Individual Differences in the Sense of Presence

Ivan Alsina Jurnet, Cristina Carvallo Beciu and José Gutiérrez Maldonado
University of Barcelona
{ivanalsinajurnet@lycos.es, cristina.carvallo@lycos.es, jgutierrezm@ub.edu}

http://www.ub.es/personal/rv/rv1.htm

Abstract

There is a lack in the literature of studies that investigate the human factors involved in the engagement of presence. The present study is addressed to investigate the influence of five user's characteristics (spatial intelligence, personality, cognitive style, computer experience and test anxiety) on the sense of presence. This study is the first one to investigate the relationship between spatial intelligence and presence, and it's also pioneer in investigating the influence of personality characteristics on the sense of presence in an immersive virtual reality system. Results suggest that spatial intelligence, introversion, and anxiety influence the sense of presence experienced by the user.

1. Introduction

One of the core features in the virtual reality treatment of psychological disorders is the sense of presence. Although there is not a common definition of presence and it is a rather difficult concept to define and measure, there is a consensus to define it as a multi-component construct influenced by technological factors on the one hand, and by human factors on the other hand. The aim of this study is the research of the human factors (spatial intelligence, personality, cognitive style, computer experience and test anxiety) that can determine the engagement of the sense of presence in environments designed to treat students with test anxiety. This is the first study that is conducted to investigate the influence of spatial intelligence in the sense of presence, also it is pioneer using an immersive virtual reality system to investigate the relationship between the personality characteristics of the users (measured through the EPQ-RS questionnaire) and presence.

According to Steuer (1), determinant factors affecting presence can be grouped into three dimensions: vividness, interactivity and user characteristics. Steuer defines vividness as the representational richness of mediated environments defined by its formal features, that is, the way in which an environment presents information to senses. Interactivity is defined as the extent to which users can participate in modifying the form and content of a mediated environment in real time. Finally, the influence of user's characteristics derives from the individual differences in the sense of presence when subjects are confronted with the same virtual environments. In a similar way, Lombard (2) pointed that presence is determined by media characteristics and user characteristics. Media characteristics are divided into: media form, that includes the properties of a display medium (such as the extent of information presented, user's ability to modify the aspects of the environment, etcetera); and media content, that includes the objects, actors, and events represented by the medium. User's characteristics refer to the range of individual differences (for example age, gender, user's perceptual, cognitive or motor abilities, and so on).

Most of the studies that attempt to specify the determinants of the sense of presence have focused in the media form, concluding that some of the factors which can influence the subjective experience of presence are: the field of view (3,4,5,6), the foreground/background manipulations (7), the update rate (8), stereoscopy (5,9, 10), geometric field of view (9), pictorial realism (11,12), image motion (5), the use of a CAVE versus a desktop VR (13) or a HMD (14), spatial sound (15), the number of audio channels (16), tactile (17,18) or olfactory cues (18), the use of head tracking (15, 19), the feedback delay (11), the possibility to interact with the virtual environment (11, 20) or the body movement (21).

Relating to the influence of media content on presence, Hoffman (22) encountered that the sense of presence of experienced chess players was enhanced when chess pieces were positioned in a meaningful way,. In this line of research, EMMA project is aimed to study if emotions may enhance presence (23). Thus, if an environment is able to produce anxiety, sadness, joy, etc. it will be more probable that the user feels present in that environment. The results obtained at this moment show that presence could be influenced by the emotions that the environment is able to provoke to the user (24, 25).

Although presence is a psychological phenomenon (26), little research has been done about the user's characteristics involved in its engagement, thus previous discussions have been typically based on informed conjecture rather than research. Despite this fact, several authors (1, 2, 27, 28) state that presence is not only a direct function of the characteristics of the system but also of the human factors. In words of Schubert (29): "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".

An interesting issue to point here is the difference between the terms "immersion" and "presence". In this line, Slater (26) distinguished between the terms immersion (an objective description of aspects of the system such as field of view) and presence (a subjective phenomenon such as

the sensation of being in a VE). Three years later, Kalawsky (30) argue that presence is a cognitive parameter whereas immersion essentially refers to the physical extent of the sensory information, being a function of the enabled technology.

The pioneer study investigating the relationship between user's characteristics and sense of presence was conducted by Slater and Usoh (31) who distinguished between exogenous and endogenous factors responsible for determining the extent of presence. These authors use the therapeutic technique known as NeuroLinguistic Programming (NLP) to characterize the user's psychological representational and perceptual systems. This model claims that subjective experience is encoded in terms of three main representation systems: Visual, Auditory and Kinesthetic, and people usually prefer one system over the others. Furthermore, the experiences and remembers of a given individual are encoded in one of these perceptual positions: first (egocentric standpoint), second (from a 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 endowed with a disembodied arrow cursor, and the experimental group had a virtual body that responded to the participant 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. Results suggested that the greater the degree of visual dominance, the higher the sense of presence, whereas those who preferred the auditory representational system experienced the lower 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.

In a similar study Slater, Usoh and Steed (32) exposed 24 subjects to a VE and found the same results encountered in the previous study; participants who preferred the visual or the kinesthetic representational system (in this case if a virtual body was included) experienced the higher levels of presence. Finally, in a study performed with 8 participants, Slater, Usoh and Chrysanthou (33) found that including dynamic shadows in a virtual environment only derived in a higher degree of presence in those individuals who preferred the visual representational system.

In 1998 Witmer and Singer (34) developed the ITQ (Immersive Tendencies Questionnaire) to measure the tendencies of individuals to become immersed in a virtual environment. The ITQ is composed by three subscales: Involvement (propensity to get involved passively in some activity like reading books), Focus (ability to concentrate on enjoyable activities, and ability to block out distractions) and Games (frequency with which the subject plays games and the level of 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 the same year, Bangay and Preston (35) found in a study with 355 participants that subjects between ages 35 and 45 tended to provide lower scores in presence than the participants between ages 10 and 20.

One year later, in the University of Valencia, Baños (36) found that absorption (defined as the tendency to become involved or immersed in everyday events or the tendency to totally immerse oneself with the attentional objects) was positively correlated with presence in virtual environments. This study found that the individuals who experienced more anxiety during the exposure, had higher scores on presence.

Corina Sas (37), in a later study, performed with 15 students, investigated the relationship between four cognitive factors (absorption, creative imagination, empathy and cognitive style), and the sense of presence experienced by the users in a non immersive virtual reality system. The results show a significant correlation between presence score and creative imagination on the one hand, and presence and empathy, on the other hand. Presence also correlates highly, but not significantly, with the absorption scale. Due to the limited size of the sample, the results that concern the cognitive style are of limited value, but it seems that participants with perceiving or feeling type experienced a higher degree of presence. Furthermore, no differences were found in the sense of presence in function of the participant's gender. One year later, Sas (38) studied the effect of cognitive styles (measured through the Myers-Briggs Type Indicator) upon the sense of presence. In the line of the anterior study, Sas encountered that subjects who scored higher in feeling type or sensitive type, experienced a higher level of presence. Also, without being significant, introverted individuals tended to experience higher presence.

Finally, in a study conducted in 2005, Schuemie (39) exposed 41 participants to a virtual environment that contain height situations. No correlation between presence and absorption, gender, computer experience or the level of acrophobia was found. Despite this, a positive correlation was found between presence and age.

This study was conducted to evaluate the impact of five individual characteristics (personality, spatial intelligence, degree of test anxiety, cognitive style and experience in the use of computers) upon the sense of presence. Schubert's (29) spatial-functional model suggests that two cognitive processes are responsible of the engagement of the sense of presence. These are 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, where the location of the own body is constructed as being contained in the space rather than looking at it from outside. Once users have developed such model 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, as pointed by Schubert (29), users need to perceive that they are capable of taking on the role they are governing 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 world to the virtual world. Thus it is expected that higher levels of spatial intelligence and more computer experience will facilitate the navigation and interaction within the virtual world, and, consequently, lead to a greater sense of presence.

In order to construct the mental representation of the virtual space, users have to suppress conflicting sensory inputs such as the stimuli of the hardware or the stimuli of 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 (29, 34). Introverts have been suggested to have a narrower focus of attention than extraverts. This narrower range of attention leads to a less extensive processing of the stimuli not related to the primary task, and, consequently, task-irrelevant or distracting information should be more easily ignored (40). Hence, due to the greater capacity of introverts to allow their attention to the main task, it may be suspected that the most introverted subjects should experience higher levels of presence in virtual environments.

Although several authors state that two of the main dimensions of presence are the sense of physical space and the selective attention to the virtual environment (2,29,34,41), this is the first attempt to investigate the influence of spatial intelligence on presence. Furthermore, to our knowledge, this is the first study utilizing an immersive virtual reality system to investigate the relationship between personality characteristics and presence. Other studies, mentioned before (37, 38), used non immersive virtual reality systems.

Cognitive style is another factor that can influence the sense of presence. Cognitive style refers to an individual preferred and habitual approach to organizing and representing information (42). One approach is the distinction between verbalizers and visualizers. Visualizers use images as a form of thinking, whereas verbalizers operate mostly in a world of words and verbal thoughts, ideas and structures. Thus, visualizers prefer visual information, and verbalizers prefer verbal or written information. Virtual reality environments offers mainly visual information to the participants, with a lower auditory stimulation, for this reason we formed the hypothesis that visualizers are likely to experience a higher degree of presence than verbalizers. Furthermore, people whose cognitive style is mainly visual, probably can construct a more accurate mental model of the virtual environments, this mental model, according to the spatial-functional model of Scubert (29), is necessary to experience presence.

Finally, the relationship between emotion and presence is investigated. Huang & Alessi (43) 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. We consider that presence is influenced by emotions. In mental health applications of virtual reality, numerous have demonstrated that emotions are especially important in order to generate and enhance the sense of presence (44,45,46,47). From this line of thinking, in this study it may be expected that high test anxious students will obtain higher levels of presence than low test anxiety students.

This study is part of a broader reseach in which the exposure to virtual environments will be used to evaluate and treat test anxiety in students. In a first stage of this project a study was conducted to explore the effectiveness of virtual environments in producing emotionally significant responses in students with high degrees of test anxiety. This study concluded that the virtual environments were able to provoke higher levels of subjective and state anxiety, and higher levels of depressed mood in high test anxiety students than in low test anxiety students. Later, a pilot study (48) showed benefits in the treatment of test anxiety by using the technique of exposure to these virtual environments, obtaining a reduction in the levels of test anxiety of the participants and an increase in their academic performance. These students also diminished their ratings of avoidance to exams.

2. Method

2.1. Subjects

The initial sample, recruited via an on-line course on test anxiety, comprised 306 university students. The Test Anxiety Inventory (49) was administered to assess subjects' degree of test anxiety. Students who presented extremely high or extremely low scores were contacted. Those with scores in or above the 75th percentile (direct punctuation > 55) on the TAI were provisionally recruited for the high test anxiety group and students with scores in or below the 25th (direct punctuation < 36) for the low test anxiety group.

Finally, 26 students agreed to take part in the study, 16 with high test anxiety and 10 with low test anxiety. Twenty-two were women (84.6%) and four were men (15.4%), with a mean age of 22.85 years (S.d.: 3.21 range 18 – 34). The high test anxiety group comprised 16 women with a mean age of 23.06 years (S.d..: 3.45), the low anxiety group comprised six women and four men with a mean age of 22.5 years (S.d..: 2.9).

2.2. Instruments

Hardware:

The virtual environments were developed on a Pentium IV, 2 GHz, Windows 2000, 768 Mb RAM, 60 Gb hard disk, 19'' monitor, Hercules 3D Prophet 9700 PRO graphics cards with 128 MB DDR and AGP 8X. An *I-visor* DH-4400VP virtual personal display was used with a resolution of 800 X 600 pixels and a visual field in diagonal of 31º, connected to a *Tracker* Intersense 3-DOF (*degrees of freedom*) which measured the position and movement of the head.

Software:

To develop 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. The Poser 4 program 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 was used to combine the objects and characters created with the different graphic design tools, and to integrate them with textures and sound. It was also used to make the environments interactive and to facilitate browsing.

Virtual scenarios:

The virtual environments were prepared in chronological order: the student's home, representing the day before and the morning of the examination, then the metro, and finally, the corridor and lecture-hall where the examination takes place. The situations and elements that comprise the environments were selected on the basis of a survey administered following a procedure that will be described later. Also a training room was created in which the students can familiarize with the technology.

-Training room:

This scenario represents a room composed by different elements like tables, chairs, a sofa, switches, and so on. In this room the students can learn to navigate in the environment, use the head tracking to look at the different directions, and interact with the objects (sit, switch on the light, etcetera).

- Home:

The scenario includes a flat, with a bedroom, (figure 1), a corridor, bathroom, dining-room (figure 2), 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.

Figure 1. View of the bedroom

Figure 2. View of the dining-room

- Metro:

This scenario represents part of the Barcelona underground system (figure 3). 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 (figure 4). During the journey, which lasts three stops, the student can study while other students talk about the examination they are about to take.

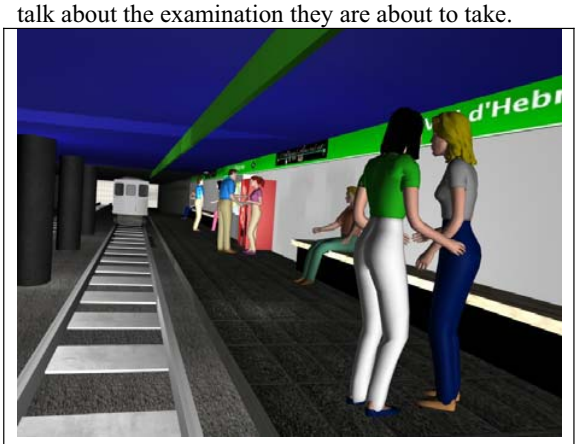

Figure 3. The metro station

Figure 4. Inside the metro.

- University:

There are two scenarios at the university. In the first (figure 5) 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 (figure 6). 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.

Figure 5. The hallway in the university

Figure 6. Inside the examination room

- Evaluation:

• TAI (Test Anxiety Inventory) (49).

A self-report questionnaire designed to measure test anxiety as a situation-specific personality trait. The questionnaire comprises 20 items in which the student must indicate how often they experience the symptoms of anxiety before, during and after the 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).

• EPQ-RS (Eysenck Personality Questionnaire Short Revised version) (50).

A self-report questionnaire designed to measure the personality characteristics. The EPQ-RS consists of 48 items, each answered on a yes-no basis, that asses the Eysenckian dimensions of extroversion, neuroticism and psychoticism. It contains three sub-scales: Extraversion, Neuroticism, Psychoticism and Social Conformity or Lie.

• Solid Figures Rotation (51).

It is a 21 item self-applied instrument designed to measure the aptitude to recognize and interpret objects in the space. In each item five different solid figures are presented. Each figure displays a three dimensional solid block. The person must decide which figure matches a given model figure seen from another perspective.

• IPQ (Igroup Presence Questionnaire) (29).

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, each one of them composed by four items, which asses Involvement (the awareness devoted to the VE), Spatial Presence (the relation between the VE and the own body), and Realness (the sense of reality attributed to the VE). Also contains one item that asses the "sense of being here".

• VVQ (Verbalizer-Visualizer Questionnaire) (52).

The VVQ is the most used measure of the relative reliance on verbal and visual code in habitual modes of thinking. It is a self-administered questionnaire constituted by 15 true-false items. The results raise a single value, the higher scores indicate visual preference while low scores are indicative of a verbal preference.

- CO (Computer experience) (53).

This instrument asseses subjects' experience with 3D games and computers. It consists in a 5 item scale rated from 1 to 5, where 1 = *very bad/never* and 5 = very good/often.

2.3 Procedure

To obtain information on the elements needed to make the environments clinically significant, we asked to a sample of 240 undergraduate students of the University of Barcelona which examination-related situations and thoughts generated the higher levels of anxiety (48). After analysis of their responses, 22 specific categories related to specific situations were established. The most frequent ones were: the comments of classmates, studying the day before the exam, bed time, waiting in the hallway, the morning of the examination, sitting in the examination room, the day before the examination, and so on. All these situations were incorporated in the three previously designed environments. Furthermore, nine categories related to anxiety thoughts were obtained, in this case the most frequent ones were the negative evaluate of owns capacities, perfectionism, worry about extern factors, worry about the negative consequences of failure, etcetera. These thoughts were inducted to the students through the conversations maintained by the virtual students in the virtual environments

In the present study, the virtual environments were presented to the two groups of students (high and low test anxiety). Exposure to the virtual environments was individual. Subjects visited all the environments in a single session (the mean duration of the sessions, including exposure to the environments and administration of the questionnaires, comprised 120 minutes). 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' behaviour in exam situations, in order to prepare a treatment program. Before starting the session, the 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 and they were told what it involved, and what tasks they could perform. Before starting the exposure to test anxiety environments, each participant was exposed to the training room with the objective that can familiarize with the virtual worlds and the virtual reality technology, and was administered the EPQ-RS, the VVQ, the Solid Figures Rotation and the CO questionnaire. After seeing each test anxiety environment each participant was administered the IPQ questionnaire.

3. Results

Multiple regression analysis were conducted to fit linear models relating the dependent variable to the independent variables. The EPQ-RS, VVQ, Solid Figures Rotation, TAI, and CO questionnaire scores were included as predictors in a linear regression with the IPQ scores in the house, metro, university, and the average score of the IPQ obtained in the three virtual environments as dependent variables. The method used in all cases was step wise.

In the regression model performed to predict the score of the IPQ in the house, only the score obtained in the Solid Figures Rotation was included in the regression equation ($R=0.503$, $p=0.009$), explaining the 25.3% of the presence's variance. As shown in table 1, the correlation between these variables was significant ($p=0.004$). The analysis also showed a significant negative correlation between IPQ and the extraversion sub-scale of the EPQ-RS ($p=0.046$). Also, no significant correlation was found between the student's test anxiety and the IPQ scores ($p = 0.125$). These results indicated that the higher scores in spatial intelligence lead to experience a higher degree of presence. Also, the most introverted students tend to feel more present in the virtual house than the extroverted.

In the second virtual environment (the metro) only the score obtained in the TAI questionnaire ($R=0.475$, $p=0.016$) was included in the regression equation, this variable explains the 22.6% of the variance of the IPQ, also the correlation between these variables was found significant ($p=0.008$). As in the anterior environment, extraversion correlated negatively with the score obtained in the IPQ ($p=0.024$). No more significant correlations were found in this environment (table 1), although the analysis also showed a small trend ($p<0.10$) toward a positive correlation between the psychoticism sub-scale of EPQ-RS and the score obtained in the IPQ questionnaire. These results show that individuals who scored higher in test anxiety experience the highest degree of presence. Also, introverts tend to obtain higher scores on presence.

In the regression analysis performed to predict the IPQ scores in the virtual university, none of the predictors was included in the regression equation. Despite this, the results showed two marginally significant correlations (table 1). On the one hand, the IPQ score correlate positively with the Solid Figures Rotation ($p=0.050$), and, on the other hand, the IPQ correlated positively with the level of test anxiety of students ($p=0.061$). Thus, in this environment, the individuals with highest scores on TAI, but mainly on the Spatial Figures Rotation, had a tendency to obtain higher scores on presence.

Finally, a composed measure of presence in the three environments was calculated as the average of the IPQ scores obtained in the house, the metro and the university. None of the predictor variables was included in the

regression equation, although significant positive correlations between presence and the scores obtained in the Solid Figures Rotation (p=0.033) and TAI (p=0.028) were found. Also, a negative significant correlation was found between the IPQ scores and the extraversion sub-scale of the EPQ-RS (p=0.043). These results indicate that the participants tend to feel more present in the environments if they are introverted or if they have a high degree of test anxiety or spatial intelligence.

Table 1. Pearson's correlation coefficients (and significance) between the scores of IPQ and EPQ, Solid figures rotation, VVQ ,CO and TAI.

	IPQ House	IPQ Metro	IPQ University	IPQ Total
EPQE	-0.338 (0.046)	-0.400 (0.024)	-0.216 (0.144)	-0.350 (0.043)
EPQN	0.089 (0.333)	0.228 (0,136)	0.091 (0.329)	0.156 (0.229)
EPQP	0.238 (0.121)	0.293 (0.077)	0.073 (0.362)	0.224 (0.140)
EPQD	0.003 (0.494)	0.106 (0.307)	-0.083 (0.344)	0.014 (0.473)
Solid Figures Rotation	0.503 (0.004)	0.220 (0.146)	0.330 (0.050)	0.373 (0.033)
VVQ	-0.044 (0.415)	0.046 (0.413)	0.095 (0.321)	0.035 (0.434)
CO	-0.218 (0.142)	-0.003 (0.495)	-0.129 (0.264)	-0.131 (0.434)
TAI	0.233 (0.125)	0.475 (0.008)	0.312 (0.061)	0.386 (0.028)

4. Discussion

Virtual reality therapy is based on the assumption that people feel present in the virtual environment. Despite individual differences can moderate presence, little research has been conducted in this line. Research into these individual moderating traits will be of value because it may enhance the number of patients that can benefit of virtual reality therapy and can help to understand why some patients don't respond to this form of therapy. Exploring these variables can help to explain why the 20% of the patients treated by Max North (28) showed little or no reduction in agoraphobic symptoms, or why half of the participants of the study conducted by Walshe (54) didn't feel present in virtual reality environments. These studies suggest that it doesn't exist a direct relationship between the sense of presence and the media characteristics. In that case, all subjects should respond in the same way when confronted with the same virtual reality system, whereas, in fact, usually, identical media form and content produce different degrees of presence in different individuals.

The results of this study suggest that test anxiety, spatial intelligence and extraversion have an important influence in the level of presence experienced by students exposed to virtual environments in order to treat their test anxiety problem, and neither verbalizer-visualizer cognitive style nor the experience with computers have a significant impact on it.

The individuals with higher spatial intelligence tend to feel more present in the virtual environments. For a better understanding of this relationship, we must take into account the sense of presence experienced in each particular environment. The results suggest that in the university, and mainly in the house, there is a high relationship between spatial intelligence and presence, but no relationship was found in the metro.

Each environment requires a different degree of interaction. The house was designed as the environment with the highest interaction degree because the participant can navigate freely and at his own pace through the different rooms, and she can interact with a great number of elements. In the virtual university the navigation is restricted; the students can only navigate freely in the hallway while they are waiting for the lecturer to arrive. Despite this, the environment requires a high degree of interaction to respond to the exam. Finally, the metro is the environment with fewest interaction opportunities (the student can only pick up his/her briefcase for study) and with less free navigation (during the journey the student is sitting). This is the first study that evaluates the influence of spatial intelligence on the sense of presence, and it seems to play an important role in interaction with the characteristics of the environments.

Regarding the personality characteristics of the users, introverts tend to experience a higher degree of presence. This relationship could be explained by the fact that introverted people are more able to select relevant information from the stimuli they are exposed to, Thus, introverted participants probably were more able to suppress the distracting stimuli and focus their attention to the virtual environments, increasing the sense of presence (29,34). Furthermore, as suggested by Gutierrez-Maldonado et al., it must be pointed that introverted people, due to their tendency to reflection and their low impulsivity, are more comfortable when interacting in a computer mediated environment, where they can control the rhythm of the interaction (55). In the virtual environments they can navigate and interact at their own pace, so they feel more comfortable, and this can lead to a higher degree of presence.

This relationship was found in the house and in the metro, not in the university. These results are consistent with those found by Sas (38), who found that, in a non immersive virtual reality system, individuals who are more introverted are likely to experience higher degrees of presence (without being statistically significant). Thus, it seems that independently of the degree of immersion, introverts tend to score high in presence.

Regarding test anxiety, the results point towards a correlation with presence in every environment, excluding the virtual home. A very strong relationship is found in the virtual metro. The high correlation obtained in the virtual metro can be due to the fact that some of the high test anxiety students had some degree of specific anxiety to the metro too. This can lead to an enhanced sense of presence of these students, and provoke, in part, the high correlation between test anxiety and presence found in this environment.

The environments represent habitual situations of exam (the participants can study, do an exam, etc.), situations that are experienced by the students since the elementary school. For these reason, it can be considered that these environments represent a meaningful situation for them. Virtual Reality needs personal relevance to achieve involvement and high presence (56). Probably the meaningfulness and personal relevance of test anxiety environments for students can lead to experience high levels of presence in most of them. Furthermore, an exam situation typically causes some degree of anxiety in students, and represents a stressful situation. This emotional activation, even higher in test anxiety students (48), can lead to experience a high degree of presence in most of them. Thus, the meaningfulness and the emotional activation of test anxiety environment can moderate the effect of the degree of test anxiety upon the sense of presence. These results suggest that there is a relationship between presence and emotions.

No relation was found between the verbalizer-visualizer cognitive style of the students and the sense of presence in none of the virtual environments. These results are discordant to those found by Slater (31, 32) who encountered that people whose preferred representational system was the visual one were likely to have a higher degree of presence than those whose primary system was auditory or kinaesthetic. Probably the differences between these studies are due to discrepancies in the media content of the environments. In the studies conducted by Slater, the virtual environments offered primarily visual stimulation. In our study the auditory stimuli are important (there are virtual students maintaining conversations), and also the students can read their notes in each environment. The individuals whose main representational system is the auditory prefer to process the information through words, and they tend to like listening and reading. For these reason, the results of these studies aren't contradictory, because they offer evidence that the sense of presence is influenced by both user's traits and media content. The differences between studies can also been motivated by the measure utilized to evaluate cognitive styles.

Finally, no differences were found in the sense of presence in function of the experience with 3D games and the use of computers. These results are similar to those found by Schuemie (39), who didn't found relationship between the computer experience and the usability of the virtual environments. Probably spatial intelligence is more important than computer experience in order to construct a mental representation of the virtual world, and facilitate the navigation and interaction through the them.

5. Conclusions

The aim of this study was to investigate the human factors that can lead to experience a high degree of presence. This study is the first one to investigate the relationship between spatial intelligence and sense of presence, it's also pioneer using an immersive virtual reality system to study the influence of the personality characteristics upon the sense of presence. It was also investigated the influence of the degree of test anxiety, cognitive style and the computer experience of the subjects on the sense of presence. Results suggest that the individuals with high spatial intelligence, introversion and test anxiety tend to experience a higher degree of presence. It's interesting to point that higher levels of spatial intelligence are necessary to experience presence in the environments with higher degrees of navigation and/or interaction. Probably the influence of the degree of test anxiety on the sense of presence is mediated by the meaningfulness and emotional activation that the environments are able to produce; to check this hypothesis in future studies it will be interesting to incorporate state-anxiety measurements. It should be noted that the sample used in this study is relatively small and most of the participants were female. In future works it would be interesting to balance the gender of the participants and increase the sample size.

This line of research will contribute to understand the mechanisms that lead to the efficacy of virtual reality exposure psychological treatments, and can help to explain why different individuals can experience different levels of presence when being confronted with the same virtual environments (1).

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