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Components of Presence and Reality Judgment as Predictors of Treatment Efficacy

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Abstract

This paper presents innovative data on the role of presence as a predictor of treatment efficacy using Virtual Reality (VR) exposure therapy. One hundred and seven people suffering mental disorders participated in this study. We analyzed the predicting role of various components of presence by means of the Presence and Reality Judgment Questionnaire. Our results indicated that "emotional involvement" and "influence of the quality of software in presence and reality judgment" were strong predictors of treatment efficacy. These results are relevant for the design of virtual environments in the field of VR therapy.

1. Introduction

In recent years, Virtual Reality (VR) has played an important role in clinical psychology, mainly as a tool for applying therapy in psychological treatments. VR allows the person to confront the feared stimuli in a more gradual and less threatening way than in reality. In this sense, VR has been used for the treatment of various psychological disorders such as anxiety disorders, eating disorders, addictive disorders, autism, and attention-deficit hyperactivity disorder, among others [1]. Because VR presents a number of potential applications, several works are being developed with the aim of studying which factors are responsible for its efficacy [2]. The authors appear to agree on the importance of the "sense of presence" which has been defined as "the sense of 'being there' in the virtual environment" [3]. In recent years, several authors have offered their own interpretations about what comprises a sense of presence, emphasizing different aspects of the experience [4-14]. Several assessment methods have appeared which reveal more about how this experience is produced.

Given the numerous approaches and definitions that have been formulated to explain the sense of presence in VR applications, there are various methods for evaluating whether the person has felt presence and has attributed reality to the experience in the virtual world. These instruments or measures are classified into both objective measures and subjective measures, including self-report instruments among the latest. The Presence and Reality Judgement Questionnaire (PRJQ) is a self-report measure developed by Baños, Botella, García-Placios, Villa, Perpiña, Alcañiz [15] which assesses not only the sense of presence experienced by the person in the virtual environment, but also the reality judgement. This term refers to the attribution of reality that the person makes about the environment that surrounds him/her. In the case of VR, this is the attribution of reality the person makes about the experience that he/she is having in the virtual world. In recent years, some studies have revealed the relevance of the reality judgement in the VR field [15-17]. The original questionnaire is composed of 77 items and the person responds in a Likert scale ranking from 0 ("I don't agree") to 10 ("I totally agree"). The items included are based on other questionnaires available in the literature.

The first validation of the questionnaire [15] was conducted with university students who did not present psychological problems. The second validation was done with clinical and subclinical populations [16]. In these studies, we observed that the characteristics of the sample groups influenced the structure of the factors. For example, for participants belonging to clinical and subclinical populations, emotions played an important role in their attribution of reality to the virtual environment. The virtual environments we used provoked emotions in the participants, and the items of the questionnaire related to emotional involvement were the most relevant. These results indicated that in order for specific clinical populations to feel present in a virtual environment, the environment must be able to evoke emotions. Therefore, it is important to consider this requirement in designing effective virtual applications for psychological treatment.

The only known work which analyzes the role of the sense of presence in therapeutic efficacy is the study conducted with an acrophobic population by Krinj, Emmelkamp, Biemond, de Wilde de Ligny, Schuemie, van der Mas [2]. In this study, they hypothesized that different devices would produce different degrees of presence. In order to induce a sense of presence, the authors used either a head-mounted display (HMD) (low presence according to the authors) or a computer automatic virtual environment (CAVE) (high presence according to the authors). However, no differences were found in effectiveness between VR exposure using HMD or CAVE. However, it may be that no differences in the therapeutic efficacy were found because the different devices did not produce different subjective levels of presence, despite their more or less immersive qualities. As previously mentioned, the data obtained by our group have showed that in populations with psychological problems, the capability of the environment to induce emotions may be more important than the degree of immersion of the system.

The aim of the present work is to analyze the relationship between sense of presence and therapeutic efficacy from a different perspective. The present study investigates the relationship between a self-report measure (PRJQ) and treatment therapeutic efficacy. We analyzed several therapeutic protocols that use VR as the exposure method in order to determine the predictive capability of therapeutic success involving the subjective measure of presence.

Our hypothesis is that the PRJQ will predict the therapeutic efficacy of treatment in several therapeutic protocols that use VR as the exposure method. We expect to find that factors related to emotions will have a higher predictive capacity of improvement. In order to test this hypothesis a regression analysis will be conducted, the independent variables being the factors of the PRJQ and the dependent variables being several measures of improvement after treatment. Specifically, these measures include the differences in the scores obtained for fear and avoidance of the main target-behavior before and after treatment, and the differences in the scores obtained for the specific questionnaire related to each of the psychological disorders.

2. Method

2.1. Participants

The sample was composed of 107 participants; 91 came from the Emotional Disorders Clinic at Jaume I University and 16 came from Washington University. The Spanish participants came to our clinic to seek psychological treatment: 13 of them had claustrophobia, 18 had flying phobia, 18 suffered from eating disorders, 6 presented acrophobia, 15 had panic disorder with agoraphobia, and 21 had small animal phobia (mice, cockroaches or spiders). All participants met DSM-IV criteria [18] for these disorders. The remaining 16 participants from Washington University came to seek help for spider phobia. All participants fulfilled the PRJQ after the first VR exposure treatment session.

2.2. Measures

- *Informed consent* to participate in this research study.
- *PRJQ* [16]. For this study we used a reduced version with 57 items, grouped into 7 factors: Emotional Involvement Reality Judgement and Presence, Interaction and External Correspondence, Influence of the Quality of the Software in the Reality Judgement and Presence, Software Ease of Use, Satisfaction with the Experience, and Attention.
- *Target Behaviors*, adapted from Marks & Matthews [19]. All participants assessed their levels of fear and avoidance in the feared situations related to their problem (0 = "No fear at all/I never avoid" to 10 = "Severe fear/I always avoid").
- *Claustrophobia Questionnaire* [20].
- *Acrophobia Questionnaire* [21].
- *Flying Phobia Questionnaire* [22].
- *Fear of Spider Questionnaire* [23]. For the assessment of cockroach and mice phobias, adaptations of this questionnaire (in which all items were referred to either as cockroaches or mice) carried out by our group were used.
- *Fear of Public Speaking Questionnaire*. Our group developed this questionnaire from the Fear of Public Speaking questionnaire by Bados [24].

2.3. Virtual reality environments and hardware

We used the following virtual environments developed by our research group:

Claustrophobia Virtual Environment: This VR program included three scenarios. The first was a 4 x 5 meter room in which the user could walk and interact with different objects. There was a big window that could be opened and closed in three steps, with a blind which could also be raised and lowered. One door led to a terrace and the other one provided access to the second scenario; this consisted of a smaller, empty room with no furniture and no windows, in which the person could walk and open and close the door. The person could make this room gradually smaller by moving one of the walls in three steps. It was also possible to block the door [25]. The third scenario was a 1 x 2 meter elevator. In the beginning, it was at the ground floor with the door open; when the person entered the elevator, the doors closed and he/she could decide which floor to go to. While the elevator was going up or down, a technical problem could be introduced by the administrator. The administrator could also alter the size of the elevator, making it smaller by gradually moving one of the walls in three steps [26].

Acrophobia Virtual Environment: This VR program consisted of two scenarios. The first one was a 32 story skyscraper located on a street with other skyscrapers. Once the user was inside the building, he/she could access to the different floors by using an elevator. The person could choose which floor to go to depending upon his/her fear. Upon arrival at the chosen floor, the user entered an apartment. In this apartment the user could access the balcony and look over the handrail that the clinician could gradually lower. Once the patient had overcome the fear of looking over the balcony from that floor, he/she could access a higher floor. As the patient got higher, the views over the balcony became more beautiful and the traffic noise decreased. The second scenario was an amusement park with a Ferris which the patient could ride. Once inside, the clinician could start the Ferris wheel and could control where the patient's chair would stop, including the highest point; the clinician could also simulate technical problems.

Body Image Virtual Environment: This environment consisted of five scenarios. The first was a kitchen with a virtual scale into which the actual weight of the patient was programmed. After eating some food in the kitchen (pizza, hamburger, salad, an apple), the patient weighed herself and estimated her new weight. The second scenario was a room in which photographs of people (male and female) with different body shapes were presented. In this scenario, the user was asked to estimate the weight of the people who appeared in the photographs. The third scenario was a room with two mirrors. In the first one, a 3D figure with the real dimensions of the patient was shown. In the second mirror, the patient could see the same figure; however, the figure was transparent and could be altered by the patient (by increasing or diminishing the size of some parts of her body). In this way, the user could compare how she perceived her figure with the real dimensions of her body. The fourth scenario was composed of a door covered with different color bands behind which the patient's real figure was shown. Finally, the fifth scenario consisted of a room with a big mirror where different body figures could be found: "How I am", "How I would like to be", "How I think a significant person sees me", and "My healthy figure" [27].

Flying Phobia Virtual Environment: This environment consisted of three scenarios. The first one was a hotel room in which the user could pack a suitcase in preparation for a flight; the user could also turn on the radio and listen to the weather forecast. In this scenario the time of day (day or night) and the weather (good or bad) could be manipulated. The second scenario consisted of an airport where the user could see the flight information panel, walk around, look at other planes taking off and listen to other people's conversations about flying and the weather conditions while waiting for the flight. In this scenario the therapist could also manipulate time of day and weather conditions. The last scenario consisted of the inside of a plane, where the user could experience taking off, flying and landing. The patient could read a magazine or listen to the radio during the flight. Again the therapist could manipulate the weather conditions and simulate turbulence [28]

The *hardware* used to apply all the VR programs consisted of a Pentium III computer, 450Mhz, 128 Mb RAM, with a Riva graphic card TNT2 with 64 Mb RAM. Also used was a windows NT/2000 operative system, a head mounted display of medium quality *Head Mounted Display (V6 de Virtual Research)*, a 2D *joystick* and a standard mouse.

Small Animal Phobia Virtual Environments:

The virtual environment used in the USA was *SpiderWorld*. This consisted of a kitchen where the users could walk and open doors and cupboards. While the person interacted with objects in the kitchen, a spider appeared. The patient thus confronted the fear until he/she could finally interact with the spider, chase it, touch it and make it get out of a vase. The hardware used consisted of a Silicon Graphics Octane MXE with option Octane Channel and a Wide vision field, an HMD (Division dVisor) and a Polhemus Fastrack traction system.

The virtual environment used in Spain for cockroach, spider and mice phobias also consisted of a kitchen, but the immersion in this scenario was created without an HMD. First, the person had to approach the small creature (cockroach, spider or mouse depending on the phobia). The number of creatures could be increased as the patient advanced in the treatment. The next objective, once the anterior was overcome, was to find and approach the creature. Their size could also be altered (small, medium and large) according to the patient's progress. The third and last objective for the patient was to find and kill the different small creatures. In this case the difficulty increased according to their size [29]. The hardware used to run this program was the same described for the VR programs above.

2.4. Results

A linear regression analysis (using the successive steps method) was applied in order to analyze the ability of the PRJQ factors to predict therapeutic improvement. This allowed us to examine whether the sense of presence and the reality judgement experienced by the patients in the virtual environments could predict treatment efficacy. The independent variables included the seven factors of the questionnaire for the total sample. As for the dependent variables, we used the difference between the scores obtained before and after treatment in the degree of fear and avoidance regarding to the main therapy target-behavior. We also used the difference between the scores obtained before and after treatment in the specific questionnaire related to each patient's problem.

Considering the degree of fear and avoidance as dependent variables, in both cases we obtained the fourth factor as a predictor variable, i.e. "*Influence of the Quality of the Software in the Reality Judgement and Presence*" ($R^2 = 0{,}059$, $t = 2{,}69$ $p<0{,}05$) and ($R^2 = 0{,}1$, $t = 3{,}37$ $p<0{,}05$), respectively. When considering the score obtained by the participants in the specific questionnaire as the dependent variable, we obtained two predictor variables: again, the fourth factor, i.e. "*Influence of the Quality of the Software in the Reality Judgement and Presence*" and the first factor, i.e. "*Emotional Involvement*".

In addition to the regression analyses, a discriminant function analysis was conducted using the steps inclusion method. For grouping variables we used the same ones as in the regression analysis. For the fear and avoidance of the target-behavior variables, the sample was divided into two groups. Group 1, named "Non responders", included those patients whose differences in the scores from pre- to post-treatment in both clinical variables were less than 3 points; we assumed they did not experience a significant change in their problem after treatment. Group 2, named "Responders", was composed of those patients whose differences in scores from pre- to post-treatment were higher than 3 points. With regard to the score in the specific questionnaire, the sample was divided into the same two groups: "Non responders" and "Responders" to treatment. In this case, since the total score of the questionnaires was different, the improvement in the scores obtained for the instruments was measured by calculating percentages. Group 1 included patients whose improvement in the questionnaire score was less than 20%, and Group 2 included those patients whose improvement was higher than 20%.

The aim of this analysis was to test whether the factors included in the PRJQ would differentiate between the aforementioned groups in each one of the clinical variables. Results showed that the fourth factor, "*Influence of the Quality of the Software in the Reality Judgement and Presence*", resulted in differentiation between both treatment improvement groups if we considered the degree of fear and avoidance related to the main target-behavior as a sign of that improvement. The factor "*Emotional Involvement*" differentiated both groups when the score in the specific questionnaire was considered as an improvement variable.

Regarding the fear of the main target-behavior, the discriminant function that reached statistical significance was: $\lambda = 0{,}96$; $\xi^2 = 4{,}18$, $p<0{,}05$ and the canonic correlation was 0,21. Factor 4 classified 67,7% of the cases correctly. Specifically, it correctly grouped 95,2% of "responders" and 12,9% of "Non responders" to treatment. These results are presented in Table 1. As for avoidance of the target-behavior, the discriminate function we obtained was: $\lambda = 0{,}95$; $\xi^2 = 4{,}52$, $p<0{,}05$ and the canonic correlation 0,22. Factor 4 correctly classified 74,2% of the cases, specifically, 97,1% of "responders" and 4,3% of "Non responders" to treatment (see Table 1). Finally, regarding the score in the specific questionnaires, we obtained the following discriminant function: $\lambda = 0{,}90$; $\xi^2 = 9{,}28$, $p<0{,}05$. In this case, Factor 1 of the PRJQ classified 69,6% of the cases correctly and was also better at classifying "Responders" to treatment (89,7%) than "Non responders" (35,3%) (see Table 1).

Degree of fear	**Number of cases**	**Correctly classified**
"Responders"	62	59 (95,2%)
"Non responders"	31	4 (12,9%)
Degree of avoidance	**Number of cases**	**Correctly classified**
"Responders"	70	68 (97,1%)
"Non responders"	23	1 (4,3%)
Specific questionnaire	**Number of cases**	**Correctly classified**
"Responders"	58	52 (89,7%)
"Non responders"	34	12 (35,3%)

Table 1 Discriminant function classification

3. Discussion

Regarding the capability of the PRJQ to predict treatment therapeutic efficacy, it could be predicted by the factor "*Influence of the Quality of the Software in the Reality Judgement and Presence*", including the extent to which the sounds and the quality of the sounds and images in the virtual world influenced how real the experience seemed to the user and helped the user feel present in the virtual environment. This was true both in cases which considered the degree of fear and avoidance related to the main target-behavior as dependent variables and in those which considered the score obtained in the specific questionnaires as dependent variables. Moreover, when we consider the score in the specific questionnaires as a dependent variable, the effectiveness of the virtual environment in evoking emotions in the patient is also a predictor of therapeutic improvement.

Therefore, although the formal characteristics of the environment are not significant enough to produce presence in a clinical population, the elements included in the virtual environment (sounds, images) and their quality seem to be key aspects for the user feel present in the virtual world and attribute reality to the experience. Besides, and according to our results, they seem to play an important role in the effectiveness of the VR treatment. It is also crucial for the patient to feel emotions in the virtual environment during the treatment sessions. This is the result we expected; the clinical participants included in this sample received treatment for specific phobia, eating disorders or agoraphobia. Through VR environments, each patient was confronted with her/his feared situation and, therefore, it was necessary that the virtual environment provoke anxiety in the patient for the treatment to be effective.

In summary, both the quality of the software's images and sounds and the fact that the patient experienced emotions during the VR therapy sessions predict good treatment results.

As for the capacity of the PRJQ to discriminate between the two groups of the sample (divided according to therapy success), our results are similar to those mentioned in the anterior hypothesis. The fourth factor, "*Influence of the Quality of the Software in the Reality Judgement and Presence*", differentiates the groups if we consider improvements in the scores obtained by the patients in the level of fear and avoidance of the main target-behavior. The first factor, "*Emotional involvement*", also differentiates the groups if we consider the scores obtained in the specific questionnaire to assess each problem as a sign of improvement. Therefore, we observe that those components of presence that predict therapeutic efficacy are the same as those that accurately classify the sample when divided according to the improvement achieved after treatment. However, we can also conclude that although the total number of cases correctly classified in the three analyses is high (67,7% in the first, 74,2% in the second and 69,6% in the third), in each case the higher percentage of participants correctly classified belongs to the "Responders" group (those who improved after treatment).

These results indicate that the quality of the software and the evocation of emotions are important cases of change. That is, if the quality of the images and sounds helps the patient to feel present in the virtual environment, and if the person feels emotions during the therapy sessions, we can ensure treatment effectiveness. However, the absence of high quality software or the lack of patient emotions does not mean that the treatment will necessarily fail. The quality of the software and the presence of emotions are not the only factors that have an influence in the therapeutic efficacy. Rather, there must be additional variables that help guarantee therapeutic success.

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