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The role of presence in the level of anxiety experienced in clinical virtual environments

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ABSTRACT

Recent reviews point towards that Virtual Reality Exposure Therapy (VRET) can be an effective medium to provide exposure therapy for anxiety disorders. The concept of presence, usually defined as the sense of being inside the virtual environment, has been considered the principal mechanism that leads to the experience of anxiety in clinical virtual environments. The present study sought to examine the relationship between sense of presence and in-session anxiety in a sample of 210 students showing high and low test anxiety when exposed to both clinical and non-stressful virtual environments. This is the largest study conducted to date with the aim of examining the relationship between presence and anxiety in clinical virtual environments, and the first to explore separately the relationship between presence and state-anxiety in phobic and non-phobic participants. The results suggest that presence was not related to anxiety in a non-stressful environment. It was also found that although presence is related to anxiety in both groups of students when exposed to clinical virtual environments, this relationship was clearly stronger for high test anxiety students. This line of research will broaden our understanding of the mechanisms that lead to the efficacy of VRET.

1. Introduction

1.1. Sense of presence in Virtual Reality Exposure Therapy

Recent reviews point towards that Virtual Reality Exposure Therapy (VRET) can be an effective medium to provide exposure therapy for anxiety disorders (Krijn, Emmelkamp, Olafsson, & Biemond, 2004; Powers & Emmelkamp, 2008). Controlled studies suggest that compared to imaginal exposure, VRET produces better outcomes for fear of flying (Wiederhold, Gervitz, & Spira, 2001) and agoraphobia (Vincelli et al., 2003). Promising results also show that VRET is as effective as exposure in vivo (the gold standard for phobia treatments) for acrophobia (Bullinger, 2005; Emmelkamp, Bruynzeel, & Van Der Mast, 2001; Emmelkamp et al., 2002), agoraphobia (Botella et al., 2004; Choi et al., 2005) and fear of flying (Anderson et al., 2006; Rothbaum, Hodges, Anderson, Price, & Smith, 2002; Rothbaum, Hodges, Smith, Lee, & Price, 2000; Rothbaum et al., 2006). In many other non-controlled studies, VRET appears to hold some promise as a valuable treatment form for arachnophobia (García-Palacios, Hoffman, Carlin, Furness, & Botella, 2002), Post-Traumatic Stress Disorder (Rizzo et al., 2009), Social Phobia (Anderson, Zimand, Hodges, & Rothbaum, 2005) and Claustrophobia (Botella, Baños, Villa, Perpiña, & García-Palacios, 2000). However, in spite of these positive results, more randomized, controlled studies are needed to establish firm conclusions on the effectiveness of VRET. In a recent meta-analytic studio conducted by Parsons and Rizzo (2008) the authors concluded that although VRET appears as an effective exposure technique, more research is still needed using greater sample sizes (with a minimum size of 30 patients). The authors also claimed for a consensus behoove research groups regarding variables that can mediate and moderate the success of this type of treatment. Precisely, as recommended by Parsons and Rizzo (2008) in the present study we used a large sample composed by 210 subjects to facilitate quantitative assessments. Our study is also focused to examine one of the potential moderator variables that Parsons and Rizzo (2008) proposed that may play a role in the successfulness of VRET: the sense of presence.

The utility of virtual reality as an exposure tool rests on the fact that virtual environments (VE) can induce anxiety responses (Alsina-Jurnet, Carvallo-Beciu, & Gutiérrez-Maldonado, 2007). This means that habituation and extinction processes can occur through the gradual, repeated and systematic exposure to these VE.

In the literature the construct of presence has been considered the principal mechanism by which virtual reality is effective as an exposure technique (Wiederhold & Wiederhold, 2005). The concept of presence is very broad, and has a variety of definitions

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and meanings. Some researchers (see, for example, Nowak & Biocca, 2003; Youngblut, 2003) distinguished between different types of presence. Co-presence can be defined as "the subjective experience of being together with others in a computer-generated environment, even when users are physically situated in different sites" (Youngblut, 2003). Social presence occurs when people feel that the interface of a given medium is able to provide some sense of access to another mind (Nowak & Biocca, 2003). But in the most common usage within the VR community, the concept of presence is derived from the term Telepresence (Minsky, 1980). In this case presence is usually defined as the "feeling of being in a world that exists outside the self" (Riva, Waterworth, & Waterworth, 2004) or as the sense of "being there", in a mediated environment (Steuer, 1992). Precisely, in the present study we will use the concept of presence in this last sense.

Most researchers agree that presence comprises three components ("the Big Three" of physical presence; Takatalo, Nyman, & Laaksonen, 2008): the ability of the VE to induce a sense of spatial awareness in the user (*Sense of Physical Space*), the attention devoted to the VE (*Engagement/Involvement*) and the participants' sense of believability and the realism of the content (*Ecological Validity/Realism*). The principal consequence of this illusion is that a user can experience the same emotions and reactions within a VE as would be expected in a similar real-world situation (Hodges et al., 1994). This suggests that presence may be related to the amount of anxiety that patients experience while immersed in clinical virtual environments. If patients are unable to involve themselves in a virtual world they cannot experience relevant emotions, and the desired processes of habituation and extinction will not occur. This implies that some degree of presence is needed in order to experience anxiety during virtual reality exposure. Despite the large amount of theoretical speculation, little research has been carried regarding the relationship between sense of presence and the level of anxiety experienced in clinical VE.

1.2. Presence and anxiety

The first study to examine the relationship between sense of presence and anxiety was conducted by Regenbrecht (Regenbrecht, Schubert, & Friedman, 1998). Thirty-five non-phobic participants were exposed to a virtual environment that simulated a cliff 8 m high. A correlational analysis failed to show a significant relationship between presence and state-anxiety. However, a multiple regression analysis with experienced fear as the dependent variable and presence, trait acrophobia and avoidance behavior as predictors revealed that sense of presence was the best predictor of in-session anxiety. Moreover, a second regression analysis that included trait acrophobia, avoidance and two sub-dimensions of presence (one mainly related to the attention devoted to the VE, and the other related to the mental construction of the virtual space) as predictors revealed that only the second presence factor (Spatial Presence) contributed significantly to the regression equation, whereas the attention devoted to the virtual environment was shown to be insignificant. These results provided some evidence that sense of presence (especially the sense of being physically located inside the VE) can determine, in part, the level of anxiety experienced within a VE. Schuemie (Schuemie et al., 2000) examined whether or not presence was related to anxiety in a clinical sample of 10 acrophobic patients. Phobic participants were exposed to three virtual environments involving height situations (a roller coaster, a swimming pool with a diving tower and a glass elevator). Although a significant correlation between presence and anxiety was found, there was no correlation between reduced levels of acrophobia at the end of treatment and sense of presence or the fear experienced in the VE. However, this study has a number of limitations, such as a small sample and the fact that the questionnaires used to evaluate presence and fear were not well validated.

Regardless of these methodological issues, the differences between the studies conducted by Schuemie et al. (2000) and Regenbrecht et al. (1998) could be due to the type of sample used (non-phobic vs. clinical sample). There is no reason to assume that high presence is related to high levels of anxiety in non-phobics, as occurs in the real world they may feel detached, bored or uninterested when confronted with VE. As stated by Slater (2003) the hallmark of presence is a behavior that is congruent with those expected in a similar real-world situation.

In contrast to these studies, Robillard (Robillard, Bouchard, Fournier, & Renaud, 2003) examined the relationship between sense of presence and anxiety in a sample that pooled both phobic and non-clinical participants. Thirteen patients diagnosed with specific phobias were exposed to various virtual environments derived from computer games and which contained phobogenic cues related to their own fears (either heights, spiders or enclosed spaces). The type of VE for each of the 13 non-phobic participants was determined by the specific phobia of the phobic patient with whom each of them was paired. A series of regression analyses showed a strong synergistic relationship between sense of presence and anxiety, suggesting that increases in presence enhance anxiety, and vice versa. Interestingly, the results also showed that phobic participants reported higher levels of presence than did their non-phobic counterparts (especially in the degree of realism attributed to the virtual environments). However, this study presents serious methodological limitations. First, the relationship between presence and anxiety was evaluated through self-report questionnaires that were administered concomitantly during and after immersion in the virtual environments, which may have inflated the weight of the relationship. Second, the authors combined the groups of phobic and non-phobic participants when examining the relationship between presence and anxiety. Since the relationship between the constructs studied could be different for the two types of participants, it would be of interest to analyse the results separately. Similarly, in a study conducted to evaluate the behavioral avoidance dynamics of people facing anxiety-provoking situations, Renaud (Renaud, Bouchard, & Proulx, 2002) pooled the results of phobic and non-phobic participants in order to determine the relationship between presence and state-anxiety. Twelve spider-fearful and 11 non-fearful subjects were exposed to a virtual environment consisting of a red background in which a virtual stimulus appeared (a virtual tarantula or a neutral stimulus represented by a grey sphere). The participants were instructed to track visually the virtual stimulus presented. As reported by Robillard et al. (2003) the results suggested a relationship between presence and anxiety. The involvement/control subscale of the Presence Questionnaire (PQ) was positively correlated with the anxiety experienced during virtual exposure, suggesting that the greater the attention devoted to the VE, the greater the level of anxiety felt. Arachnophobic individuals also reported higher scores on the involvement/control subscale of the PQ than did non-fearful subjects. Although not conclusive, this result suggests that emotion could influence the amount of attentional resources directed to a virtual stimulus, supporting the idea that phobic individuals experience virtual environments in a different way than non-fearful subjects.

Krijn evaluated the relationship between presence and anxiety in the context of two controlled treatment studies. In the first, (Krijn, Emmelkamp, Biemond et al., 2004) 24 acrophobic patients were randomly assigned to either a high or a low presence treatment group. The patients assigned to the high presence condition were exposed to virtual environments through a Computer Automated Virtual Environment (CAVE) system, while subjects in the low presence condition wore a Head Mounted Display (HMD).

Participants in both groups were exposed to four virtual environments related to heights (shopping mall, fire escape, roof garden and a building site). The results showed that sense of presence was higher for the high presence group, although no relationship was found between presence and state-anxiety in any of the treatment sessions. Moreover, presence had no direct effect on treatment effectiveness. Despite these negative results the authors found an interesting relationship between low levels of presence and treatment drop-out. Indeed, one of the principal limitations of VRET is the relatively high number of drop-outs, which can account for around 25% of patients (Emmelkamp et al., 2002; Kahan, Tanzer, Darvin, & Borer, 2000; Krijn, Emmelkamp, Biemond et al., 2004; Mühlberger, Herrmann, Wiedemann, Ellgring, & Pauli, 2001; Mühlberger, Wiedemann, & Pauli, 2003; Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001; Rothbaum et al., 2002). In the second treatment study, Krijn (Krijn, Emmelkamp, Olafsson, Schuemie, & Van der Mast, 2007) evaluated the relationship between self-reported presence and anxiety in 26 acrophobic patients. In line with the previous study no relationship was found between presence and subjective anxiety. Unfortunately, the authors provide no data about the role of presence with respect to treatment success.

As part of a broader study that sought to test the effectiveness of virtual reality as an exposure technique for fear of flying, Price (Price & Anderson, 2007) examined the relationship between phobic anxiety, presence and in-session anxiety. In this case, a clinical sample of 36 fearful flyers was exposed to a virtual plane. The authors found a linear relationship between self-reported presence and the amount of anxiety. More interestingly, a series of regression analyses showed that presence mediated the relationship between trait anxiety (degree of phobia) and in-session anxiety. Those subjects with greater phobic anxiety experienced more presence, which in turn led them to experience higher levels of anxiety. In partial support of this idea, presence was also found to be associated with the number of phobic elements contained in the virtual environment. Finally, and in line with the results reported by Krijn, Emmelkamp, Biemond et al. (2004) and Krijn et al. (2007), the authors failed to find a relationship between the level of presence experienced within the virtual environment and the effectiveness of the VRET. In contrast to these results Bouchard (Bouchard, Robillard, & Dumoulin, 2006) found that when assessed regularly during VR therapy sessions, presence can predict treatment outcome. However, despite this isolated positive result, it seems that while presence is needed to experience anxiety it is insufficient in itself when it comes to obtaining positive treatment benefits. It is likely that an effective treatment requires not only the emotional activation of the patient, but also the habituation and extinction of the anxiety response.

In summary, the empirical results of research that has examined the relationship between presence and anxiety are inconclusive: while some studies report a positive relationship others have not found this. Unfortunately, these studies suffer from serious methodological limitations that make it difficult to draw firm conclusions. Future research must therefore make use of large samples and well-validated questionnaires based on more than a single item.

The few existing studies also fail to evaluate separately the responses of phobic and non-phobic individuals. In most research the sample was entirely composed of phobic patients, whereas in the only two studies in which the sample comprised both phobic and non-clinical participants the results were pooled. Thus, the possible differences between phobic and non-clinical individuals remain poorly understood. Furthermore, additional studies that examine independently the relationship between the constructs of presence and anxiety in both clinical and non-clinical samples are needed. It is likely that only in phobic individuals is the illusion of "being there" related to the experience of distress and anxiety while immersed in clinical VE.

In this regard, it should be noted that most studies take no account of the multi-dimensionality of the presence construct, and when this is done the results are inconsistent. Regenbrecht et al. (1998) found that *Physical Presence* but not *Involvement* could predict the level of anxiety, whereas the results reported by Renaud et al. (2002) suggested that *Involvement* but not *Physical Presence* was related to anxiety. Thus, there is a need for statistically and methodologically sounder studies with larger samples sizes in order to provide better empirical data about which of the components of presence are more strictly related to anxiety in clinical VE. Finally, it should be noted that research to date has also been limited to studying the relationship between presence and anxiety in patients diagnosed with specific phobias such as acrophobia or flying phobia. This implies that further research is needed in which the relationship between these constructs is studied in patients diagnosed with more complex and heterogeneous anxiety disorders.

1.3. Current study

In light of the limitations mentioned before, the present study sought to examine the relationship between sense of presence and in-session anxiety in a large sample of 210 students who presented high and low test anxiety when exposed to both clinical and non-stressful virtual environments. This is the largest study conducted to date with the aim of examining the relationship between presence and anxiety in clinical virtual environments, and the first to explore separately the relationship between presence and state-anxiety in phobic and non-phobic participants.

Slater (Slater et al., 2006) claims that the "presence response" is related to the fact that users can experience similar emotions to those they would have been expected to experience in a similar real-world setting. Thus, it would seem that if students (despite their level of test anxiety) feel a high sense of presence in a non-stressful VE this does not necessarily mean they would experience anxiety; indeed, they may also experience other kinds of emotions such as happiness, relaxation, etc., as occurs in the real world. Hence, the first hypothesis of the study is that presence would not be correlated to State-Anxiety during the exposure to a non-stressful virtual environment (H1).

H1: Presence would not be correlated with State-Anxiety in a non-stressful virtual environment.

At all events, it is important to note that a real exam situation usually causes some distress to the majority of students, and this may mean that presence and anxiety will be related when both groups of students are confronted with test anxiety environments (H2). We consider that only when the students can feel physically inside these environments will they be able to experience anxiety as a result of the virtual exam.

H2: Presence would be correlated with state-anxiety in clinical virtual environments.

However, it is implausible to assume that participants with low test anxiety show the same levels of anxiety as the high test anxiety group, even when they are highly present in the virtual environment. Thus, the third hypothesis is that presence will be more strongly related to anxiety in students with high test anxiety (H3).

H3: Presence will be more related to state-anxiety in students with high levels of test anxiety compared to their non-test anxiety counterparts.

Finally, given that there is still no consensus about which subdimensions of presence are most strongly related to anxiety, we also evaluate the impact of each of these components (Spatial Presence, Involvement, Realness and Sense of Being There) upon the level of anxiety experienced by students.

This study is part of a broader research project in which the exposure to virtual environments is being used to evaluate and treat test-anxiety disorder. In the first stage of this project (Alsina-Jurnet et al., 2007) we explored the effectiveness of virtual environments in producing emotional responses in students with high degrees of test anxiety. We concluded that virtual environments were able to provoke higher levels of subjective anxiety, state-anxiety and depression in students with high test anxiety than in their low test anxiety counterparts. Within this project we also evaluated the influence of user characteristics (test anxiety, spatial intelligence, verbal intelligence, personality and computer experience) on their sense of presence (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). The results showed that students with high test anxiety feel more presence than those low in test anxiety when exposed to stressful environments. Introversion and spatial intelligence were found to be related to the sense of presence experienced by high test anxiety students. It is important to note that this type of research may enhance the selection of patients who would profit most from treatment using virtual reality. In addition, a pilot treatment study (Carvallo-Beciu, Alsina-Jurnet, & Gutiérrez-Maldonado, 2004) showed benefits in the treatment of test anxiety by exposing participants to these virtual environments, obtaining a significant reduction in their levels of test anxiety and an increase in their academic performance. Rates of exam avoidance also fell.

2. Methods and materials

2.1. Subjects

Two hundred and ten students from the University of Barcelona agreed to take part in the study (173 women, 82.4%; 37 men, 17.6%). Mean age was 23.19 (*SD*, 3.76; range, 18–45). The Test Anxiety Inventory (TAI) (Spielberger, 1980) was administered to all subjects, the mean TAI score being 44.24 (*SD*, 14.39; range, 20–77). Students with scores in or above the 70th percentile (direct score >53) on the TAI were assigned to the high test anxiety group, while the others formed the non-phobic group. The high test anxiety group comprised 60 women and eight men with a mean age of 22.35 (*SD*, 2.67; range, 19–34). The non-test anxiety group comprised 142 students: 113 females and 29 males aged 18–45 ($M = 23.58$; *SD*, 4.12). Mean TAI scores were 62.16 (*SD*, 6.55; range, 53–77) for the high test anxiety group and 36.30 (*SD*, 8.60; range, 20–52) for the non-test anxiety group.

Participants reported that they met the following inclusion criteria: (a) they were not taking any form of prescribed medication, (b) they were not suffering any diagnosed psychological disorder, (c) they were not receiving any form of psychological therapy, (d) they had no serious medical problems (such as heart disease or epilepsy) and (e) they were native speakers of Spanish.

2.2. Hardware

The virtual environments were displayed on a Pentium IV, 2 GHz, Windows 2000, 768 MB RAM, 60 Gb hard disk, Hercules 3D Prophet 9700 PRO graphics card with 128 MB DDR and AGP 8X. An *I-visor* DH-4400VP virtual personal display was used with a resolution of 800 × 600 pixels and a visual field in diagonal of 31°, connected to a *Tracker* Intersense 3-DOF (*degrees of freedom*) which measured the position and movement of the head. Sounds were played on the PC's stereo speakers.

2.3. Software

The students were exposed to the TAVE (Test Anxiety Virtual Environments) software. TAVE contains a series of virtual environments prepared in chronological order and which represent a habitual exam situation: the student's home, representing the day before and the morning of the examination (see Fig. 1); the metro, representing the journey to the exam situation (see Fig. 2); and finally, the corridor and lecture-hall where the examination takes place (see Fig. 3). A detailed description of the development and validation of TAVE can be found in Alsina-Jurnet et al. (2007).

2.3.1. Home

The scenario includes a flat, with a bedroom, a corridor, bathroom, dining-room, kitchen and hall. The first scene shows the student's bedroom at 11 o'clock on the night before the examination. In the room there is a desk with a textbook, and there are signs reminding him/her that there is an examination the next day. To increase the level of presence and to provoke the same emotional and cognitive reactions as in real situations, the students are able to carry out the same actions as s/he would carry out on the day before a real examination: s/he can turn the lights on and off, open the windows, put on music, lie down on the bed, eat or drink, study, go to the bathroom, brush their teeth, have a shower and so on. There are also clocks all over the house so that the student knows how much time there is left to study, or can decide when to go to bed.

This scenario is also used to represent the start of the examination day. The alarm clock rings at 7.30 am. As in the previous scenario, the students do all the things they would normally do; in addition, they now dress, prepare the belongings that they will take to the university, have breakfast and so on.

2.3.2. Metro

This scenario represents part of the Barcelona underground system. The initial view shows the station entrance. Ahead of the student are the steps leading to the platform. Once there, the student hears the conversations of groups of other students waiting for the train. After a minute's wait the train arrives and the student gets on and sits down. During the journey, which lasts three stops, the student can study while other students talk about the examination they are about to take.

2.3.3. University

There are two scenarios at the university. In the first the student is waiting in the hallway, outside the lecture-room where the examination will take place. During the wait, s/he is surrounded by other students talking about the subjects, the examination,

Fig. 1. View of the virtual house.

Fig. 2. Inside the train.

Fig. 3. Inside the examination room.

how they have prepared for it and so on. After 5 min the lecturer arrives with the examinations and tells the students they can go in. The second scenario presents the lecture-room where the examination will take place. The student is now seated and waits as the lecturer hands out the examinations. After the lecturer's instructions, the examination appears on the student's desk. Students have to answer 25 general knowledge questions. The format is multi-choice, with four possible answers for each question.

2.3.4. Living room

A living room was also created in which the students could familiarize themselves with the technology and which provided a neutral, emotionally non-significant environment for use as baseline. In this situation the students can performed the same actions than they would carry out in a similar real-world situation (s/he can explore the situation at his/her own peace, sit on a chair situated in front of a desktop, lie down on a sofa, turn the lights on and off and so on).

2.4. Measures

2.4.1. TAI (Test Anxiety Inventory) (Spielberger, 1980)

A self-report questionnaire designed to measure test anxiety as a situation-specific personality trait. The questionnaire comprises 20 items in which students indicate on a 1–4 point Likert scale (1, hardly ever; 4, almost always) how often they experience the symptoms of anxiety before, during and after examinations. The TAI contains two subscales, of eight items each, which assess *worry* (cognitive aspects, e.g., during tests I find myself thinking about the consequences of failing) and *emotionality* (physiological aspects, e.g., I feel my heart beating very fast during important tests).

2.4.2. IPQ (Igroup Presence Questionnaire) (Schubert, Friedmann, & Regenbrecht, 2001)

A self-report questionnaire designed to measure sense of presence in virtual reality environments. It comprises 14 items rated on a seven-point Likert Scale. The IPQ contains three subscales that measure different dimensions of presence. The Involvement subscale is directed to evaluate the attention devoted to the VE (e.g., I was not aware of my real environment), the Spatial Presence subscale is related to the sense of being physically inside the VE (e.g., I had a sense of acting in the virtual space, rather than operating something from outside) and Realness evaluates the sense of reality attributed to the VE (e.g., how much did your experience in the virtual environment seem consistent with your real world experience?). It also contains a general item that assesses the "sense of being here" (in the computer generated world I had a sense of "being there"). To obtain the presence scores for emotional environments, the mean of the IPQ scores obtained in the three test anxiety environments (house, metro and university) was calculated.

2.4.3. STAI (Strait-Trait Anxiety Inventory) (Spielberger, Gorsuch, & Lushene, 1970)

A self-report questionnaire that assesses state- and trait anxiety. Only the state-anxiety subscale (STAI-S) was used in this study. This scale comprises 20 items (e.g., I am presently worrying over possible misfortunes) scored on a Likert scale from 0 (not at all) to 3 (a great deal). In the present study, and in order to obtain state-anxiety scores in the emotional environments, the mean score of the three test anxiety environments (house, metro and university) was calculated.

2.5. Procedure

TAVE software was presented individually and students visited all the environments in a single session. The mean duration of the sessions, including exposure to the environments and administration of the questionnaires, was 120 min. The procedure was double blind, that is, the researcher who administered the environments was unaware of the subject's TAI score, and students did not know their score or the aim of the research. They were told only that the study was designed to obtain information on students' behavior in exam situations in order to prepare a treatment programme. Before starting the session, participants were told that they would be shown a series of virtual environments simulating what students go through before and during an examination, starting with the previous evening and finishing with the examination itself. They were told that the exam consisted of a general knowledge test, which would be graded. They were asked to act as they would normally prior to and during an examination; they were told what the exam involved, and what tasks they could perform in each virtual environment.

Before starting the exposure to virtual environments the students completed the TAI. The neutral environment was then administered and the subjects completed the STAI-S and the IPQ questionnaire. Afterwards, they were immersed in the three test anxiety environments (the house, metro and university) and the STAI-S and the IPQ questionnaire were again administered after exposure to each virtual environment.

3. Results

Means and standard deviations for all the questionnaires can be found in Table 1. Scores for the IPQ questionnaire and each of their subscales indicate the mean item response.

A repeated-measure ANOVA (2 emotional conditions × 2 groups) were performed to investigate the differences in the STAI-S and the IPQ total score between the two groups of students after the exposure to the neutral and test anxiety environments. A main effect of the emotional condition was found for STAI-S ($F(1, 198) = 429.06$, $p < .001$) and the IPQ total score ($F(1, 201) = 243.98$; $p < .001$), indicating that the levels of state-anxiety and presence were higher in the test anxiety environments than in the non-emotional living room. A main effect of "group" was also found for the STAI-S ($F(1, 198) = 88.16$, $p < .001$) and IPQ total score ($F(1, 201) = 5.51$; $p = .020$). The high test anxiety group presented higher levels of anxiety and presence than the low test anxiety group during virtual exposure. Finally, the interaction between situation and group was also significant for STAI-S ($F(1, 198) = 29.28$, $p < .001$) and the IPQ total score ($F(1, 201) = 4.75$; $p = .030$). This indicates that the differences in state-anxiety and presence between the two groups of students were higher in the emotional environments than in the neutral one.

Next, a series of correlational analyses were performed for both groups of students to test the relationship between sense of presence and state-anxiety while immersed in the VE. In the neutral environment no significant correlations were found between state-anxiety and either IPQ total score or any of its subscales for the two groups of students (high and low test anxiety) (Table 2). This indicates that in a non-stressful virtual environment the sense of presence are not related to the levels of anxiety that the students feel.

In test anxiety environments the analysis conducted for the low test anxiety group showed weak but significant correlations between state-anxiety and both Spatial Presence ($r = .225$, $p = .008$) and the Sense of Being There ($r = .184$, $p = .031$). Marginally significant correlations were also found for the IPQ total score ($r = .162$, $p = .059$) and Realness ($r = .157$, $p = .065$). Finally, Involvement was found to be unrelated to anxiety ($r = .079$, $p = .357$). In the high test anxiety group the results revealed a significant positive correlation between state-anxiety and the IPQ total score ($r = .536$, $p < .001$). As regards the specific components of presence a significant positive correlation was also found between state-anxiety and Spatial Presence ($r = .461$, $p < .001$), Involvement ($r = .400$, $p = .001$), Realness ($r = .571$, $p < .001$) and Sense of Being There ($r = .454$, $p < .001$).

Due to the relationship found between presence and state-anxiety for high test anxiety students, a stepwise regression analysis was performed for this group. The scores obtained on the IPQ and each of its dimensions (Spatial Presence, Involvement, Realness and Sense of Being There) were included as predictors, while the STAI was included as the dependent variable. Thus, the contribution of each factor to the explanation of state-anxiety can be investigated. The results revealed that only the scores on the Realness subscale accounted for a significant amount of variance in STAI ratings ($F(1, 62) = 29.53$, $p < .001$, $R_2 = .326$). This supports a linear relationship between realism and state-anxiety, and thus higher perceived realism was related to greater anxiety ($\beta = 0.571$, $t = 5.434$, $p < .001$).

4. Discussion

The utility of VRET is based on the assumption that patients must be able to feel present in virtual environments.

From a theoretical point of view the literature posits the construct of presence, defined as the "sense of being there", as the factor that enables anxiety and distress to be experienced in clinical virtual environments. More than 10 years ago Hodges et al. (1994) was the first to postulate the necessity of presence for effective phobia treatment. However, to date, few studies had been conducted with the aim of understanding the relationship between presence and anxiety. Research into the influence of presence on the level of anxiety felt in VE would be of value as it could indicate whether presence should be maximized in a treatment setting by using highly immersive (or highly expensive) virtual reality systems, or by detecting the patient characteristics that can lead to the experience of higher levels of presence. Unfortunately, however, the literature has yielded mixed findings: while some studies have reported a linear relationship between presence and anxiety, others have failed to find a significant relationship between them. These contradictory findings may be due both to methodological limitations (such as small samples or the use of poorly validated questionnaires) and to the fact that the few existing studies also fail to analyse separately the relationship between presence and anxiety in phobic and non-phobic patients. Thus, there is a need for methodologically sounder studies that are designed to test whether presence leads to the experience of higher levels of anxiety in samples of both clinical and non-phobic participants. Moreover, it is important to note that to date the relationship between presence and anxiety has mainly been addressed in patients diagnosed with flying phobia or acrophobia, and further research is still needed in order to examine whether presence is also related to anxiety in patients diagnosed with other anxiety disorders.

The main goal of this study was to improve upon the methodology of previous research and to analyse the possible link between presence and anxiety in students with high and low test anxiety when exposed to both clinical and non-stressful virtual environments. The findings revealed, firstly, that in a non-stressful virtual environment (a living room) presence was not related to anxiety in either high or low test anxiety students. It is important to note here that since test anxiety is not orthogonal to trait anxiety, when exposed to a non-emotional virtual environment, high test anxiety students tend to experience higher levels of anxiety than their low test anxiety counterparts (Alsina-Jurnet & Gutiérrez-Maldonado,

Table 1
Means and standard deviations for the IPQ and the STAI-S in the neutral and test anxiety environments for high and low test anxiety students.

	Neutral virtual environment				Test anxiety environments			
	Low test anxiety		High test anxiety		Low test anxiety		High test anxiety	
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
IPQ	2.72	0.88	2.87	1.00	3.56	0.90	3.97	0.78
SP	3.15	1.04	3.17	1.09	3.80	0.89	4.14	0.71
INV	2.66	1.23	2.78	1.38	3.38	1.20	3.78	1.08
REAL	2.18	0.96	2.48	0.92	3.31	0.89	3.79	0.89
G	3.12	1.56	3.29	1.65	4.12	1.16	4.68	0.98
STAI-S	14.52	7.84	20.18	10.50	28.39	10.39	43.85	9.40

IPQ, Igroup Presence Questionnaire; SP, Spatial Presence; INV, Involvement; REAL, Realness; G, General item ("sense of being there"); STAI-S, State-Trait Anxiety Inventory, State subscale.

Table 2
Correlations between presence and state-anxiety for both groups of students when exposed to clinical and non-stressful virtual environments.

	Neutral virtual environment		Test anxiety environments	
	Low test anxiety STAI	High test anxiety STAI	Low test anxiety STAI	High test anxiety STAI
IPQ	−0.082 (0.332)	−0.083 (0.519)	0.162 (0.059)	0.536** (<0.001)
SP	−0.097 (0.249)	−0.089 (0.493)	0.225** (0.008)	0.461** (<0.001)
INV	0.009 (0.916)	−0.058 (0.656)	0.079 (0.357)	0.400** (0.001)
REAL	−0.107 (0.205)	−0.035 (0.785)	0.157 (0.065)	0.571** (<0.001)
G	−0.099 (0.242)	−0.148 (0.250)	0.184* (0.031)	0.454** (<0.001)

IPQ, Igroup Presence Questionnaire; SP, Spatial Presence; INV, Involvement; REAL, Realness; G, General item (“sense of being there”).
* The correlation is significant at level .05 (bilateral).
** The correlation is significant at level .01 (bilateral).

2010). However, as expected, the fact that both high and low test anxiety students felt themselves to be inside the virtual living room did not necessarily mean that they had to experience high levels of anxiety. As occurs in the real world they may experience another type of emotion, for instance, they might feel bored, uninterested, happy and so on. As pointed out by Slater (2003), presence simply implies that people “have a similar emotional response as they do in similar circumstances in the real world”. Since it is agreed that presence and emotions are distinct but related (Bouchard, 2004; Slater, 2004), it would be of interest in future studies to investigate whether, in a non-stressful virtual environment, presence is significantly related to the same kind of emotions as those expected in the real world. For example, presence may be related to depression when a patient diagnosed with a major depressive disorder is immersed inside a non-clinical virtual environment.

Another important finding was that for high test anxiety students there was a strong relationship between state-anxiety and both overall levels of presence and each of its components (Spatial Presence, Realism, Involvement and Sense of Being There). It seems that these students only feel afraid when they experience a high level of presence. These results corroborate the findings of both Price and Anderson (2007) and Schuemie et al. (2000), who found a positive relationship between self-reported presence and in-session anxiety in patients diagnosed with specific phobias; however, they contradict the findings of Krijn, Emmelkamp, Biemond et al. (2004) and Krijn et al. (2007). Interestingly, a regression analysis showed that the degree of realism which students attributed to the VE played a major role in the development of anxiety. Thus, the greater the participants' sense of believability and realism of the content presented in the VE, the greater the level of anxiety. This suggests that much effort is needed in order to increase the perceived realism of clinical virtual environments. Some results reported by Robillard et al. (2003) and Baños et al. (2004) suggest that one way to increase presence and reality judgement would be through an adequate content design. As pointed out by Baños et al. (2004): “This content design would have to include those elements relevant for every specific emotional problem, that is, those elements with the potential of activating emotions. Therefore, the focus must be on the psychological aspects more than on the technical aspects”. It would also be of interest to detect the individual characteristics of patients that might be related to a high sense of presence and, especially, a high perceived realism. In this regard, Alsina-Jurnet and Gutiérrez-Maldonado (2010) found that patients with high levels of spatial intelligence or introversion tended to experience higher levels of presence while immersed in clinical virtual environments; more specifically, their results showed a strong relationship between these individual traits and perceived realism. Despite this type of study may help to detect those patients who are likely to benefit from VRET, must research has to be done before we can select people for virtual reality services on the basis of their individual characteristics (Sacau, Laarni, & Hartmann, 2008). Future studies are needed to evaluate what happens with those patients that are not prone to experience presence. Maybe these users only need longer exposure therapy sessions in order to become more familiar and more attention focused with the medium, leading to an increment of presence. Another hypothesis is that these patients cannot be helped at all through VRET. In this case another approach, such as the use of non interactive virtual environments in individuals who lack of spatial intelligence, could be more engaging.

As regards the low test anxiety group the results showed a weak but positive correlation between state-anxiety and the overall score for presence, Realism, Sense of Being There and, especially, Spatial Presence. These results are consistent with those reported by Regenbrecht et al. (1998), who found a similar correlation between presence and anxiety in a sample of non-phobic participants. In the study by Regenbrecht, Spatial Presence was also found to be the factor most strictly related to the experience of anxiety in non-clinical subjects. This suggests that in non-clinical samples, high levels of Spatial Presence are moderately related to anxiety and arousal.

The results of the present study show that although presence is related to anxiety in both groups of students, this relationship is clearly stronger for high test anxiety students. This suggests that presence does not always, or simply, imply a very strong emotion, but also an intensity of this feeling that is congruent with that experienced in the real world. Thus, for example, in a real test situation low test anxiety students feel moderate levels of anxiety. If in the virtual simulation of this situation this group shows mild levels of anxiety, then this would be a sign of high levels of presence. In support of this conclusion our results show that high levels of presence are related to high levels of state-anxiety in the group of high test anxiety students, and to a lesser extent in low test anxiety students.

It should be noted that the methodology of this study has some caveats. First, the majority of the participants were women. Furthermore a large amount of females comprised the high test anxiety group compared to the non-test anxiety group, which could impact somewhat the generalization of the results. However, literature shows that degrees of test anxiety differ according gender. In a study conducted by Hernández (2005), the author found that the number of females with high levels of test anxiety can duplicate or quintuplicate the number of males. Despite this, more research is needed in order to evaluate the relationship between presence and anxiety on high test anxiety males. Second, all the measures used in this study were self-report, which are prone to some bias. Future work should implement more objective measures in order to measure both presence and anxiety.

Nevertheless, this study also provided some light about the mechanisms that can lead to the successfulness of VRET. Our results suggest the importance of the sense of presence (more specifically perceived realism) as a mediating variable between the media and the level of anxiety induced by it. This implies that presence could be essential for the efficacy of VRET. If patients are not able to involve themselves in an anxiety-triggering virtual environment they cannot experience those relevant emotions needed to

conduct this type of treatment. Thus, exploring and understanding this variable can help to explain why some patients cannot benefit from VRET (see, for example, North, North, & Coble, 1996). Is important to note that our results confirm the importance to thoroughly investigating which systems characteristics (such as the use of a Head Mounted Display vs. a computer screen) and which personality characteristics (for a recent discussion see Alsina-Jurnet & Gutiérrez-Maldonado, 2010) are related to the engagement of the sense of presence and, more concretely, reality judgement within a VR clinical setting. As pointed by Baños et al. (2000) the study and assessment of reality judgement in virtual worlds is not only important for VR, but also for the general field of psychology. The question "How do people decide whether something is real or not?" has intrigued most psychopathologist through the history. Maybe focusing on this topic we will be able to improve our understanding of many mental disorders.

5. Conclusions

For therapeutic reasons it is important to determine the most critical elements involved in the experience of anxiety and distress within VE. In the literature the construct of presence has been identified as the principal factor that enables phobic anxiety to be expressed during exposure to clinical virtual environments. However, the few existing studies that examine the relationship between presence and state-anxiety have yielded contradictory results; moreover, these studies present serious methodologically problems and they have only focused on patients diagnosed with specific phobias.

The aim of the present study was to provide answers to certain questions arising out of previous research, and shed some light on the issue of when and under what circumstances presence is related to anxiety. With this objective in mind the relationship between presence and in-session anxiety was examined in students with high and low test anxiety when exposed to both clinical and non-stressful VE. It is important to note that this is the largest study conducted to date with this purpose, and it is also the first to analyse separately the relationship between the two constructs in phobic and non-phobic participants. The results showed that presence was not related to anxiety in a non-clinical environment. As occurs in the real world the students, while exposed to a non-stressful environment, may feel a wide range of emotions that are not strictly related to anxiety. In test anxiety environments the results revealed some interesting relationships between presence and state-anxiety for both groups of students. For low test anxiety students the analysis showed a weak but positive relationship between presence and anxiety, suggesting that presence is not always related to the experience of strong emotions but also to an emotion that is qualitatively and quantitatively similar to that experienced in the real world. As regards high test anxiety students the results showed a strong relationship between presence and anxiety, and specifically, perceived realism was found to be the principal factor that enables phobic anxiety to be expressed during VRET. In future studies we plan to evaluate the relationship between presence and state-anxiety within a complete psychotherapeutic process. In line of the results encountered in our study, we expect that this relation may fluctuates over the course of an exposure treatment. It may be that during the first sessions the relationship between both constructs will be high. But as habituation towards the feared stimulus occurs across the sessions (and the anxiety response goes down) the relation can be gradually weaker. As suggest our results, feeling a high level of presence in a non-stressful situation does not implies a high level of anxiety.

The results of the present study provide new evidence that in phobic patients an increased amount of presence is related to an increased amount of state-anxiety. This line of research will broaden our understanding of the mechanisms that lead to the efficacy of VRET and may suggest that in clinical settings the sense of presence should be maximized in order to experience high levels of anxiety.

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