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Influence of personality and individual abilities on the sense of presence experienced in anxiety triggering virtual environments

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Abstract

In the literature, there are few studies of the human factors involved in the engagement of presence. The present study aims to investigate the influence of five user characteristics – test anxiety, spatial intelligence, verbal intelligence, personality and computer experience – on the sense of presence. This is the first study to investigate the influence of spatial intelligence on the sense of presence, and the first to use an immersive virtual reality system to investigate the relationship between users' personality characteristics and presence. The results show a greater sense of presence in test anxiety environments than in a neutral environment. Moreover, high test anxiety students feel more presence than their non-test anxiety counterparts. Spatial intelligence and introversion also influence the sense of presence experienced by high test anxiety students exposed to anxiety triggering virtual environments. These results may help to identify new groups of patients likely to benefit from virtual reality exposure therapy.

Keywords: Individual differences; Anxiety; Personality; Intelligence; Sense of presence; Virtual reality

1. Introduction

1.1. Presence definitions

One of the core features in virtual reality treatment of psychological disorders is the sense of presence. The term "sense of presence" is normally used to describe the illusion of "being there" in a mediated environment. One of the most important consequences of this illusion is that a virtual environment can evoke the same reactions and emotions as the experience of a similar real-world situation (Hodges et al., 1994). This implies that sense of presence is essential to conduct Virtual Reality Exposure Therapy (VRET). In VRET the patient is gradually exposed by means of virtual reality environments to those stimuli that elicit fear, and thought the prolonged and repeated exposure the anxiety response disappears. Thus, if patients are not able to involve themselves in a virtual world they cannot experience these relevant emotions, and the desired processes of habituation and extinction of the anxiety response will not occur. Recently, Price and Anderson (2007) found that the sense of presence can mediate the relation between pre-treatment anxiety and the amount of anxiety experienced during VRET.

Although there is no generally accepted definition of presence, and in spite of the difficulties involved in its measurement, most researchers agree that it is a multi-component construct. Thus, some factor analysis studies (Schubert et al., 2001; Lessiter et al., 2001) suggest a multidimensional structure for presence based on three factors: *Sense of Physical Space* (the sense of being located in a contiguous spatial environment), *Engagement/Involvement* (attention devoted to the virtual environment) and *Ecological Validity/Realism* (the participant's sense of believability and realism of the content).

Most researchers also agree that presence is influenced by both technological and human factors. Lessiter et al. (2001), for example, suggested that sense of presence is determined by media and user characteristics. Media characteristics are divided into media form, which includes the properties of a display medium (such as the extent of

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information presented, the degree of control that participants have over positioning their sensors within the environment, and their ability to modify the aspects of the environment), and media content, which includes the objects, actors, and events represented by the medium. For their part, user characteristics cover the range of individual differences (for example age, gender, their perceptual, cognitive or motor abilities, and so on).

To date, most of the attempts to specify the determinants of sense of presence have focused on the media form, and have concluded that some of the factors which may influence the subjective experience of presence are: field of view (Freeman et al., 2005; Ijsselsteijn et al., 2001; Lin et al., 2002; Prothero and Hoffman, 1995; Seay et al., 2001), foreground/background manipulations (Prothero et al., 1995), update rate (Barfield et al., 1998), stereoscopy (Freeman et al., 2000; Hendrix and Barfield, 1996a; Ijsselsteijn et al., 2001), geometric field of view (Hendrix and Barfield, 1996a), pictorial realism (Hoffman and Bubb, 2003; Welch et al., 1996), image motion (Ijsselsteijn et al., 2001), the use of a CAVE versus a desktop VR (Axelsson et al., 2001) or an HMD (Krijn et al., 2004), spatial sound (Hendrix and Barfield, 1996b), the number of audio channels (Västfjäll, 2003), the inclusion of tactile (Dinh et al., 1999; Hoffman et al., 1996), olfactory (Dinh et al., 1999) or auditory cues (Viaud-Delmon et al., 2006), the use of head tracking (Barfield et al., 1997; Hendrix and Barfield, 1996b), the feedback delay (Welch et al., 1996), the possibility of interacting with the virtual environment (Welch et al., 1996, Larsson et al., 2001; Freeman et al., 2005) or body movement (Slater et al., 1998).

However, although presence is a psychological phenomenon (Slater and Wilbur, 1997), the user characteristics involved in its engagement have not been widely studied. Most previous discussions have been based on informed conjecture rather than research. Nonetheless, several authors (for example Barfield et al., 1995; Hodges et al., 1994; Lombard and Ditton, 1997; North et al., 1996; Steuer, 1992) state that presence is a direct function not only of the characteristics of the system but of aspects of personality as well. To quote Schubert et al. (2001): "Stimuli from a VE are only the raw material for the mind that constructs a mental picture of a surrounding world, instead of a mental picture of pixels on the display in front of the eyes". From this perspective, presence is an active, creative process for the mind, rather than a passive processing of a large amount of sensory information. This suggests that presence can be influenced by individual factors, either situation-specific states or more endurable dispositions (i.e., traits) (Sacau et al., 2005).

1.2. User characteristics and presence

The pioneer study of the relationship between user characteristics and sense of presence was conducted by Slater (Slater and Usoh, 1993) who distinguished between exogenous and endogenous factors responsible for determining the extent of presence. To characterize the users' psychological representational and perceptual systems, the authors used a model which claims that subjective experience is encoded in terms of three main representation systems – visual, auditory and kinesthetic – and that subjects usually prefer one system over the others. Furthermore, the experiences and memories of a given individual are encoded in one of three perceptual positions: first (an egocentric standpoint), second (the standpoint of another person) or third (from a non-personal view). In their study, 17 students were assigned to either an experimental group ($n = 9$) or a control group ($n = 8$). The control group was provided with a disembodied arrow cursor, and the experimental group had a virtual body that responded to the participant's movements. All the students were exposed to the same virtual environment (VE): a corridor with six doors each leading to a room that exercised a feature of a VE–person interaction. The results suggested that the greater the degree of visual dominance, the higher the sense of presence. Subjects who preferred the auditory representational system experienced a lower sense of presence. The use of a kinesthetic system correlated with high presence in the experimental group but correlated negatively in the control group. The level of presence also increased when the subjects preferred the first perceptual position, the egocentric standpoint. In a similar study Slater et al. (1994) exposed 24 subjects to a VE and found the same results as those reported in the previous study; participants who preferred the visual or the kinesthetic representational system (in this case if a virtual body was included) experienced higher levels of presence. Finally, a study performed with 8 participants (Slater et al., 1995) found that the inclusion of dynamic shadows in a virtual environment only produced a higher degree of presence in individuals who preferred the visual representational system.

In a study of 355 participants, Bangay and Preston (Bangay and Preston 1998) found that subjects aged between 35 and 45 tended to have lower presence scores than those aged between 10 and 20. In contrast, Schuemie et al. (2005) found a positive correlation between presence and age in a sample of 41 participants exposed to a virtual environment containing height situations (that comprised a fire stair and the top floor of a building). Moreover, no correlation between presence and absorption, gender, computer experience or the level of acrophobia was found.

In order to measure the tendencies of individuals to become immersed in a virtual environment, Witmer and Singer (1998) designed the Immersive Tendencies Questionnaire (ITQ). The ITQ comprises three subscales: involvement (propensity to become passively involved in an activity such as reading books), focus (ability to concentrate on enjoyable activities, and ability to block out distractions) and games (frequency with which subjects play games and the level of their involvement in these games). The authors encountered a significant correlation between the ITQ and the sense of presence measured through the Presence Questionnaire (PQ) in only two of four experiments, although they found a significant positive correlation when they combined data across the experiments. Bouchard's research group (Renaud et al., 2007; Robillard et al., 2003; Bouchard et al., 2004) also found significant positive correlations between the ITQ and the sense of presence. Despite these positive results, others failed to find significant correlations between the ITQ and the amount of presence that a person feels within a virtual environment (for example Murray et al., 2007; Nuñez, 2003; Renaud et al., 2002). These contradictory results imply that further research is needed to establish whether the ITQ can predict the level of presence, and under what circumstances.

Recently, another research group (Thornson et al., 2009) had developed and validated the Tendency toward Presence Inventory (TPI), a cross-media questionnaire directed to evaluate the persons' tendency to experience presence. This questionnaire comprises six factors: cognitive involvement (active), spatial orientation, introversion, cognitive involvement (passive), ability to construct mental models and empathy. Despite this, future work is still needed in order to evaluate the predictive validity of these factors.

Baños et al. (1999) examined the role of absorption and dissociation in reality judgment in virtual environments. The term *absorption* refers to "the tendency to become involved or immersed in everyday events or the tendency to totally immerse oneself with the attentional objects", while dissociation refers to "a disruption in the normally integrated functions of consciousness, memory, identity, or perception of the environment". The authors found that both absorption and dissociation were positively and significantly correlated with reality judgment and sense of presence. The results of this study also suggest that presence can be influenced by specific states of the user, as individuals who experienced more anxiety during the exposure had higher presence scores. In a sample comprising ten individuals diagnosed with agoraphobia and nine healthy subjects, Viaud-Delmon et al. (2006) also found a significant correlation between the sense of presence experienced within a virtual city and derealization. Similarly, in a study of 64 volunteers, Murray et al. (2007) explored the relationship between a group of psychological variables (absorption, dissociation, immersive tendencies and locus of control) and sense of presence. In this case, strong relations were found between dissociation and external locus of control and presence. However, neither absorption nor ITQ were related to the sense of presence.

In a later study, performed with 15 students, Corina Sas (Sas and O'Hare, 2003) investigated the relationship between four cognitive factors (absorption, creative imagination, empathy and cognitive style), and the sense of presence experienced in a desktop virtual reality system. The results showed a significant correlation between presence score and creative imagination on the one hand and between presence and empathy on the other. Presence also correlated highly, but not significantly, with the absorption scale. Due to the limited size of the sample, the results for cognitive style are of limited value, but it seems that participants of perceiving or feeling type experienced a higher degree of presence. Furthermore, no differences were found in sense of presence in terms of the participant's gender. In another study, Sas et al. (2004) studied only the effect of cognitive styles on the sense of presence. In accordance with their previous study, Sas found that subjects who scored higher on feeling or sensitive type experienced a higher level of presence. Moreover, though the difference was not statistically significant, introverted individuals tended to experience more presence.

Within the MEC (Presence: Measurement, Effects, Conditions) Project, a series of studies were conducted in order to evaluate the impact of personality characteristics on sense of presence. Laarni et al. (2004) exposed 80 volunteers to a multimedia presentation performed on a desktop computer. The results showed that extraversion, impulsivity and self-transcendence enhanced the subjective sensation of presence. The authors also found a positive significant correlation between the ITQ scale and both Spatial Presence and Engagement. In another study by this research group (Sacau et al., 2005) 240 students were exposed to a linear text, a hypertext, a film or a virtual environment. In this case, a regression analysis showed that three personality variables (domain specific interest, absorption and agreeableness) were significant predictors of Spatial Presence.

Finally, Hecht and Reiner (2007) investigated the relation between the user's cognitive style in the field dependency-dimension and the degree of object-presence experienced by 18 participants in a haptic virtual environment. A correlational analysis showed that field-independent individuals experienced higher presence than their field-dependent counterparts. The authors suggested that field-independent individuals achieve more presence because they are better at reorganizing their immediate perceptual field and construct it more creatively using their internal knowledge.

Is important to note that research into these individual moderating traits will be of value because it may increase the number of patients that can benefit from virtual reality therapy and may help to explain why some patients do not respond. If patients aren't able to involve themselves within a virtual environment they can't experience those relevant emotions needed to conduct exposure therapy. Thus exploring individual characteristics can help to explain why 20% of the patients treated by North et al. (1996) showed little or no reduction in agoraphobic symptoms (maybe they didn't feel present inside the virtual environments constructed), or why half of the patients in the study by Walshe et al. (2003) did not feel present in virtual reality environments designed to treat driving phobia. Moreover, to date, one of the principal limitations of VRET is the relatively high number of drop-outs found in some studies (Emmelkamp et al., 2002; Kahan et al., 2000; Krijn et al., 2004, Mühlberger et al., 2001; Mühlberger et al., 2003; Rothbaum et al., 2001; Rothbaum et al., 2002). Krijn et al. (2004) recorded a patient drop-out rate of approximately 25%. There is now some evidence of a linear relationship between the high drop-out rates and low levels of presence (Krijn et al., 2004). In view of these findings, there seems to be a clear need for studies of the individual characteristics that influence the sense of presence in order to determine which patients are likely to participate in VRET successfully.

1.3. Current study

Due to the apparent influence of user characteristics on the sense of presence, and in view of the lack of studies in this area, we decided to evaluate the impact of five user characteristics – test anxiety, spatial intelligence, verbal intelligence, personality and computer experience – on the sense of presence experienced by university students exposed to test anxiety environments.

Schubert's spatial-functional model (Schubert et al., 2001) suggests that two cognitive processes are responsible for the engagement of the sense of presence: representations of bodily actions as possible actions in the virtual environments, and the suppression of antagonistic sensory information. This model claims that users need to construct a mental model of the virtual space, in which the location of their own body is considered as being contained in the space rather than being seen from outside. Once users have developed a model of this kind, they are able to play an active part and take control over their actions. Although becoming immersed in a virtual environment leads to a greater sense of presence, according to Schubert et al. (2001) users need to perceive that they are able to take on the role they are playing within the virtual environment. Users who place themselves in the virtual space by navigating and interacting with the objects are more likely to experience presence as they mentally remove themselves from the real to the virtual world. But in order to construct this mental representation of the virtual space, users have to suppress conflicting sensory inputs, such as the stimuli of the hardware or stimuli from the real world. The suppression of conflicting stimuli and the allocation of attention to the virtual stimuli can lead to the engagement of the sense of presence.

According to Schubert's model, in the present study we expect that both spatial intelligence and computer experience facilitate the active construction of a mental model of the virtual space by adding and accurately integrating spatial information into the mental model of the virtual environment. Participants with higher levels of spatial intelligence will probably be able to place themselves within this virtual space. Thus, the user will appear to be in a physical location different from his environment in the real world, enhancing the sense of spatial presence. Hence our first hypothesis (H1) states:

H1. Spatial intelligence would be correlated with sense of presence.

We also hypothesized that computer experience is likely to facilitate navigation and interaction within the virtual world. Thus, Involvement can be enhanced as attention can focus on details of the virtual reality (instead of navigation tools, etc.) (H2)

H2. Computer experience will have an impact upon the sense of presence.

Verbal intelligence is a construct mainly related to semantic information, and involves the mastery of language. People with high levels of verbal intelligence are good at writing, reading or talking. Also, they can work better in words and language than in images. We expect that these verbal abilities haven't a relevant impact on neither the spatial knowledge acquisition of a Virtual Environment nor the navigation performance within the virtual reality spaces. Thus, in the present study is hypothesized that these verbal abilities can't enhance the sense of presence (H3).

H3. Verbal intelligence would not be correlated with sense of presence.

We also expect the more introverted subjects to experience higher degrees of spatial presence and involvement within the virtual environments. It has been suggested that introverts have a narrower focus of attention than extraverts. This narrower range of attention leads to a less extensive processing of stimuli not related to the primary task; therefore, task-irrelevant or distracting information should be more easily ignored (Althaus et al., 2005; Blumenthal, 2001). Hence, due to the greater capacity of introverts to attend to the main task, introverted students may be expected to direct more attentional resources to virtual environments and thus experience higher levels of involvement. But introverts also perform better in sustained attention tasks than extraverts (Koelega, 1992). This better attention allocation should facilitate both the construction of the mental model of the virtual environment by ensuring that they register the building blocks of spatial information (Sacau et al., 2005) and the direction of the attention to the virtual reality environments throughout the exposure session. This can lead introverts to experience higher levels of involvement and sense of being inside the virtual environments (H4).

H4. Introversion would be correlated with the sense of presence.

But for subjects to experience presence, virtual environments need emotional relevance. Hoorn (Hoorn et al., 2003) argued that this personal relevance is a more important factor than achieving highly realistic solutions. Huang and Alessi (Huang and Alessi, 1999) also pointed out that various mental health conditions, such as depression, anxiety, or psychotic disorders, are likely to influence the sense of presence, since they are known to have a clear effect on how people experience the world around them. In this regard Robillard (Robillard et al., 2003) found that phobic participants experience higher levels of presence when confronted with virtual anxiety cues (spiders, heights or enclosed spaces) than their non-phobic counterparts. In another study (Renaud et al., 2002) 12 spider phobics and 12 control participants were exposed to a virtual tarantula spider. In this case the results also suggested that fearful subjects reported higher levels of involvement during the exposure than non-fearful subjects. These studies suggest that phobic individuals feel more presence within a virtual environment related to their own fears than non-phobic ones. Thus, in our studies we expected that high test anxiety students will experience higher levels of presence than non-test anxiety students when exposed to test anxiety virtual environments (H5).

H5. The level of presence will be higher for high test anxiety students than their non-test anxiety counterparts when exposed to a virtual exam situation.

In this line, to investigate the influence of emotions on the sense of presence, Bouchard (Bouchard et al., 2004) experimentally manipulated the level of anxiety in 31 snake phobics immersed in a virtual environment. In some immersions the participants were falsely led to believe that the environment was infested with poisonous, aggressive and dangerous hidden snakes, while in other immersions the subjects were told that there were no snakes at all. The results showed a higher sense of presence in high anxiety immersions. Baños (Baños et al., 2000, 2001) also found significant differences in the responses of mental health patients and non-patients when exposed to various virtual environments. Supporting these results, in a sample of 36 flying phobics, Price and Anderson (2007) found a significant correlation between the amount of phobic elements included in a virtual environment and the level of presence experienced by the participants. Finally, a series of studies conducted as part of the EMMA Project (Baños et al., 2004a, 2004b; Riva et al., 2007) also demonstrated the influence of emotions upon the sense of presence. The results of these studies showed a higher feeling of presence in emotional than in non-emotional virtual reality environments.

As the present study was to be conducted with students, we predicted that (H6):

H6. The feeling of presence would be higher in test anxiety environments than in non-emotional environments.

Although several authors have stated that two of the main dimensions of presence are the sense of physical space and the attention devoted to the virtual environment, this is the first attempt to investigate the possible influence of spatial intelligence on the sense of presence. Furthermore, to our knowledge, this is the first study to use an immersive virtual reality system (in which a HMD display is used) to investigate the relationship between personality characteristics and presence. Other studies mentioned above (Laarni et al., 2004; Sacau et al., 2005; Sas and O'Hare, 2003; Sas et al., 2004) used non-immersive virtual reality systems (such as a desktop computer) or other media.

Our study is part of a broader study in which the exposure to virtual environments will be 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 depressive mood in high test anxiety students than in their low test anxiety counterparts. In addition, a pilot study (Carvallo-Beciu, et al., 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 university students of the University of Barcelona agreed to take part in the study (173 women, 82.4% and 37 men, 17.6%). The mean age was 23.19 (S.D.: 3.76, range: 18–45). The Test Anxiety Inventory (TAI, Spielberger, unpublished) was administered to all subjects. The mean TAI score was 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 years (S.D.: 2.67, range 19–34). The non-test anxiety group comprised 142 students, 113 females and 29 males aged 18–45 years ($M = 23.58$, S.D.: 4.12). Mean TAI scores were 62.16 (S.D.: 6.55, range 53–77) for the high test anxiety group and 36.30 (S.D.: 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 don't have serious medical problems (such as heart disease or epilepsy) and (d) they were native speakers of Spanish.

2.2. Instruments

2.2.1. 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.

As a motion input device we used a standard mouse and the keyboard of the computer.

2.2.2. Software

To construct the virtual environments, tools of two kinds were used:

- Modeling and animation tools: the scenarios, virtual elements and animated 3D objects were constructed with 3D Studio Max 6. Poser 4 was used to design the characters, which were animated with Character Studio 4.0. Adobe Photoshop 6.0 was used to create the textures and images.
- Interactive development applications: Virtools Dev 2.5 Educational Version was used to combine the objects and characters created with the different graphics design tools, and to integrate them with textures and sound. It was also used to make the environments interactive and to facilitate navigation.

Fig. 1. View of the bedroom.

2.2.3. The scenarios

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; the metro, representing the journey to the exam situation; and finally, the corridor and lecture-hall where the examination takes place. A detailed description of the development and validation of TAVE can be found in Alsina-Jurnet et al. (2007).

2.2.3.1. Home. The scenario includes a flat, with a bedroom, a corridor, bathroom, dining-room, kitchen, and hall (see Fig. 1). 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.

2.2.3.2. Metro. This scenario represents part of the Barcelona underground system (see Fig. 2). 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.

Fig. 2. Inside the metro.

2.2.3.3. 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, how they have prepared for it, and so on. After five minutes 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 (see Fig. 3). The student is now seated and waits as the lecturer hands

Fig. 3. Inside the examination room.

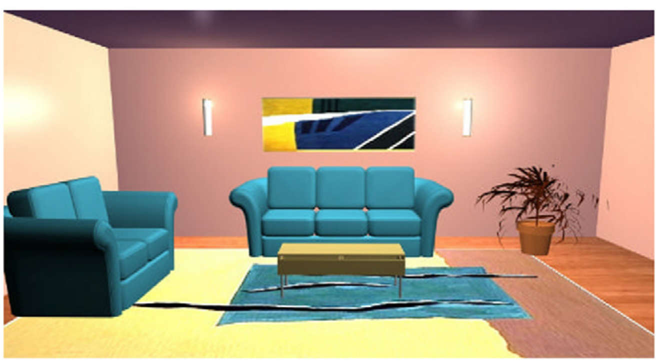

Fig. 4. View of the non-emotional living-room.

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.

2.2.3.4. 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 (see Fig. 4). 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).

2.2.4. Evaluation

2.2.4.1. TAI (test anxiety inventory) Spielberger (unpublished). A self-report questionnaire designed to measure test anxiety as a situation-specific personality trait. The questionnaire comprises 20 items in which students indicate how often they experience the symptoms of anxiety, before, during and after examinations, on a 1 to 4 point Likert scale (1 = hardly ever; 4 = almost always). The TAI contains two sub-scales, of eight items each, which assess *worry* (cognitive aspects) and *emotionality* (physiological aspects).

2.2.4.2. EPQ-RS (Eysenck personality questionnaire short Revised Version). Eysenck and Eysenck (2001). A self-report questionnaire designed to measure the personality characteristics. The EPQ-RS consists of 48 items, each answered on a yes-no basis, which assess the Eysenckian dimensions of Extroversion, Neuroticism and Psychoticism.

2.2.4.3. Solid Figures rotation. Yela (1968). A 21-item self-applied instrument designed to measure the ability to recognize and interpret objects in space. Five different solid figures are presented in each item. Each figure displays a three-dimensional solid block. The person must decide which figure matches a given model figure seen from another perspective.

2.2.4.4. Vocabulary subtest of WAIS-III. Wechsler (1999). The Vocabulary subtest of WAIS comprises 35 oral and visually presented words that the participant defines orally. This scale assesses knowledge of vocabulary and has been widely used as a brief assessment of general verbal intellectual function.

2.2.4.5. CO (computer experience). Schuemie (2003). This instrument assesses subjects' experience with 3D games and computers. It comprises a 5 item scale rated from 1 to 5, where 1 = *very bad/never* and 5 = very good/often.

2.2.4.6. IPQ (Igroup presence questionnaire). Schubert ET Al. (2001). A self-report questionnaire designed to measure the sense of presence in virtual reality environments. It comprises 14 items rated on a seven-point Likert Scale. IPQ contains three subscales, which assesses involvement (awareness of the VE), spatial presence (relation between the VE and the subject's own body), and realness (sense of reality attributed to the VE). It also contains a general item that assesses the "sense of being here". To obtain the presence scores for emotional environments, the mean of the IPQ scores obtained in the three test anxiety environments was calculated.

2.2.4.7. STAI (strait-trait anxiety inventory) Spielberger ET Al. (1970). Spanish adaptation: N. Seisdedos (1988). Ediciones TEA, S.A. A self-report questionnaire that assesses state and trait anxiety. Only the state anxiety sub-scale was used in this study. This scale comprises 20 items scored on a Likert scale from 0 (not at all) to 3 (a great deal). In the present study, in order to obtain state-anxiety scores in the emotional environments, the mean score of the three test anxiety environments was calculated.

2.2.4.8. CDB (Barcelona depression questionnaire). Pérez ET Al. (2004). A self-report instrument for measuring changes in depressive state. It comprises 23 items, each one an adjective describing depressive symptoms (sad, frustrated, irritated, etc.); subjects put a cross on the line corresponding to their experience of this particular mood, ranging from "I don't feel like this now" to "I feel like this now". With the aim to obtain the depressive mood scores during the exposure to the test anxiety environments, the mean score of the three test anxiety environments was calculated.

2.2.4.9. SUDS (subjective units of discomfort scale). Wolpe (1969). Subjects indicate their maximum level of anxiety on a scale of 100 points (0 = zero and 100 = extreme anxiety). To obtain the subjective anxiety scores for emotional environments, the mean of the SUDS scores obtained in the three test anxiety virtual environments was calculated.

2.3. Procedure

The virtual environments were 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. More concretely, the exposure to the non-emotional living room was about 10 min, the time spent in the virtual house was 20–25 min, the metro's journey lasted 8 min, and finally the student visited the virtual university during 15 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 program. 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 TAI, the EPQ-RS, the Solid Figures Rotation, the Vocabulary subtest of WAIS-III and the CO questionnaire were administered. Next the neutral environment was administered and the subjects filled the STAI-S, the CDB, the SUDS and the IPQ questionnaire. Afterwards, they were immersed in the three test anxiety environments (the house, metro, and university) and the STAI-S the CDB, the SUDS and the IPQ questionnaire were again administered after the exposure to each virtual environment.

3. Results

A series of repeated-measure ANOVA 2×2 were performed, with the group of students (high or low test anxiety) as a between-subjects factor, and the emotional condition (neutral vs. emotional) as a within-subjects factor. The dependent variables were the STAI-S, SUDS and CDB scores. Means and standard deviations for these questionnaires are shown in Table 1.

A main effect of the emotional condition was found for STAI-S (F (1198) = 429.06, $p < 0.001$), SUDS (F (1201) = 694.66, $p < 0.001$) and CDB (F (1200) = 272.38, $p < 0.001$), indicating that the levels of state-anxiety, subjective anxiety and depressive mood varied according to the environment in which the students were exposed. The results also showed a main effect of the group for STAI-S (F (1198) = 88.16, $p < 0.001$), SUDS (F (1201) = 52.95, $p < 0.001$) and CDB (F (1200) = 59.14, $p < 0.001$). The high test anxiety group presented higher levels of anxiety and depressive mood than the low test anxiety group during virtual exposure. Interestingly, the interaction between situation and group was also significant for STAI-S (F (1198) = 29.28, $p < 0.001$), SUDS (F (1201) = 52.28, $p < 0.001$) and CDB (F (1200) = 60.82, $p < 0.001$), indicating that the differences in the levels of anxiety and depressive mood between the two groups of students were higher in the test anxiety environments than in the neutral one. In general, these results indicate that test anxiety environments were effective in inducing anxiety and depressive mood responses, and that the responses of both groups of students were similar to those of a real test situation.

A series of ANOVAs were then performed on the designs of repeated measures (2×2) with emotional condition (neutral vs. emotional) as within-subjects factor and with group (low test anxiety vs. high test anxiety) as between-subjects factor. The IPQ presence scores were used as dependent variables. Means and standard deviations for

Table 1
Means and standard deviations for the STAI-S, the SUDS, and the CDB of the high and low test anxiety students after exposure to the neutral and test anxiety environments.

	Neutral environment			Test anxiety environments		
	STAI	SUDS	CDB	STAI	SUDS	CDB
Low test anxiety	14.52(7.84)	12.03(15.76)	377.85(330.68)	28.39(10.39)	45.09(21.74)	750.54(560.26)
High test anxiety	20.18(10.50)	16.50(19.45)	556.18(524.19)	43.85(9.40)	74.56(18.95)	1596.61(725.99)

the IPQ and each of the four subscales are shown in Table 2.

The results showed a main effect of ''emotional condition'' for the IPQ total score (F (1201) = 243.98; $p < 0.001$), spatial presence (F (1201) = 124.75; $p < 0.001$), realness (F (1202) = 342.92; $p < 0.001$), involvement (F (1202) = 95.83; $p < 0.001$) and ''sense of being there'' (F (1202) = 133.85; $p < 0.001$). These results indicated that the levels of presence varied according to the environment to which the students were exposed. A main effect of ''group'' was also found for the IPQ total score (F (1201) = 5.51; $p = 0.020$), ''sense of being there'' (F (1202) = 4.08; $p = 0.045$) and realness (F (1202) = 9.91; $p = 0.002$), but not for spatial presence (F (1201) = 2.08; $p = 0.151$) and involvement (F (1202) = 2.54; $p = 0.113$). Significant differences were found in the overall levels of presence experienced by the students, thus high test anxiety students experienced more presence while immersed in virtual environments. In particular these results suggest that the level of test anxiety influences the ''sense of being there'' and the reality judgement attributed to virtual reality environments. Interestingly, an interaction effect between situation and group was found for the IPQ total score (F (1201) = 4.75; $p = 0.030$) and spatial presence (F (1201) = 4.29; $p = 0.028$). No interaction was found either for involvement (F (1202) = 2.57; $p = 0.110$) or for realness (F (1202) = 1.96; $p = 0.162$) and a marginally significant difference was found for ''sense of being there'' (F (1202) = 3.67; $p = 0.057$). This indicates that the differences in the sense of presence between the two groups of students were higher in the emotional environments than in the neutral one. Moreover, the data showed that this overall difference was due almost entirely to the test anxiety students' considerably higher scores on spatial presence when exposed to the test anxiety environments.

Next, correlational analyses were conducted for both groups of students to test the relationship between the sense of presence experienced in test anxiety environments and user characteristics. In the low test anxiety group, no significant correlations were found between user characteristics and either IPQ total score or any of its subscales (Table 3).

In the high test anxiety group, a significant positive correlation was found between the IPQ total score and the

Table 2
Means and standard deviations for the IPQ questionnaire in the neutral and test anxiety environments for both groups of students (high and low test anxiety).

	Neutral environment					Test anxiety environments				
	IPQ	SP	INV	REAL	G	IPQ	SP	INV	REAL	G
Low test anxiety	2.72(0.88)	3.15(1.04)	2.66(1.23)	2.18(0.96)	3.12(1.56)	3.56(0.90)	3.80(0.89)	3.38(1.20)	3.31(0.89)	4.12(1.16)
High test anxiety	2.87(1.00)	3.17(1.09)	2.78(1.38)	2.48(0.92)	3.29(1.65)	3.97(0.78)	4.14(0.71)	3.78(1.08)	3.79(0.89)	4.68(0.98)

Table 3
Correlations between user's characteristics and sense of presence in low test anxiety students.

	IPQ	SP	Inv	Realness	General
EPQE	0.034(0.687)	0.148(0.079)	−0.049(0.565)	−0.070(0.408)	0.099(0.241)
EPQN	−0.053(0.534)	−0.060(0.475)	−0.036(0.668)	−0.021(0.803)	−0.053(0.527)
EPQP	−0.012(0.888)	−0.011(0.900)	−0.004(0.965)	−0.015(0.864)	−0.012(0.883)
Solid rotatory figures	0.087(0.307)	−0.018(0.829)	0.143(0.093)	0.074(0.387)	0.130(0.126)
Vocabulary	−0.003(0.979)	0.055(0.644)	−0.021(0.853)	−0.078(0.512)	0.042(0.727)
CO	0.009(0.919)	−0.072(0.396)	−0.013(0.879)	0.150(0.075)	−0.013(0.877)

Table 4
Correlations between user's characteristics and sense of presence in high test anxiety test students.

	IPQ	SP	Inv	Realness	General
EPQE	−0.317*(0.012)	−0.339**(0.007)	−0.232(0.069)	−0.265*(0.037)	−0.307*(0.015)
EPQN	0.120(0.352)	−0.018(0.890)	0.219(0.087)	0.110(0.396)	0.039(0.764)
EPQP	0.051(0.695)	0.109(0.399)	0.040(0.756)	−0.037(0.773)	0.129(0.317)
Solid rotatory figures	0.404**(0.001)	0.234(0.070)	0.453**(0.000)	0.353**(0.005)	0.382**(0.002)
Vocabulary	−0.010(0.969)	0.119(0.627)	0.005(0.983)	−0.138(0.573)	−0.060(0.807)
CO	0.090(0.488)	−0.049(0.706)	0.136(0.297)	0.129(0.323)	0.119(0.360)

*The correlation is significant at level 0.05 (bilateral).
**The correlation is significant at level 0.01 (bilateral).

Solid Figures Rotation questionnaire (r = .404, $p = .001$). A significant negative correlation was also found between the IPQ total score and the score on the extraversion scale of the EPQ-RS ($r = -.317$, $p = .012$) (Table 4). These results show that the high test anxiety students who score higher on introversion or had more spatial intelligence experienced higher levels of presence within test anxiety environments.

Regarding the specific components of presence, the results revealed a significant negative correlation between extraversion and spatial presence ($r = -.339$, $p = 0.007$), realness ($r = -.265$, $p = 0.037$) and "sense of being there" ($r = -.307$, $p = 0.015$). The analysis also showed a positive significant relation between the Solid Figures Rotation and involvement ($r = .453$, $p < 0.001$), realness ($r = .353$, $p = 0.005$) and "sense of being there" ($r = .382$, $p = 0.002$).

4. Discussion

Virtual reality therapy is based on the assumption that people feel that they are present in virtual environments. Although user characteristics can moderate presence, it is an issue that has not been adequately researched to date. Research into the influence of the user characteristics on the sense of presence felt in VE would be of value because may enhance the selection of patients who would profit most from treatment using virtual reality.

The present study suggests, firstly, that test anxiety environments were effective in eliciting emotional responses, and that the responses of both groups of students were similar to those that would be expected in a real world exam. Our university students showed higher levels of state-anxiety, subjective anxiety and depressive mood in test anxiety environments than in the neutral environment. Moreover, test anxiety students showed a greater increase in anxiety and depressive mood between the neutral and the emotional environments than non-test anxiety students. These results corroborate those found in a previous study (Alsina-Jurnet, et al., 2007) which showed that these test anxiety environments were able to provoke anxiety responses and depressive mood in students with high test anxiety.

Our results show a relationship between the constructs of emotions and presence. Regarding the affective content of the virtual environments, the results show that the students feel a greater sense of presence in test anxiety environments than in the neutral environment. As the environments that represent habitual exam situations (revising, doing the exam, etc.) are situations that students have been familiar with since elementary school, they can be expected to represent meaningful situations for them. Indeed, virtual reality needs this personal relevance to achieve involvement and high presence (Hoorn et al., 2003). The exam situation typically causes some degree of anxiety in all students, and represents a stressful situation. This emotional activation, even higher in test anxiety students, causes most of them to experience some degree of presence. These results corroborate those reported by other researchers (Baños et al., 2004a; Baños et al., 2004b; Bouchard et al., 2004; Riva et al., 2007). Therefore, virtual reality applications directed to the treatment of psychological disorders should include specific elements and situations that are able to activate emotions in virtual environments (Alsina-Jurnet et al., 2007; Price and Anderson, 2007). Despite demonstrating an empirical link between anxiety and presence, we can't be confident at all of a casual relationship. Is possible that these variables are correlated because presence is influenced by a third moderating or mediating variable. Future studies are needed in which both constructs will be manipulated independently. This type of research could sheld some light about the nature of the relationship between presence and anxiety.

The high test anxiety group felt more presence in virtual environments than the low test anxiety group. The differences in the sense of presence (and especially on Spatial Presence and "Sense of Being There) were significantly higher in test anxiety environments than in the neutral one. Overall, these results support the findings of other researchers who found that phobic patients feel more presence when confronted virtually with their fears than non-phobic subjects (Renaud et al., 2002; Robillard et al., 2003). This effect can be explained by the fact that a user's typical response when exposed to high anxiety stimuli is to be on alert and ready to respond. This predisposition to act could enhance the sense of Spatial Presence and the "Sense of Being There" (Freeman et al., 2005). Schubert (1999) also quoted that spatial presence is related to the perceived ability to act inside the virtual environment, and depends on the mental representation of a large body of possible actions within the virtual world.

As regards user characteristics, the results show that spatial intelligence and introversion play an important role in determining the level of presence experienced by high test anxiety students when exposed to anxiety triggering virtual environments. Neither verbal intelligence nor experience with computers have a significant impact.

As far as users' personality characteristics are concerned, introverts with high test anxiety tend to experience a higher degree of presence. This relationship was found for the overall presence score, and for "spatial presence", "realism" and "sense of being there". As suggested by Gutiérrez-Maldonado et al. (2001) introverted people, due to their tendency towards reflection and their low impulsivity, are more comfortable when interacting in a computer-mediated environment in which they can control the rhythm of the interaction, navigate and interact at their own pace. This may lead to the engagement of a higher degree of presence.

As noted above, introverts are also more able to select relevant information from stimuli and more able to apply their attention continuously to meaningful information. As they are unlikely to miss relevant information, introverts probably recollect more spatial information while exposed to virtual environments, leading to the construction of a more accurate mental representation of the virtual world. These subjects can then place themselves within this mental representation and experience higher degrees of ''spatial presence'' and ''sense of being there''. In future studies we plan to evaluate objectively whether introverts can construct a better representation of the virtual world. In general, our results are consistent with those reported by Sas et al. (2004), but contradict those found by Laarni et al. (2004).

Our results also show that students with high test anxiety and higher scores on spatial intelligence tend to feel more presence in test anxiety environments. This relationship was found for the IPQ total presence score and for involvement, realness and the ''sense of being there''. Probably those with high spatial intelligence are quicker to learn what the virtual world is like (for example, the location of the bedroom in which they can study, or the metro entrance, etc.); these students can apply more attentional resources to the ideas and the story related within the virtual environment, increasing the interest and the attention devoted to this virtual space. As people with high spatial intelligence are good at orienting themselves in a three-dimensional space, they are also likely to navigate and interact more easily within virtual environments. As Sheridan (1992) stressed, presence will probably increase as one's ability to modify physical objects in a virtual environment increases and when one has greater control over the task at hand. The present study shows that, in anxiety triggering virtual environments, spatial intelligence is linked to the sense of presence. Furthermore, no relationship was found between verbal intelligence and sense of presence.

Finally, in high test anxiety students no differences were found in the sense of presence in relation to their experience with 3D games and the use of computers. These results are similar to those reported by Schuemie et al. (2005), who found no relationship between computer experience and ability to use the virtual environments.

No significant correlations between user characteristics and sense of presence were found in low test anxiety students. It seems that to induce a high level of presence, virtual environments firstly need emotional relevance; when they fail to activate the emotional structure of the participants the levels of presence remains relatively low regardless of the user characteristics. Baños et al. (2004b) found that in non-emotional virtual environments the characteristics of the virtual reality system (media form) was more relevant than for emotional environments. On the other hand, our study shows that personality characteristics were more relevant in emotional environments than in non-emotional ones. Though further research is needed, it seems that media form plays a greater role in determining the sense of presence in non-emotional environments, and that user characteristics are involved in determining the sense of presence in virtual environments that contain affective content.

The methodology of this study has some limitations. First, the numbers of females were higher for the test anxiety group compared to the non-test anxiety group, which could impact the generalization of the results. Despite this is important to note that test anxiety differ according gender. In a study by Hernández (2005) it was found that the number of females with test anxiety can quintuplicate the number of males. In future it will be of interest to evaluate the impact of user's characteristics in 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. Finally, it must be noted that in all cases the virtual environments were administered following the same order. The students firstly visit the non-emotional living room and then the three test anxiety environments; this should lead to potential bias due to the order of exposure. Also it must be noted that the students spent more time in the test anxiety environments compared to the neutral living room, which can impact the level of presence experienced by them. In future studies it will be needed to study in detail how and under what circumstances the level of presence may fluctuates over the time, increasing or decreasing through the virtual experience. Thus, it should be of interest to present the virtual environments in a randomly order.

Nevertheless, our findings bridge the empirical gap between user's characteristics and sense of presence, providing some light about the mechanisms that can lead to the successfulness of VR applications. Concretely, this study suggests the relevance of Spatial Intelligence and Introversion as mediating variables between an affective anxiety-triggering media experience and the sense of presence. Within a clinical VR setting our results can help to detect those patients who are likely to benefit from VRET. Is important to note that if patients aren't able to involve themselves within an anxiety-triggering environment they can't experience those emotional reactions that can lead to the efficacy of this type of treatment. This implies that exploring and analysing individual differences in the sense of presence can explain why some patients can't benefit from VRET. As noted by some researchers (Sacau et al., 2008) much money can be saved if virtual reality services are directed to those people who are best able to benefit from them. In spite of this, much effort is still needed before we can select VR patients in basis of their individual characteristics.

Our results also corroborate the importance of thoroughly investigating cognitive factors when designing interactive media, suggesting that user's characteristics can't be longer ignored by neither presence researchers nor VR designers. The role of studying user's characteristics comes under remit of user-centered design (Kaber et al., 2002). Once we understand individual differences in terms of user's abilities to focus, capture, process, or make use of VR systems, we will be able to accommodate these differences.

5. Conclusions

The aim of this study was to investigate the human factors that may lead individuals to experience a high degree of presence. This study is the first to investigate the relationship between spatial intelligence and sense of presence. It breaks new ground in using an immersive virtual reality system to study the influence of personality characteristics on the sense of presence. It also investigated the influence of the degree of participants' test anxiety, verbal intelligence and computing experience on sense of presence. The results first show a relationship between emotion and sense of presence, finding that presence was higher in emotional environments than in a neutral one. Moreover, test anxiety students experienced a higher degree of presence than low test anxiety students, especially in test anxiety environments.

The results also showed that high test anxiety individuals with higher scores on spatial intelligence or introversion tend to experience greater presence within emotionally significant virtual reality environments than high test anxiety students with lower scores on these dimensions. Interestingly the results showed that introversion is related to "spatial presence", "sense of being there" and "realism", whereas spatial intelligence is related to "involvement", "sense of being there" and "realism". These results suggest a relationship between spatial intelligence and the sense of presence experienced specifically within immersive virtual reality environments but an issue that remains unclear is whether spatial intelligence is also relevant in other simulated scenarios. Users may experience high levels of presence in either virtual environments or fictional narratives, but, in all probability, the mediating cognitive processes that lead to the sense of presence are different in the two contexts. As pointed out by Schubert and Crusius (2002), literature seems to produce presence mainly through the use of the power of narration, and so in this case the impact of the users' ability to mentally manipulate 3D objects on the feeling of presence is probably less relevant than in virtual environments. To answer this question we recently initiated a project designed to test the impact of spatial and verbal intelligence on the sense of presence experienced while a participant is either reading or writing a text. This line of research can help to understand the paradox of the "book problem" (Biocca, 2002), that is, the fact that people can experience presence in narratives presented in book form, in which immersion would appear to be very low.

No relationship was found between sense of presence and either computer experience or verbal intelligence. Nor was any relationship found between user characteristics and sense of presence in low test anxiety students. These results suggest that, in order to feel high levels of presence, virtual reality first needs to have emotional relevance; when this is achieved, user characteristics can play an important role.

This line of research will broaden our understanding of the mechanisms that lead to the efficacy of virtual reality exposure therapy, and can help to explain why different individuals experience different levels of presence when confronted with the same virtual environments.

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