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Evaluation of a Brazilian simulator for virtual reality behavior therapy[1]

Avaliação de um simulador brasileiro para terapia comportamental com realidade virtual

Evaluación de un simulador brasileño de terapia conductual con realidad virtual

Marcela Roberta Jacyntho Zacarin
Universidade Estadual de Londrina
❖
Elizeu Borloti
Universidade Federal do Espírito Santo
❖
Verônica Bender Haydu ✉
Universidade Estadual de Londrina

ABSTRACT

Behavioral therapy combined with a virtual reality exposure (VRE) component can be useful for the treatment of fears and phobias. This study aimed to: (a) describe and evaluate a behavioral therapy procedure amplified by VRE for the treatment of fear of height and (b) record sense of presence and cybersickness during exposure to assess the Virtua Therapy simulator. The procedure consisted of: an initial session; six therapy sessions, which included graduate exposure, prevention of escape-avoidance responses, and functional analyses of behaviors; two follow-up sessions. Sense of presence and cybersickness were recorded. The intervention decreased the participants' levels of anxiety and the frequency of avoidance of situations involving heights in the virtual environment, and they reported decreases in day-to-day avoidance responses, demonstrating therapeutic effects. The simulator produced sense of presence. Cybersickness occurred primarily during the first session, indicating habituation effect. It was concluded that the Virtua Therapy simulator is an appropriate device for behavioral therapy.

Keywords: virtual reality exposure therapy, acrophobia, fear of heights, behavior analysis

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✉ haydu@uel.br
Departamento de Psicologia Geral e Análise do Comportamento, Universidade Estadual de Londrina. Rod. Celso Garcia Cid, Km 380, Campus Universitário. Caixa Postal: 10011. Londrina, PR, Brasil. CEP: 86057-970.

RESUMO

Terapia comportamental combinada à exposição por realidade virtual (*virtual reality exposure* – VRE) pode ser útil no tratamento de medos e fobias. Este estudo visou a: (a) descrever e avaliar um procedimento terapêutico comportamental ampliado pela VRE para o tratamento do medo de altura e (b) registrar o senso de presença e o *cybersickness* durante a exposição para avaliar o simulador Virtua Therapy. O procedimento consistiu em: uma sessão inicial; seis sessões terapêuticas, que incluíram exposição graduada, bloqueio de fuga-esquiva e análises funcionais de comportamentos; duas sessões de seguimento. O senso de presença e o *cybersickness* foram registrados. A intervenção diminuiu os níveis de ansiedade dos participantes e a frequência de esquiva de situações que envolviam altura no ambiente virtual, e eles relataram redução de respostas de esquiva no dia a dia, demonstrado efeito terapêutico. O simulador gerou senso de presença. O *cybersickness* ocorreu principalmente durante a primeira sessão, indicando efeito de habituação. Concluiu-se que o simulador Virtua Therapy é um recurso apropriado para terapia comportamental.

Palavras-chave: terapia de exposição por realidade virtual, acrofobia, medo de altura, análise de comportamento

RESUMEN

La terapia comportamental combinada con la exposición por realidad virtual (*virtual reality exposure* – VRE) puede ser útil en el tratamiento de miedos y fobias. Este estudio buscó: (a) describir y evaluar un procedimiento terapéutico comportamental ampliado por VRE para el tratamiento del miedo a la altura, (b) registrar el sentido de presencia y el *cybersickness* durante la exposición, para evaluar el simulador Virtua Therapy. El procedimiento consistió en: una sesión inicial; seis sesiones terapéuticas, que incluyeron exposición graduada, bloqueo de fuga-esquiva, análisis funcionales de comportamientos; dos sesiones de seguimiento. El sentido de presencia y el *cybersickness* eran registrados. La intervención disminuyó los niveles de ansiedad de los participantes y la frecuencia esquiva de situaciones que envolvían altura en el ambiente virtual y ellos relataron reducción de respuestas de esquiva en el día a día, demostrado efecto terapéutico. El simulador generó sentido de presencia. El *cybersickness* ocurrió principalmente durante la primera sesión, indicando efecto de habituación. Se concluyó que el simulador Virtua Therapy es un recurso apropiado para terapia de conducta.

Palabras clave: terapia de exposición por realidad virtual, acrofobia, miedo de altura, análisis de comportamiento

Virtual reality (VR) technology is increasingly applied to interventions in the areas of psychology and psychiatry and has been particularly useful in the treatment of anxiety disorders, including phobias. In such cases, technological resources (simulators) which allow the simulation of virtual environments enable exposure therapy. Simulators developed explicitly for the use in psychotherapy are new in Brazil, and the combination of other behavioral therapeutic procedures (based on principles of behavioral analysis) besides de graduated exposure is rare even in the international literature (cf., Botella, Fernandez-Alvarez, Guillen, Garcia-Palacios, & Banos 2017; Opriş, Garcia-Palacios, Botella, Szamoskozi, & David, 2012). Therefore, assessing a new Brazilian simulator and a behavioral program that includes a virtual reality component is of central importance.

Virtual reality (VR) consists of a computer-generated environment that typically integrates

three-dimensional images, produced by 3D projection glasses or video eyewear, and three-dimensional sounds, provided by stereo headsets. The technology usually enables real-time tracking of navigation and other interaction and feedback devices integrated into a computer. These devices are essential to produce immersion and generate sense of presence.

Sense of presence is the feeling of being there in the VR environment, which involves operant responses (either public or private) maintained by their consequences, and reflex responses (either public or private) elicited by stimuli of the VR environment (Zacarin et al., 2017). In virtual reality exposure therapy (VRET) of fears and phobias, sense of presence is necessary for the manifestation of emotions, such as anxiety (Price & Anderson, 2007). Therefore, feeling sense of presence and anxiety in VR environments is necessary for the production of therapeutic results.

The present study focuses on the assessment of a new simulator and the evaluation of a behavioral therapeutic procedure in a clinical sample with acrophobia (fear of heights). Acrophobia is characterized by DSM 5 (American Psychiatric Association – APA, 2013) as a specific phobia of the natural environment subtype, related to excessive fear of situations involving heights, such as bridges, elevated walkways, stairs, elevators (particularly panoramic ones), balconies, and terraces of buildings. Fear of flying is generally related to acrophobia (Coelho, Waters, Hine, & Wallis, 2009). The anticipation of facing such situations produces typical anxiety-related responses, including tachycardia, sweating, tremors, and temporary numbness in parts of the body. When these situations cannot be avoided, the subject usually faces them with fear. Avoidance and escape behaviors from these situations are frequent and significantly hinder the daily routine, social life, and occupational functioning of the subject.

Exposure to situations/objects that provoke fear is a technique commonly used for the treatment of fears and phobias (Abramowitz, Deacon, & Whiteside, 2011). Zamignani (2001) suggested that exposure should be gradual, with repeated exposure to the feared stimulus. Exposure can be accomplished in the imaginary form, using videos, in vivo, and through VR. In contrast to in vivo exposure, exposure to VR scenarios allows the therapist to exert greater control over the stimuli presented to the client and maintains client privacy. Also, VRET procedures have lower rates of treatment discontinuation than in vivo exposure procedures (Wallach, Safir, & Barziv, 2009), and, according to Rothbaum, Garcia-Palacios, and Rothbaum (2012), it also appeals to younger generations because of their close contact with this technology.

VRET has limitations, like the possibility of errors in the system during exposure (Rothbaum et al., 2012) and the possibility of cybersickness, such as nausea, headaches, and blurred vision (Bruck & Watters, 2011). Exposure sessions should not be lengthened because of cybersickness increases during prolonged periods of exposure (Kennedy, Stanney, & Dunlap, 2000). However, habituation occurs, and cybersickness typically decreases with repeated VR exposure (Hodder & Howarth, 2008). Therefore, despite its limitations, VR can be used to treat different types of anxiety disorders in protected environments and is less harmful than in vivo.

To compare VRET and in vivo exposure therapy in the treatment of acrophobia, Emmelkamp et al. (2002) developed a study with thirty-three participants distributed in two groups. They underwent three one-hour sessions (sixteen participants received in vivo exposure, and seventeen received VRE). Exposure was gradual,

and the therapist gave verbal guidance and encouragement during the sessions. The results indicated statistically significant improvements measured by the *Attitude Towards Heights Questionnaire*, the *Acrophobia Questionnaire*, and the *Behavioral Avoidance Test* (BAT), maintained up to six months follow-up. VRET was as effective as in vivo exposure therapy since there were no statistical differences between the data of the two groups of treatment. This study and those developed by Coelho, Silva, Santos, Tichon, and Wallis (2008) and Krijn et al. (2004) reported similar results focused on exposure to the VR as the therapeutic procedure.

Besides focusing on exposure to VR, VRE frequently combines other psychotherapeutic procedures, such as cognitive behavioral therapy protocols (e.g., Braga et al., 2017). However, behavioral therapy procedures which emphasize functional analysis of behaviors (Skinner, 1953), as mentioned earlier, are hardly ever combined to VRE (cf., Botella et al., 2017). Functional analysis of behavior consists of identifying the relationships between antecedent and consequent environmental events, and the responses emitted by an organism, to predict and control behaviors. Combined with VRE, functional analysis improves the intervention strategy, allowing access to the coping behaviors during the exposure to the scenarios presented by the simulator and in everyday life (stimulus generalization).

Virtua Therapy is one of the first simulators developed in Brazil that is specific for therapeutic objectives and available on the Brazilian market. This study assessed this simulator with a clinical sample. It aimed to: (a) describe and evaluate a behavioral therapy procedure amplified by VRE for the treatment of fear of height, (b) record sense of presence and cybersickness generated during exposure to assess the Virtua Therapy simulator.

METHOD

Participants

Participants were four female psychology students aged 20 to 28 years. They reported previous experiences of fear of heights and, during the period of this study, were neither undergoing drug treatment for anxiety nor reported using illicit drugs. he exclusion criteria was reported labyrinthitis and the presence of neurological disorders, such as epilepsy. An announcement on a university website informed about the study. The experimenter who performed the therapeutic sessions had experience in functional analysis of behavior.

Material and apparatus

Virtua Therapy simulator developed by Oniria LD Software Ltda. presented the simulation. The simulator included Oculus RIFT®, a joystick, a headset, a Dell Inspiron 142640 notebook with a 1GB Nvidia Geforce dedicated video card. An Android cell phone and a Mindfield® eSense Skin Response biofeedback device measured the participant's galvanic skin response.

The VRE scenario consisted of a ten-story building under construction. The lower floors of the building were completed, and the upper floors were unfinished. The building had an internal central void running from the ground floor to the top floor. The interior of the building could be visualized from all floors from balconies, which provided access to the rooms on each floor. These balconies had protective parapets only on the lower floors (first, second, and third floors). Each room on the ground floor had all four walls, whereas the rooms on the upper floors (starting on the fourth floor) had no walls, only the supporting pillars. The building included two

operating elevators, one with sealed walls and a glass floor, which enabled the participant to observe the movement of the elevator from the shaft, and a freight elevator (with panoramic view), which allowed the observation of the landscape outside the building as it moved. A green line on the floor of the building guided the participant through the scenes.

Instruments and measurement

Acrophobia Questionnaire. This instrument evaluates fear/phobia of height. Developed by Cohen (1977), it contains (a) a list of situations involving heights and a scale between 0 and 6 used to indicate level of anxiety ranging from no anxiety (0) to extremely anxious (6), and (b) the same list of situations involving heights and a scale between 0 and 2 used by the participants to indicate whether these situations would not be avoided (0), might be avoided (1), or would be avoided (2).

Semi-Structured Interview Script. This script aimed to investigate the severity and context of fear/phobia. The script contained the following questions: (a) How long have you experienced fear of heights? (b) In what situations are you afraid of heights? (c) Do you confront these situations? (d) What do you feel in those situations? To what extent? (e) Do you believe that your fear of heights limits your daily routine?

Sense of Presence Inventory (SPI). This inventory was developed for this study and contained fourteen items that were answered using a Likert-type scale ranging from 1 to 5. Its objective was to evaluate sense of presence during the interaction with VR scenarios. Some items specify how the exposure occurred, i.e., whether the participants interacted with the VR scenario in the same way they would interact with a non-virtual scenario. Other items refer to the effect of the stimuli (virtual and non-virtual), i.e., whether the participant felt a greater sense of presence in the physical context around them than in the simulated scenarios. In scoring the items like these, the tabulation is such that a high score indicated a low sense of presence.

Simulator Sickness Questionnaire (SSQ). This questionnaire aimed to determine the occurrence of cybersickness during immersion in VR scenarios. Developed by Kennedy, Lane, Berbaum, and Lilienthal (1993), it includes sixteen items containing descriptions of conditions of discomfort (e.g., nausea and headache).

Recording sheet. A sheet of paper used to record daily occurrences (in the periods between sessions) in which the participants faced situations involving heights. The recording sheet required the following data: date, antecedent stimulus, participant response, and consequences of the emitted responses. This sheet provided data to perform the functional analysis of behaviors.

Procedure

Upon initial contact, the therapist informed the participants that they would take part in a study that included sessions with continuous exposure to heights stimuli. Those participants agreed to join in signing the free and informed consent form approved by the Research Ethics Committee of the third author's institution. Both assessment and treatment were free of charge. The experimenter instructed the participants to attend the sessions (held in a room of the psychology clinic) without deprivation of food or sleep (to decrease the likelihood of cybersickness). Then, the participants filled out the *Acrophobia Questionnaire* and underwent a semi-structured interview. After this, the therapist taught the participants diaphragmatic breathing exercises, to be performed during the intervention sessions. At the end of the session, the therapist delivered the recording sheet, and she

instructed the participants to report any episode that occurred in the period between the opening session and the first intervention session. She described how to fill out the recording sheet with examples of events that the participants reported.

Behavioral therapy. The procedure consisted of six individual sessions. A graded sequence of levels of height scenarios was created based on descriptions provided by the participants. The result of this hierarchy was similar among the participants because all of them reported similar levels of fear at greater heights, in places without protective parapets, and in elevators, particularly panoramic ones. At the beginning of each session, the therapist asked the participants about their well-being and inquired about the deprivation of food and sleep. After that, the therapist discussed and analyzed the episodes of fear of heights described in the recording sheet. If the participant did not deliver the recording sheet, the therapist inquired about the episodes reported in previous sessions and discussed them once more.

Before exposure, the therapist provided instructions depending on the scheduled session. The instructions for the first two sessions were:

> Enter the building under construction, which will be in front of you in the scenario. Note the green line on the floor. This line will prevent you from getting lost. In general, I would like you to explore the floors that you will be visiting today. In this context, exploring means looking through the windows and moving closer to the parapet of the balconies located at the void at the center of the building. Approach and look through the elevator shaft, which is open. Starting on the second floor, use this shaft to look at the floors below and the central void. Also, look through the windows to the city landscape and the trees outside the building. Look around and try to learn how to handle the joystick. Then, follow the green line on the floor and proceed to the first floor. When you reach this floor, I want you to do what I just said: Explore! Note that the staircase is open at the side, and I would like you to look down and observe the ground floor. Then, follow the green line again and proceed to the second floor. Explore this floor in the same way you explored the other floors.

In addition to the instructions, the therapist informed the participants that, if they began to feel anxious, they could stop moving through the scene and perform the diaphragmatic breathing exercise. Furthermore, if they started feeling very uncomfortable, they could request the interruption of the session. At this point, the therapist helped the participant put the electrodes of the biofeedback device on their fingers. The participant should perform the diaphragmatic breathing exercise three times. Subsequently, the therapist initiated exposure and stood beside the participant during each session.

The participant initiated exploring the VR from the outside of the building (Sessions 1 and 2) and subsequently visited the inside, moving to the first and second floors after exploring the ground floor. The therapist reinforced coping behaviors and offered encouragement by saying “Well done, keep it up” and other feedback responses to coping scenes of height. The therapist also encouraged the participant to stay on height scenes for a few seconds (five to seven seconds). The participants could spend as much time in each scenario as they needed for their anxiety to decrease; they could

progress at their own pace. To signal the end of the exposure, the therapist touched the shoulder of the participant and asked her to close the eyes for the removal of the Oculus RIFT®.

After the completion of the exposure, the therapist helped the participant with the removal of the apparatus and administered the *Acrophobia Questionnaire* and *Sense of Presence Inventory*. Then, the therapist initiated a dialogue with the following questions: How was visiting a virtual building? What did you feel? Did you do anything to feel less anxious? Describe what you did. During the dialogue, the contingencies experienced were analyzed, considering the events that occurred before and after the responses emitted in the virtual environment and how these events control and maintain the emitted responses. The therapist approved coping behaviors of height situations. After the session, the participants performed the breathing exercise three times. In the end, the therapist delivered a new recording sheet to be filled in before the next session.

In Sessions 3 and 4, after functional analyses of the data registered on the recording sheet, the therapist helped the participants to put on the apparatus and executed the same procedure as in session 2. Exposure began on the second floor where the staircase had no sidewalls, and continued to the third and fourth floor, including exposure to the elevator. The instructions for the latter two sessions were:

> When exposure begins, follow the green line on the floor and proceed to the third floor. Note that one of the sidewalls of the stairs is missing. I would like you to look through the windows and observe the landscape and the ground floor through the central void of the building. When you arrive at the third floor, do what you did on the other floors: Explore. Follow the green line again and enter the elevator. Note that the elevator floor is made of glass. I would like you to look down for a long as possible. When the elevator doors open, leave the elevator and explore the scenario. Note the presence of another elevator in the scenario, but I would like you not to use it at this time. Note that from this point on, the rooms do not have walls. Explore the scenario, approach the edge of the building slab and look at the city landscape and the ground below.

Exposure ended in the same manner as in the previous sessions, with the delivery of the questionnaires and recording of the VR experience. Sessions 5 and 6 had the same sequence of activities as in the earlier sessions. The participants were exposed to the scenario where they left off in the last session and visited the sixth and seventh floors and the panoramic freight elevator scenarios. The therapist gave the following instructions:

> Explore the floor where you stand. Then, follow the green line and move towards the freight elevator. Enter the elevator and look around and down as it moves. When the elevator stops, exit and explore the top floor. Note that it mostly lacks walls. Admire the city landscape and the trees below.

In the last session, the therapist delivered the *Acrophobia Questionnaire* and the other instruments. After that, the experimenter thanked the participants and instructed them to fill in the recording sheets and answer the *Acrophobia Questionnaire* one month and three months from that day and to send them to the therapist by e-mail.

RESULTS

In the initial interview, all participants reported having an excessive fear of heights and that these feelings worsened at comparatively greater heights and in elevators. The participants were unable to say at what point in their lives the fear of heights began, and that they often had to manage situations to avoid heights, but the fear behavior did not limit their daily routine. P1 reported that her fear of elevators was intense and that there were situations in which she used the stairs of a building to climb nine floors instead of using the elevator. P2 reported that she avoided balconies and high places in her house, as well as elevated walkways. P3 stated that she avoided changing light bulbs, climbing stairs, and crossing streets via elevated walkways. P4 reported that she avoided elevators, balconies, and stairs without protection and that her husband was also afraid of heights, so both avoided facing situations involving heights.

The everyday life behaviors described in the recording sheets were identified as a function of contingencies of positive and negative reinforcement. Generally, negative reinforcement maintained avoidance. In one case, secondary positive consequences reinforced the occurrence of fear: P4 reported that her husband approved (positive reinforcement) fear responses she exhibited. Other participants (P1, P2, P3) indicated that, by avoiding situations involving heights, they also eliminated tasks that they disliked and avoided feelings of discomfort and strong emotions elicited in situations involving heights (negative reinforcement). However, friends and significant others ridiculed the way they behaved towards such situations (punishment), which upset them.

As the VR sessions progressed, P1 and P2 reported that family members and friends began to encourage them to face situations involving heights. P2's boyfriend began to accompany her on elevated walkways and elevators and to praise her when she faced these situations. P4 reported that she began to realize how much her husband's fear influenced hers and that she was "transferring her fear of heights to her son," as she instructed him to avoid heights because they were dangerous.

In the first three sessions with VR exposure, the participants avoided height scenarios. Although they were explicitly instructed to approach the parts of the building that exposed them to heights, including windows and balconies, they did not contact them or approached them very slowly. As the sessions progressed, the frequency of avoidance of heights decreased, and approaching behaviors increased.

The therapist requested that the participant fill out the *Acrophobia Questionnaire* before and after treatment and in the one-month and three-month follow-up sessions. Higher scores specify greater fear or avoidance of situations involving heights. The top section of Figure 1 shows the distribution of the scores obtained in the first part of the questionnaire related to fear in different situations involving heights. The bottom section shows the distribution of scores of avoidance responses to conditions of heights. Participants' scores for fear decreased between pre-intervention and post-intervention measurements (top section of Figure 1). P1 shows the largest difference (reduction of 58%), and P2 the smallest difference (reduction of 26%). Also, the scores in the one-month follow-up decreased compared with the post-intervention scores for all participants (decreases of 72%, 70%, 59%, and 73% for P1, P2, P3, and P4, respectively). The scores in the three-month follow-up further decreased for P1, P2, and P3 (81%, 61%, 64%, respectively), whereas P4's score did not change compared with her one-month follow-up score. The avoidance response scores of all participants

decreased (lower part of Figure 1). The decreases were by 72%, 29%, 65%, and 84% for P1, P2, P3, and P4, respectively. The scores decreased by 70% and 82% for P2 and P3, respectively, in the one-month follow-up, but did not change for P1 and P4 compared with the scores for the questionnaire post-intervention. The comparison between the one-month and three-month follow-ups show that the score for P1 decreased by 33%, whereas the score for the other participants did not change.

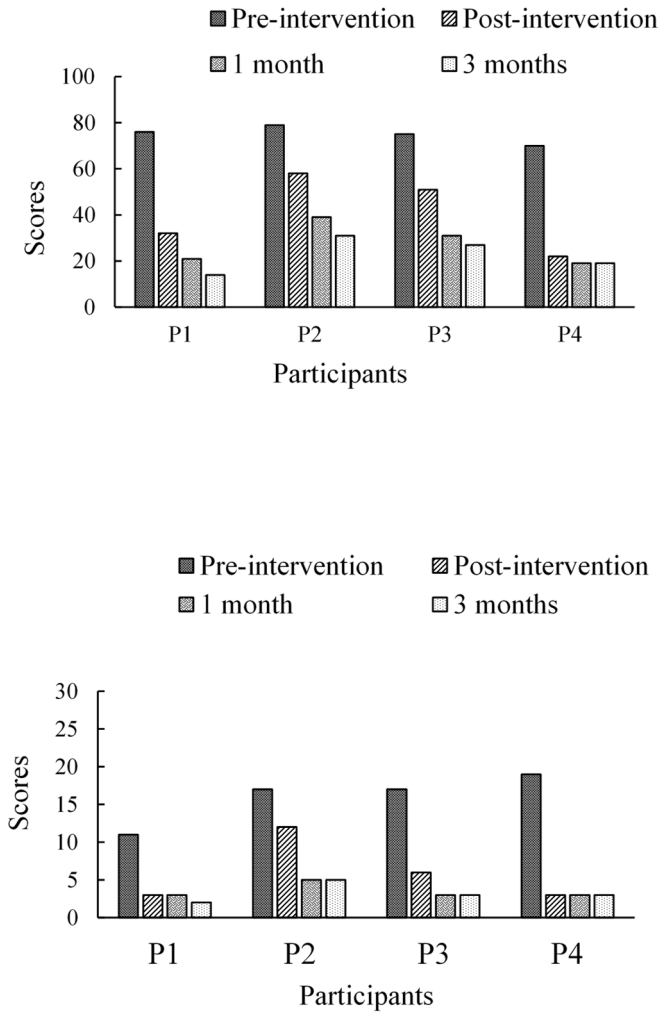

Figure 1. Distribution of acrophobia Questionnaire scores for fear of heights (top) and avoidance (bottom) in pre-intervention and post-intervention sessions and one- and three-month follow-ups.

Figure 2 shows the scores of the *Sense of Presence Inventory*, *Simulator Sickness Questionnaire*, and the variance of the galvanic skin response of each participant (calculated as the difference between the highest and lowest value divided by the highest value). The curves with the variance of the galvanic skin response indicate a downward trend during the sessions, despite the presence of peaks at different sessions. Except for P2 (whose Session 4 data was lost due to download failure), the scores in the last session were lower than those obtained in the other sessions. Some peaks occurred in sessions 4 and 5, in which the participants came into contact with situations of greater heights compared with Sessions 1 and 2. The *Simulator Sickness Questionnaire* data indicated that the score was highest in the first session and tended to decrease throughout the sessions. The exception was P2, who presented cybersickness more often in Sessions 3 and 5, in which the scenario involved greater heights compared with previous sessions.

The maximum possible score for the *Sense of Presence Inventory* was 60. For P1 and P2 (see Figure 2), the lowest scores were observed in the

first session (first contact with the VR technology), in which the participants walked on the ground floor to become familiarized with the technology and were exposed to small heights (windows) before moving to the second floor. P3 also showed low scores in the third session, in which she reported that the dark corners in this scenario resembled a video game that she had recently played. However, in Sessions 5 and 6, she reported a higher sense of presence scores. P4 described a lower sense of presence score in the second session, and she believed that it might be because she had taken a test that day and was slightly worried about it. The highest scores occurred in the last sessions (involving greater heights) for P1 and P4, in the third and fourth sessions for P2, and the second session for P3. In most of the sessions, sense of presence was above the intermediate value that would be a score equal to 30.

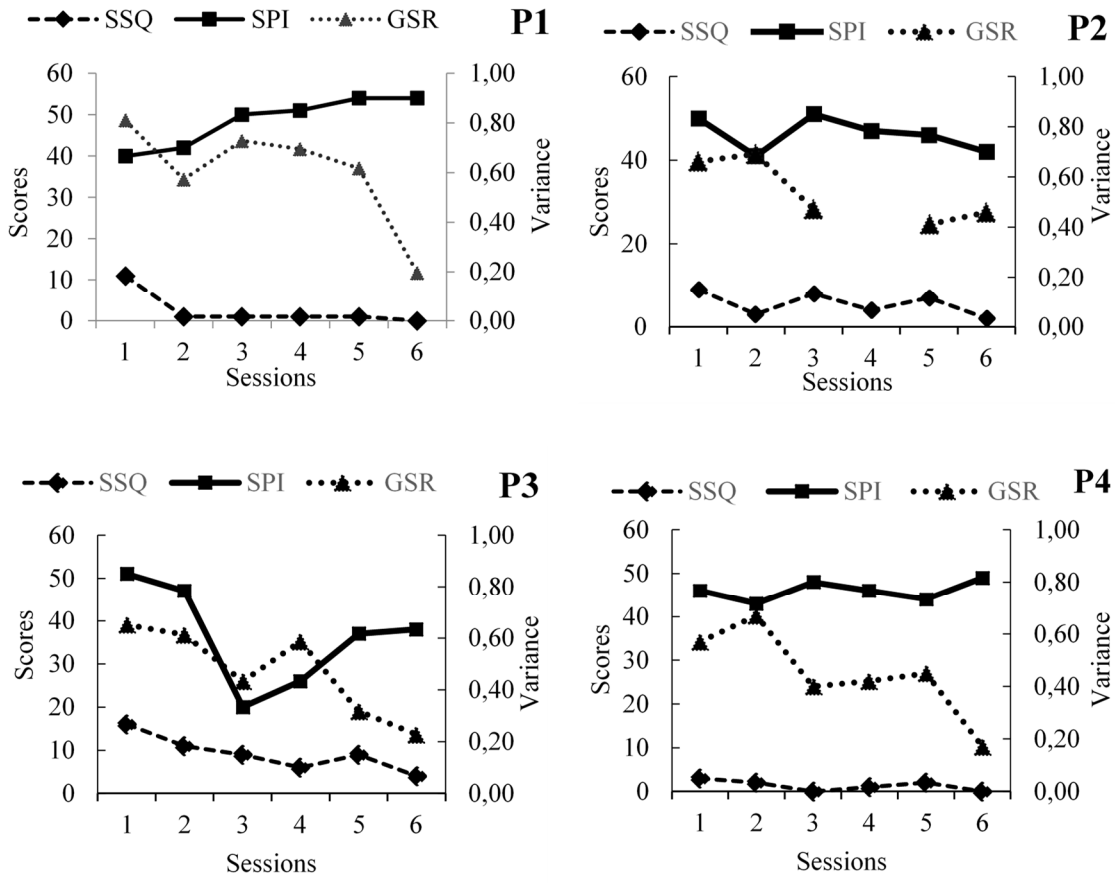

Figure 2. Distribution across the intervention sessions of *Simulator Sickness Questionnaire* (SSQ) and *Sense of Presence Inventory* (SPI) scores plotted on the left ordinate, and of the index of the variance of the galvanic skin response (GSR) plotted on the right ordinate. Due to technical problems, P2's GSR data from the fourth session were lost.

Figure 3 shows the distribution of the number of opportunities in which the participants had to face situations of height and the frequency of approaching behavior in the intervals between sessions registered on the recording sheet. P1 and P4 approached heights most of the time. P1 did not face any situation that occurred between Sessions 1 and 2, and P4 did not face any situation that happened between the initial session and the first intervention session. P4 stated that, because she was approaching height scenarios in a VR context, she believed she should also do so in a real-world setting and was putting that into practice. P3 faced all situations involving heights starting in the fifth intervention session. However, in the one-month follow-up, she reported that she had not approached a unique situation of the ten she encountered, and then she faced all conditions between the one-month and the three-month follow-ups. P2 reported facing four of the six situations she encountered. She stated

that she met very high places that she still feared, but in the three-month follow-up session she reported having approached situations involving heights that she had not previously approached, such as elevated walkways and stairs.

In the last intervention session, all participants reported that the functional analyses, VR exposures, reinforcements, and feedbacks were essential to decreasing frequency of avoidance behavior. They said that the VR scenarios were authentic. P3 and P4 indicated that VR exposure allowed them to acknowledge that their fear of heights was not as intense as they imagined. They believed that dangerous things could occur if they approached height situations, but that this had changed with VR exposure. At the follow-up reports, all participants described that their fear of heights had decreased and that they were exposing themselves to situations involving heights more frequently when the opportunities arose.

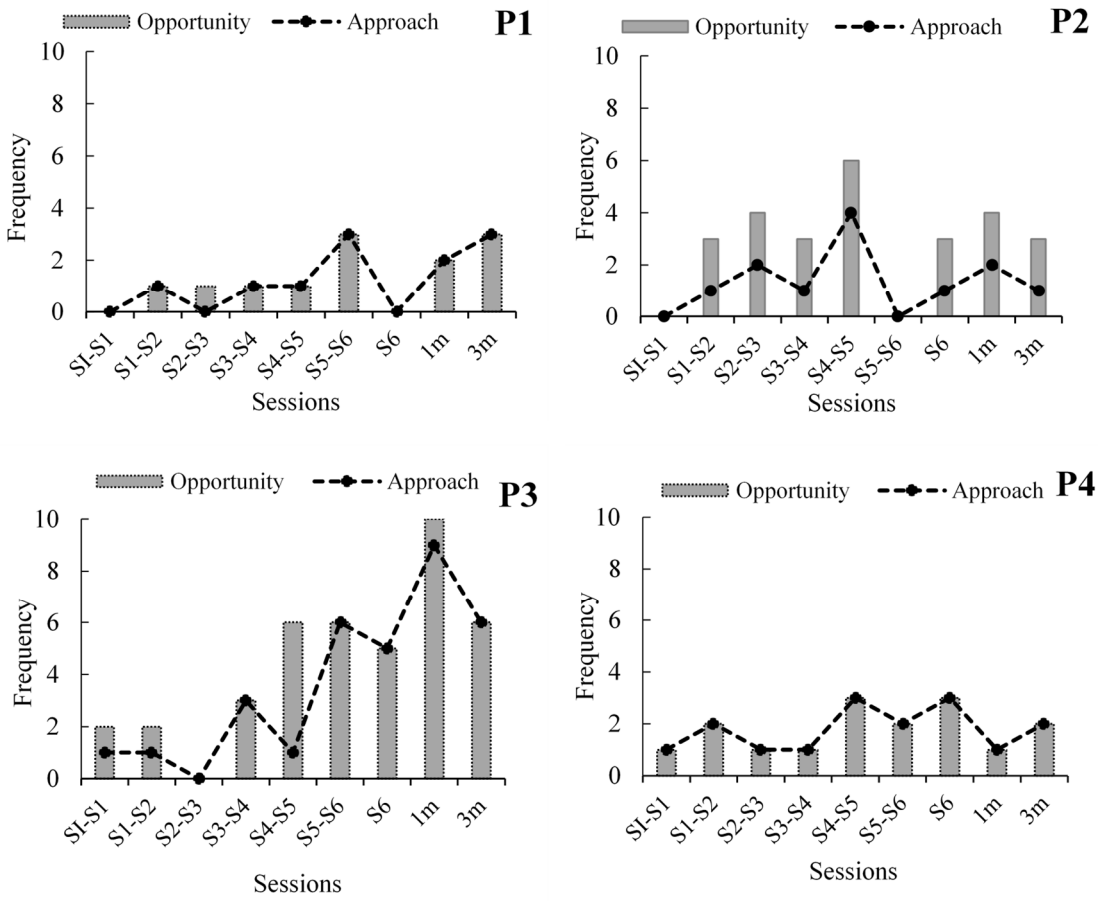

Figure 3. Distribution of the number of opportunities in which participants experienced situations of heights and how often they approached these situations on a daily basis, according to the data presented on the recording sheet. The records were made between the initial session (IS) and S1, S1, and S2, …, 1-month follow-up, and 3-month follow-up.

DISCUSSION

This study assessed a VR simulator with a clinical sample and aimed to describe and evaluate a behavioral therapy procedure combined to VRE for the treatment of fear of height. During the initial interview, all participants reported fear of heights and that they avoided height places as much as possible. They usually chose alternative routes that did not contain elevated walkways, asked for help when they needed to change light bulbs, avoided high stairs, and did not step onto balconies, among others. They also reported that their fear of heights did not interfere meaningfully with their daily routines, but that they wanted to overcome it.

Therefore, this fear cannot be classified as an anxiety disorder based on DSM 5 (American Psychiatric Association, 2013). However, it occurred with a frequency and intensity that justified therapeutic intervention based on the *Acrophobia Questionnaire*.

The fear intensity and avoidance frequency measured from self-reports (*Acrophobia Questionnaire*) showed a reduction of post-intervention scores and follow-up scores. These results corroborate those obtained by Coelho et al. (2008) and Krijn et al. (2004). Krijn et al. conducted 90-minute sessions, differing from the duration of the sessions of the present study, which lasted 10 minutes. However, even with much shorter exposure periods, it was possible to demonstrate the effectiveness of the exposure procedure. Further results (variance of the galvanic skin response) suggest that anxiety responses decreased during the intervention. The variance of the galvanic skin response curves indicates a downward trend during the sessions.

During exposure, the therapist encouraged and reinforced the participants to approach height scenes and stay there for a few seconds. The participants reported this was very aversive at the beginning. However, P1 mentioned that it was crucial for improvement and had encouraged her to face more situations out of the virtual context. This detail of procedure was similar to that of Coelho et al. (2008), which reposted that "VR treatment was determined to be at least as effective, if not more efficient that real-world exposure" (p. 212). A procedural difference of the present study compared with previous studies (e.g., Coelho et al., 2008; Krijn et al., 2004) was the functional analyses of behaviors, considering the relation between avoidance/approach responses and their antecedents and consequent events on daily life. This procedure allowed the analysis of contingencies related to fear of heights and was essential to identify the variables that controlled these behaviors. The identification of these variables enables the participants to modify the contingencies that controlled the avoidance and fear behaviors. For example, the participants reported that, initially, fear was intense and that they identified consequences in the situations involving heights that were not consistent with the consequences that could occur. After the intervention, P3 and P4 reported that they realized that their fear was not as intense as imagined and that facing these situations would not produce adverse consequences such as falling and getting hurt as they thought. Moreover, all participants reported that they began to face heights with less fear after the end of the exposure sessions, and this behavior continued upon follow-up.

The procedure performed in this study decreased cybersickness during VR exposure. Bruck and Watters (2011) found that this type of discomfort occurred in 60% to 80% of users of VR technologies. In the present study, this event occurred primarily in the first session, which involved the initial contact of the participants with the technology. The cybersickness score for P2 and P3 increased in the fifth session, with vertigo arising as the most common effect (both participants reported feeling slightly sleepy). However, these scores decreased in the sixth session. In general, the decrease in cybersickness scores was more pronounced after the third exposure session. Howarth and Hodder (2008) observed similar results, wherein cybersickness declined over the sessions, particularly after the fifth exposure session.

About sense of presence, except for P3, the lowest scores in the *Sense of Presence Inventory* were observed in the first session. P3 reported a lower sense of presence score in Sessions 3 and 4. She said

that such scene resembled a video game that she had played recently, but even so the scenario caused anxiety. Price and Anderson (2007) highlighted that sense of presence is an essential phenomenon since it is necessary that users feel anxiety in the intervention scenarios. The results indicate that the simulator used in this study produced sense of presence and that this might have contributed to the therapeutic effect of the exposure in reducing anxiety, as confirmed by the reduction in the variance of the galvanic skin response.

It is necessary to interpret the results of this study with caution because of some methodological limitations. First, the participants were from a clinical sample, so several details could not be controlled, including the fact that the participants were also exposed to the feared scenarios in the day by day situations – controlling this variable could be questioned from an ethical point of view. Second, a small number of participants and the lack of a control group reduced the external validity of the results. Third, we used the first version of Virtua Therapy, and specific scenarios of the simulator were relatively dark, resembling video game scenarios, and interfered with the sense of presence of at least one of the participants. Despite these limitations, the Virtua Therapy simulator was able to generate sense of presence and to decrease cybersickness with repeated exposure, which suggests that its use can be recommended for therapeutic interventions.

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