

Promoting More Natural Interaction

In the MH field, the feeling of presence (that is, the perception that an experience is real and not mediated by technology) affects the patient's anxiety level and the clinical outcome. Giuseppe Riva and his colleagues argue that for technology-mediated therapy to be effective, the mediation should disappear from the client's awareness and should enable a common ground between the patient and therapist.⁵ Therapist-client interaction is a main factor in creating this common ground. So, we believe that introducing more natural interactions with the therapist and with virtual animals will increase the patients' sense of presence and their reality judgment (that is, the perception of the therapeutic scenario as being real).

Improving Engagement in the Therapy

Many clinical researchers consider decreased patient motivation as a main reason for treatment failure. We believe that computer games could increase motivation and engagement in therapy.

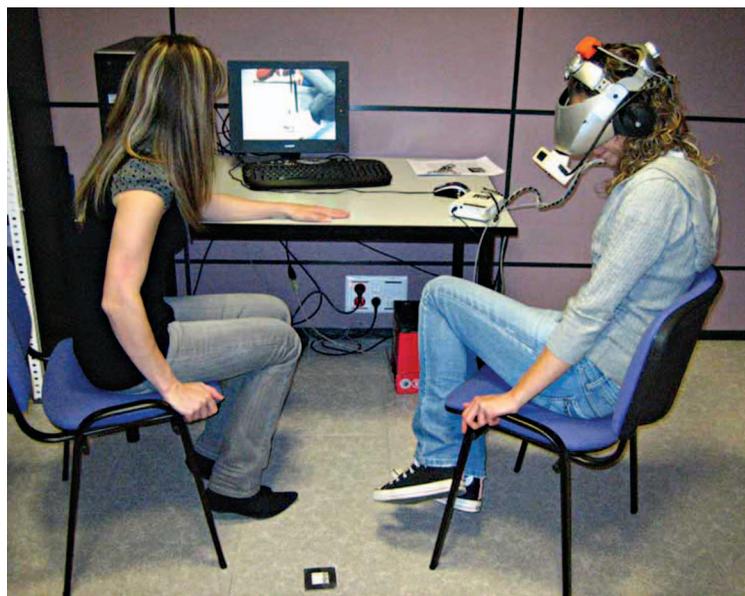
Researchers have already applied computer games to different MH disorders. For example, Cristina Botella and her team at the University of Jaume I recently evaluated a mobile therapeutic game for cockroach phobia. The patient played the game at home as a form of self-exposure exercise for nine days before the therapy. The game reduced patient anxiety and avoidance before the therapy session even started.⁶

Illuminating the Therapeutic Experience

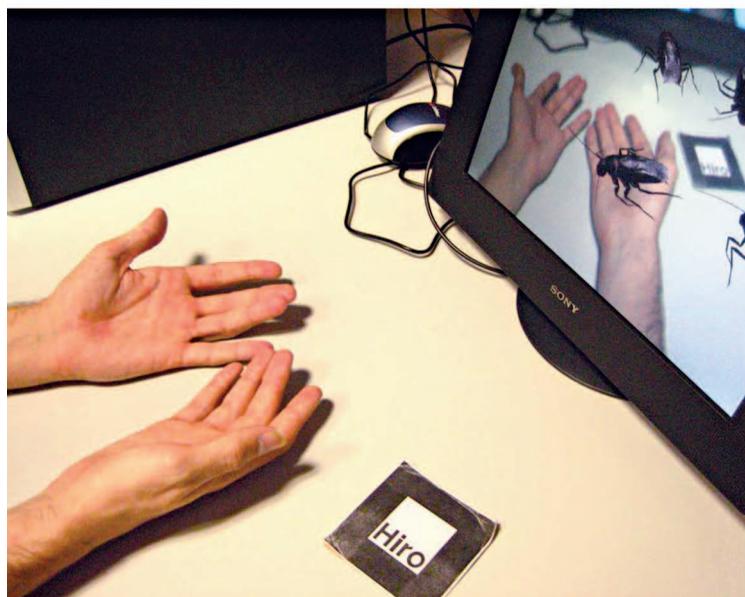
TL (see Figure 2) allows for face-to-face therapy involving direct confrontation and interaction with a virtual animal in a real environment. We aimed to provide phobia sufferers a tool to deal with their feared animals at the lowest anxiety level in a highly interactive and engaging environment. While using TL, patients can discover information about the feared animals, confront them, and test their capacities regarding them.

When developing TL, we applied user-centered design. Specifically, we based the functional requirements on interviews with therapists and on our in situ analyses of traditional and technology-mediated therapies.

As Table 1 shows, TL offers several advantages over some other therapies for treating small-animal phobia.



(a)



(b)

Figure 1. Augmented reality (AR) exposure therapy for small-animal phobias. (a) A global view of a patient (on the right) and therapist (on the left) during therapy. (b) What the patient sees in the head-mounted display.

TL—Technologically Speaking

TL is a tabletop system that integrates the user's hands, a coffee mug, a cardboard box, a flyswatter, and finger and object detection and tracking over a flat surface (a table or floor). We programmed it in C, using Visual C++ version 9.0 as the development environment, and we incorporated AR options with Gamestudio version 8.10.

Detecting and Tracking Objects

We developed finger and object detection using the FingerSimpleGeom tracking library. To perform

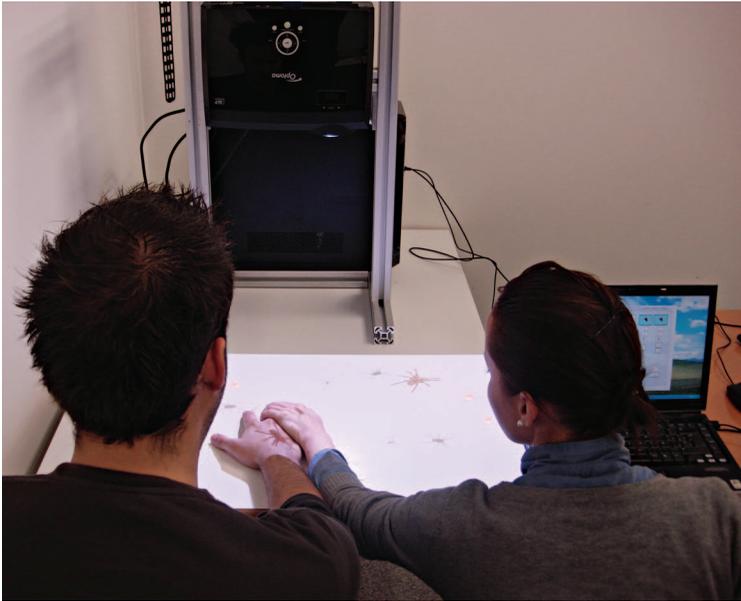


Figure 2. The Therapeutic Lamp (TL), a projection-based AR system for therapy for small-animal phobias. The therapist (on the right) controls the system with a laptop; the patient (on the left) observes virtual animals walking on his and the therapist's hand.

this detection, TL uses a depth-sensing Kinect-type camera (ASUS XPro). With this sensor, TL can determine how far the object represented by a specific pixel in an image is from the camera. It thus detects and interprets the movements of the user's fingers and the coffee mug, cardboard box, and flyswatter. The depth sensor provides images with a resolution of 640×480 pixels, a field of view of approximately 57×43 degrees ($87 \text{ cm} \times 67 \text{ cm}$ at a distance of 80 cm), and a spatial resolution of 1.3 mm per pixel. Bilateral filtering smooths the image's depth and increases system performance.

To detect how the user's fingers and objects interact with the surface, we first calibrate the background and train TL to recognize fingers and the objects. During the therapy session, TL performs background subtraction to fit the contours extracted from depth segmentation images to the

finger and object models. If the contours match those models, TL detects and tracks them and can use them to perform predetermined actions.

TL displays the system output with a $1,024 \times 768$ resolution Optoma EX610SP projector whose axis is almost perpendicular to the flat surface. The combination of the projected images and our detection and tracking software allows the flat surface to behave like an interactive surface.

Modeling the Animals

TL currently provides therapy for cockroach and spider phobias. For the cockroach application, we modeled an American cockroach with wings, an American cockroach without wings, and a black cockroach (see Figures 3a through 3c). For the spider application, we modeled a small spider, medium-size spider, and tarantula (see Figures 3d through 3f).

We wanted to make the animals as real as possible, paying attention to their structure, movements, and texture. Specifically, we created two textures for each type of cockroach (black and red) and spider (brown and yellow); these textures correspond to a particularly anxiety-provoking characteristic for patients. We created the textures in Adobe Photoshop CS5 and applied them to the models. We also created seven types of animations: standing still, paralyzed, dead, moving, moving the wings, flying, and making a web (for the medium-size spider).

We created the models and their animations in Autodesk 3ds Max, exported them in FBX format, and saved them as MDL files through Gamestudio.

The GUI

We also used Gamestudio to develop the GUI, which has three menus.

The *configuration menu* (see Figure 4a) lets the therapist change the animals' number and size, control their movement, make them appear dead

Table 1. The advantages of the Therapeutic Lamp (TL) for treating small-animal phobias.

Treatment characteristic	Therapy			
	Traditional	VR	Augmented reality	Therapeutic Lamp (TL)
Control of the animal	—	Yes	Yes	Yes
A safe environment	—	Yes	Yes	Yes
A real-world or close-to-real-world environment	Yes	—	Yes	Yes
Natural patient-therapist communication (absence of a visual display to mediate communication)	Yes	—	—	Yes
Natural or close-to-natural interaction with the animal (human fingers interacting with real objects)	Yes	—	—	Yes
Use of therapeutic games	—	—	—	Yes

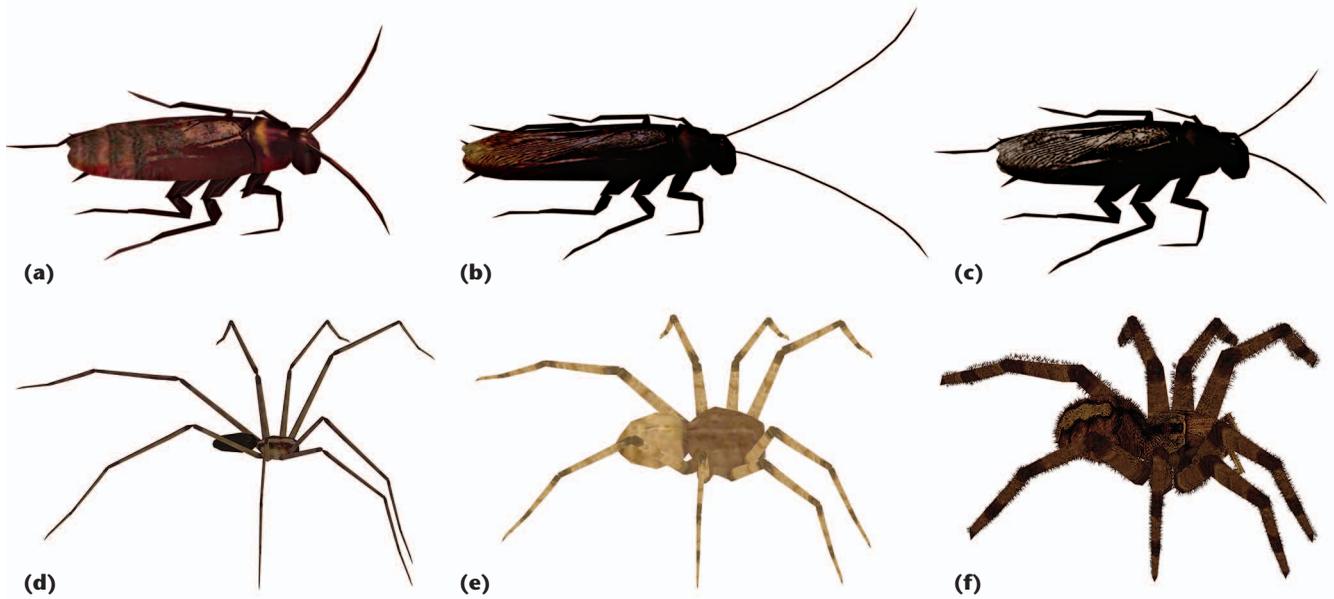


Figure 3. Models of (a) an American cockroach with wings, (b) an American cockroach without wings, (c) a black cockroach, (d) a small spider, (e) a medium-size spider, and (f) a tarantula. We wanted to make the animals as real as possible, paying attention to their structure, movements, and texture.

or paralyzed, make a cockroach move its wings or fly, or make a spider build a web. The therapist can also let the patient

- observe an animal on his or her hands and personal objects,
- interact with an animal with his or her fingers (The patient can drag the animal to different locations or change the animal's angle. The therapist can also cause the animal to follow or flee from the patient's fingers.),
- interact with an animal with different objects (catch the animal with a coffee mug, look for an animal hidden under a cardboard box, or kill the animal with a flyswatter), and
- play a serious game (catch as many animals as possible in a limited amount of time in a virtual kitchen).

The *clinical-data menu* (see Figure 4b) lets the therapist introduce the patient's clinical data (the anxiety level, avoidance, and irrational beliefs) during therapy, observe the therapy's evolution on a graph, and keep a record of the data as an Excel log.

Finally, the *notes menu* lets the therapist write comments and observations about the patient during therapy and keep a record as a text file.

These options help provide progressive therapy that gives the patient the opportunity to first observe the feared animal, then interact with the animal with his or her hands or an object, and finally interact with the animal in the fun context of a serious game.

TL—Practically Speaking

We evaluated TL to obtain user feedback in the context of real use. Because of ethical issues, we validated the system with a subclinical population (participants not diagnosed as phobia sufferers but with relatively high anxiety and avoidance scores toward the animals).

Participants

The 26 volunteers comprised 14 men and 12 women; the mean (M) age was 27.62 and the standard deviation (SD) was 5.51. They were subject to these inclusion criteria: no prescribed medication use, no current alcohol or drug dependency, no diagnosis of a psychological disorder, and no serious medical problems (for example, heart disease or epilepsy). The mean anxiety and avoidance scores were 42.54 out of 126 (SD = 31.06) for spiders and 35.77 out of 126 (SD = 25.44) for cockroaches.

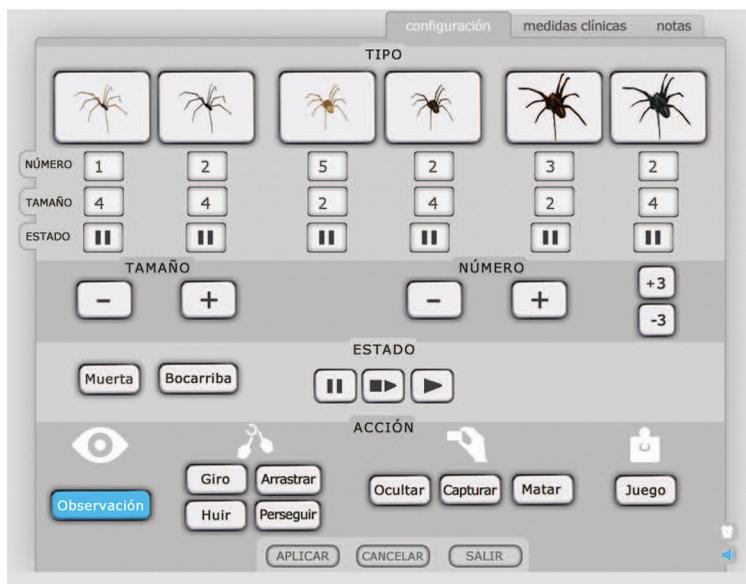
We also had four therapists view a demonstration session on video. All of them had at least three years' experience in the therapeutic field with both technology-mediated and traditional therapies.

Instruments

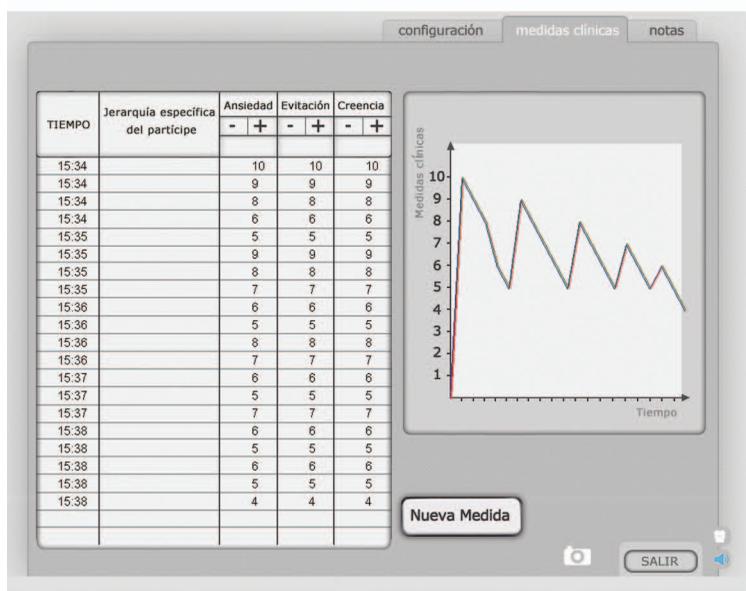
To measure the participants' experience during an exposure session, we used six common clinical instruments.

The Spider and Cockroach Anxiety and Avoidance Questionnaire defined the degree (on a scale of 0 to 7) to which each participant was afraid of and avoided spiders and cockroaches before the session.

The Self-Efficacy Belief Questionnaire defined the degree (on a scale of 0 to 7) to which each participant



(a)



(b)

Figure 4. Two views in the TL GUI. (a) In the configuration menu, the therapist applies different therapeutic exercises. (b) In the clinical-data menu, the therapist introduces the clinical data and observes its evolution.

believed that he or she could confront a real cockroach or spider before and after the session.

The Subjective Units of Discomfort Scale defined the evolution of the degree (on a scale of 0 to 10) to which the participant felt anxiety regarding the feared animal at the beginning and end of each exercise in the session.

The Presence and Reality Judgment Questionnaire defined the degree (on a scale of 0 to 10) to which each participant felt present and considered the animals to be real at each exercise's start.

The Usefulness Questionnaire defined the degree (on a scale of 0 to 7) to which each partici-

part considered the session to be a useful, valuable therapeutic tool after the session.

We also asked the therapists to define the degree (on a scale of 0 to 7) to which they considered TL to be a useful therapeutic tool.

The Exposure Session

The session comprised 12 exercises based on one of the clinical protocols (that is, one intensive exposure session):

- The participant observed three dead and three paralyzed animals.
- The participant observed six animals standing still.
- The participant observed six moving animals.
- The participant observed 30 moving animals.
- The participant observed 30 animals crawling on his or her hands (see Figure 5a).
- The participant observed a flying cockroach and a spider making a web.
- The therapist made 60 animals run away from the participant's fingers.
- The therapist made 30 animals follow the participant's fingers.
- The participant looked for 12 animals hidden under the cardboard box (see Figure 5b).
- The participant captured 12 animals with the mug.
- The participant killed 30 animals with the flyswatter (see Figure 5c).
- The participant played the therapeutic game (see Figure 5d).

The exercises progressed from those that potentially created less anxiety to those that created the most anxiety.

Results

We performed all statistical analyses with SPSS 17.0 (IBM's predictive-analytics software), with an alpha level of 0.05. The results indicate that TL seems an effective, well-adapted tool for small-animal phobia treatment.

The participants' anxiety scores were relatively high at each exercise's beginning but dropped by the end (see Table 2). We observed a similar process between the session's beginning and end. Although the anxiety scores weren't as high as in other studies with a clinical population (for example, 9 out of 10 at the session's beginning), the results demonstrate a similar anxiety curve and habituation effect.

The participants' belief in their capacity to confront the animal without getting anxious increased

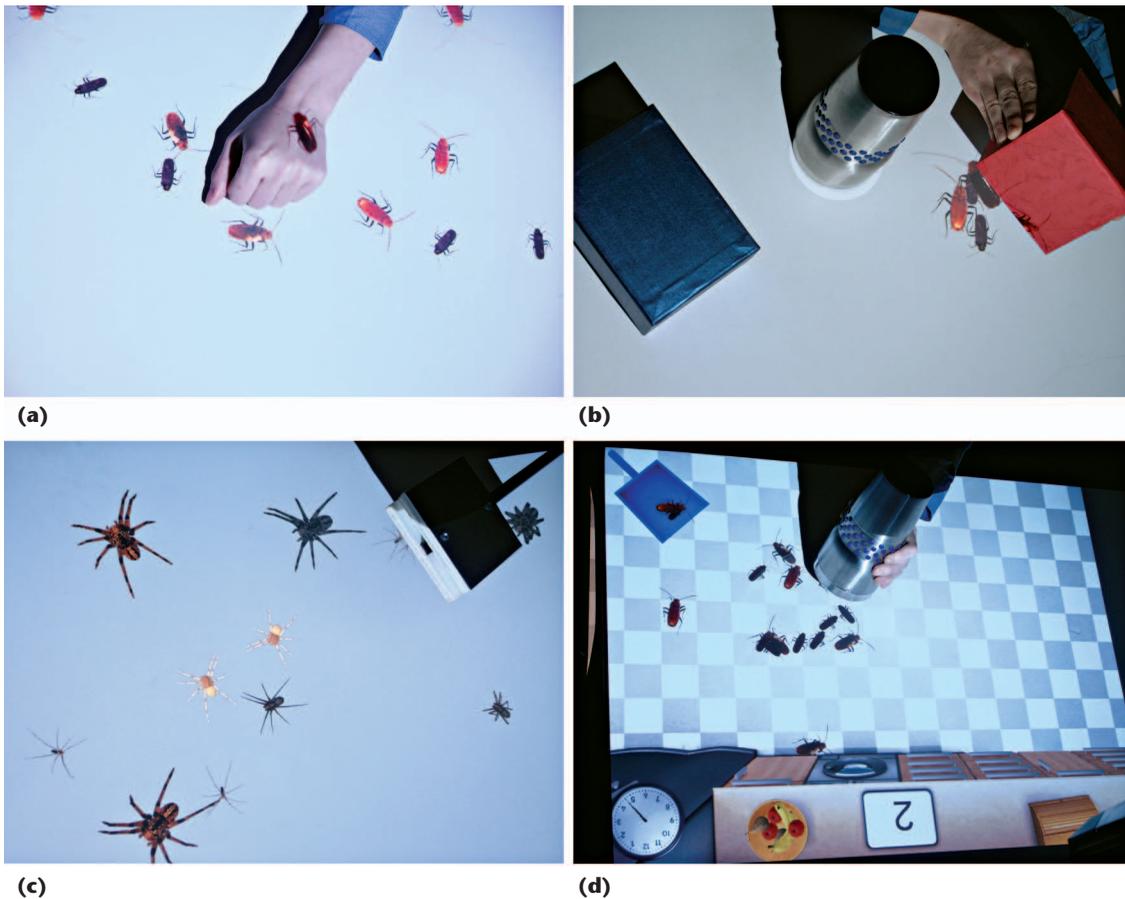


Figure 5. Some exposure session exercises. The participant (a) observes cockroaches walking on his or her hands, (b) looks for cockroaches hidden under a cardboard box, (c) kills spiders with a flyswatter, and (d) plays a therapeutic game in which he or she catches as many cockroaches as possible in a limited amount of time in a virtual kitchen.

Table 2. Participants' mean anxiety at the exercises' beginning and end (on a scale of 0 to 10). The standard deviation is in parentheses.

Exercise	Beginning	End
Observing three dead and three paralyzed animals	2.56 (2.08)	1.24 (1.17)
Observing six animals standing still	2.85 (2.31)	1.42 (1.45)
Observing six moving animals	4.68 (2.46)	1.96 (1.37)
Observing 30 moving animals	5.31 (2.75)	1.81 (1.63)
Observing 30 animals walking on the participant's hands	4.27 (2.99)	2.00 (1.94)
Observing a cockroach flying and a spider making a web	2.50 (2.38)	1.38 (1.86)
Making 60 animals run away	3.85 (2.26)	1.85 (1.46)
Making 30 animals follow the participant	3.96 (2.36)	1.69 (1.54)
Looking for 12 hidden animals	3.57 (2.71)	1.57 (1.75)
Capturing six animals with the mug	1.83 (2.10)	0.87 (1.42)
Killing 30 animals with the flyswatter	3.35 (2.92)	1.39 (1.78)
Playing the therapeutic game	2.31 (2.46)	0.73 (1.31)

significantly after the session (see Figure 6).

The participants felt the virtual animals' presence relatively well ($M = 4.92$; $SD = 1.21$) and considered them to be rather real ($M = 4.54$; $SD = 1.36$).

Finally, all the participants considered TL to be particularly useful for learning to confront the feared animal ($M = 6.13$; $SD = 0.67$). Four of the

therapists considered the system to be valuable for treating small-animal phobias ($M = 6.09$; $SD = 1.41$).

The results suggest that TL can indeed illuminate the experience of both the patient and therapist during phobia treatment. However,

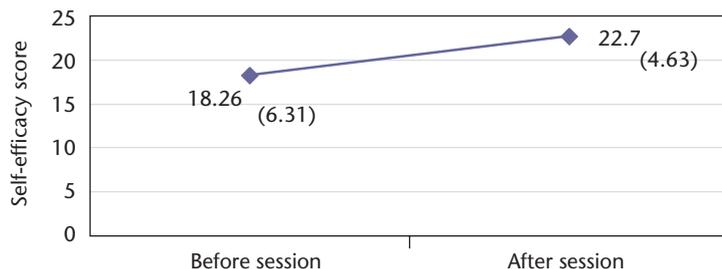


Figure 6. The participants' mean total self-efficacy belief score (out of 28) before and after the experimental session. (The standard deviation is in parentheses.) The participants' belief in their capacity to confront the feared animal without getting anxious increased significantly.

because we evaluated the system with a subclinical population, this first validation is limited. Nevertheless, the participants' and therapists' positive feedback and our data's similarity to clinical data from other phobia-treatment systems encourage us to validate TL with a clinical population.

To evaluate TL's clinical effectiveness, we'll perform an intensive therapeutic session with phobia patients and compare the results to those for other technology-mediated and nonmediated therapies. Because anxiety activation and habituation were visible in our preliminary validation, we believe that the results with a clinical population will translate to the real world. We also believe that the technology we applied in TL can be a useful therapeutic tool for other psychological disorders. ■■

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