

The relationship between individual characteristics and experienced presence

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Abstract

People experience different levels of presence (e.g. Krijn et al., 2004; Walshe, Lewis, Kim, O'Sullivan, & Wiederhold, 2003), and different levels of cybersickness (Sharples, Cobb, Moody, & Wilson, 2008) even though they are immersed in the same virtual environment setting. In the current study, we raised the question how differences in individual characteristics might relate to differences in sensed presence for a virtual environment related to public speaking. The individual characteristics included in the experiment were related to visual abilities, personality traits, cognitive styles, and demographic factors. We recruited 88 participants, who were first immersed in a non-stereoscopic neutral environment, and then in a public speaking world: once with stereoscopic rendering and once without stereoscopic rendering, in a counter-balanced order. The results showed that immersive tendency and monocular visual ability were significantly correlated with presence and these correlations were consistent among the three virtual environments. Immersive tendencies and its subscale “involvement” were also found to be significantly correlated with cybersickness in all three worlds. Screening people on these variables may help to recognize the users who are more likely to benefit from virtual reality applications and may help to reduce the number of dropouts during virtual reality exposure therapy.

Key words: individual characteristics, presence, cybersickness, public speaking world, neutral world, stereoscopy

1 Introduction

Presence is normally used to describe the illusion of being in the virtual environment rather than in the real world in which the user is physically located (Witmer & Singer, 1998). It is suggested that the efficacy of virtual reality systems is directly related to the quality of presence (Wiederhold & Wiederhold, 2005). It is also argued that presence is a key component contributing to realistic responses in virtual environments (Slater, 2009).

Individuals experience various amounts of presence in similar virtual environments. For example, Krijn et al. (2004) excluded 10 out of 37 patients from an experiment in virtual reality exposure therapy (VRET), because the virtual environment did not arouse sufficient anxiety. Patients who experienced no anxiety and dropped out reported significantly lower presence than the patients who completed the therapy. In Walshe, Lewis, Kim, O'Sullivan, and Wiederhold (2003), only 50% (7/14) of the patients with driving phobia who felt immersed in a virtual driving environment successfully finished the treatment. Hence, a deeper understanding of the determinants of presence may help to identify the individuals that would benefit most from virtual reality.

Individual differences that may determine people's susceptibility to feel present include visual acuity, cognitive abilities, personality, personal experience, etc. (IJsselsteijn, de Ridder, Freeman, & Avons, 2000; Sacau, Laarni, & Hartmann, 2008; Stanney, Mourant, & Kennedy, 1998). There are several possible ways in which individual differences may affect the sense of presence. For example, less involvement in common activities may result in less immersive tendencies, expertise in computer technology may create disbelief in the virtual environment, less developed spatial abilities may yield problems in generating a mental representation of a mediated virtual world, etc. Because of all these reasons, people may feel less immersed in virtual environments and their experienced levels of presence may be diminished. The role of individual factors in experienced presence has started to draw researchers' attention (Sacau et al., 2008). However, empirical results are still scarce in this area and further studies are needed. Therefore, in the current study, we address the question whether we can predict how much presence people will experience in virtual environments based on their individual characteristics.

We particularly focus this research question in the practically very relevant context of virtual reality exposure therapy for social phobia. Worldwide, mental illnesses are recognized as the major cause of disability, and five of the top ten causes of disability are

neuropsychiatric disorders (Lopez & Murray, 1998). It is estimated that 43% of the adult Dutch population is affected by a mental illness in their lifetime and 19.6% of the Dutch population experiences an anxiety disorder (de Graaf, Ten Have, van Gool, & van Dorsselaer, 2011). Social phobia is frequently identified as one of the most prevalent anxiety disorders (Klinger et al., 2004). About 12.1% of the adult US population (Ruscio et al., 2008) and 9.3% of the adult Dutch population meet diagnostic criteria for social phobia at some point in their life (de Graaf et al., 2011). The most common lifetime social fears are public speaking (21.2%) and speaking up in a meeting or class (19.5%) (Ruscio et al., 2008). Therefore, for virtual reality exposure therapy treating social phobia, most studies focus on the fear of speaking in front of a virtual audience (Anderson, Zimand, Hodges, & Rothbaum, 2005; Harris, Kemmerling, & North, 2002; Slater, Pertaub, Barker, & Clark, 2006; ter Heijden & Brinkman, 2011). Patients show significantly reduced anxiety after exposure to an audience of avatars in virtual reality (Anderson et al., 2005; Harris et al., 2002; Lister, Piercey, & Joordens, 2010; Robillard, Bouchard, Dumoulin, Guitard, & Klinger, 2010).

One particular concern for patients engaged in VRET is the possibility of side effects such as cybersickness (Wiederhold & Wiederhold, 2005). Cybersickness is an unwanted psychophysiological response to the perceptual illusions of virtual environments. Symptoms include headache, blurred vision, dizziness, nausea, etc. (Kennedy, Lane, Berbaum, & Lilienthal, 1993). Cybersickness is, to a large extent, similar to motion sickness. Therefore, cybersickness is particularly an issue in dynamic virtual reality environments, where motion in the visual information is in conflict with vestibular signals. Cybersickness, however, can also be induced in more static virtual reality environments, due to limitations in the rendering equipment used. For example, a heavy head-mounted device (HMD) may cause neck strain or headache if the strapping band is too tight around the forehead. Also incongruities between monocular depth cues and stereo vision may cause eyestrain and cybersickness related symptoms (Lambooj, Fortuin, Ijsselsteijn, Evans, & Heynderickx, 2010).

Therefore, the main goal of this study is to investigate which of the various effects of individual characteristics on presence, some of which are addressed in literature (Ijsselsteijn et al., 2000; Murray, Fox, & Pettifer, 2007; Sacau et al., 2008; Sas, 2004; Wallach, Safir, & Samana, 2010) is of relevance in the public speaking domain. In addition, we evaluate whether these variables can also predict cybersickness in the same virtual environment. To

this end, eighty-eight participants were recruited. Individual characteristics including visual abilities, immersive tendencies, absorption, locus of control, empathy, spatial intelligence and demographic factors were first tested. After that all participants were immersed in three different virtual environments: a non-stereoscopic virtual neutral world, a non-stereoscopic virtual public speaking world and a stereoscopic virtual public speaking world. The relationships between individual characteristics and presence averaged across the three virtual environments were investigated. The presence differences caused by stereoscopic rendering and task requirement were also calculated by subtracting presence scores between different worlds, and the relation between the individual characteristics and these presence differences was studied. Finally, we performed correlation analyses between individual characteristics and cybersickness scores, and conducted semi-partial correlations between individual characteristics, presence and cybersickness.

1.1 Individual characteristics impacting on presence

Based on available literature (IJsselsteijn et al., 2000; Sacau et al., 2008), we identified the following individual characteristics as possibly affecting perceived presence in virtual environments: visual ability, immersive tendency, absorption, locus of control, empathy, spatial intelligence and demographic factors. Rather than only aiming to find predictors for an individual's presence level, we aim to find out which individual characteristics are the underlying reasons why some people experience more presence than others.

Visual ability. Visual ability comprises multiple aspects, of which especially stereo acuity is important when content is rendered stereoscopically. Stereoscopic acuity is a measure of the ability to detect the depth of a test stimulus with respect to a comparison stimulus that is in the plane of zero disparity (Howard & Rogers, 2002). Stereoscopic acuity is suggested to be an important factor for perceived presence when content is shown stereoscopically (IJsselsteijn et al., 2000). However, Hale and Stanney (2006) did not find a significant difference in the sense of presence between two groups, i.e. one with good stereo acuity and one with low stereo acuity with 23 participants in each group. Whether this finding can be replicated in the current study is investigated. Since so far, to our knowledge, no empirical research has investigated the effect of visual acuity on presence, we included this possible effect in our study.

Immersive tendency. The immersive tendency questionnaire (ITQ) was originally designed to measure differences in the tendencies of individuals to experience presence in an immersive virtual environment (Witmer & Singer, 1998). Most of the items of the ITQ measure “involvement” in common activities. It is expected that individuals who tend to become more “involved” also have greater immersive tendencies, and that increased involvement can result in more presence in an immersive environment. The rest of the items measures immersive tendency and assesses users’ ability to focus or redirect their attention (Witmer & Singer, 1998). Most previous studies found a significant correlation between presence and ITQ scores (Laarni, Ravaja, Saari, & Hartmann, 2004; Wallach et al., 2010; Witmer & Singer, 1998). Johns et al. (2000) found a significant correlation between immersive tendencies and presence only in an immersive environment that included factors that were thought to facilitate presence. However, no significant relationship between ITQ and presence was found in a study with 64 participants by Murray et al. (2007). Considering all these studies, ITQ might be relevant to experienced presence, and as such, is included in this study.

Absorption. Tellegen and Atkinson (1974) defined absorption as a state of ‘openness to experiencing, in the sense of readiness to undergo whatever experiential events, sensory or imaginable, that may occur, with a tendency to dwell on, rather than go beyond, the experiences themselves and the objects they represent’. Persons who are more absorbed in the virtual environment are expected to experience higher levels of presence. However, the results so far about the relationship between presence and absorption are not conclusive. Sas (2004) found that individuals who were more absorbed experienced a significantly greater level of presence, whereas Murray et al. (2007) and Schuemie, Abel, van der Mast, Krijn, and Emmelkamp (2005) reported that they did not find significant correlation between absorption and presence with 64 participants and 41 participants respectively.

Locus of control. Locus of control refers to “the degree to which persons feel that they control events in their own lives (internal locus of control), or that such events are influenced by outside forces, chance or luck (external locus of control)” (Rotter, 1966). Wallach et al. (2010) found that internal locus of control predicted experienced presence in a fear of flying experiment. However, in a study of navigation, way-finding and place experience within a virtual city, significant correlations were found between presence and external locus of control (Murray et al., 2007). The contradictory results suggest that the relationship between presence and locus of control is dependent on the task. Whether a

relationship with locus of control can be found in the public speaking domain is tested in the current study.

Empathy. Empathy refers to an individual's spontaneous emotional response to the experience of other people (Eisenberg, 1994). Wallach et al. (2010) found a positive correlation between presence and empathy. Sas (2004) found that individuals who were more empathic experienced a significantly greater level of presence. However, only the fantasy dimension of empathy was measured in Wallach et al. (2010). In the research of Sas and O'Hare (2003), the highest correlation was found between fantasy and presence. The fantasy scale measures the tendency to identify with characters in movies, novels, plays and other fictional situations. The other aspects of empathy, such as the "Perspective-taking", "Concern" and "Distress" aspects, are more related to one's feelings for other people. It is suggested that these other aspects of empathy become relevant when a virtual environment includes virtual characters (Nicovich, Boller, & Cornwell, 2005; Wallach et al., 2010). Whether this suggestion is true is tested in the current study.

Spatial intelligence. The mental rotation test (which measures the ability to mentally rotate 3D shapes) can be used to measure spatial processing and spatial intelligence (Jansen & Heil, 2010). Persons who have a higher level of spatial intelligence may be good at generating a mental representation of the virtual environment and can easily be immersed in it. Alsina-Jurnet and Gutierrez-Maldonado (2010) found that spatial intelligence influenced the sense of presence, but only for the group of participants that scored high on test anxiety. However, the proportion of females was higher in the high test anxiety group (60 females and 8 men) than in the low test anxiety group (113 females and 29 men) which could impact the generalization of their result. Furthermore, no result about the difference in presence between males and females was given in the literature (Alsina-Jurnet & Gutierrez-Maldonado, 2010). Therefore, we question in our current study whether the relationship between spatial intelligence and presence can be replicated in the public speaking domain, starting from a similar ratio between males and females.

Other factors. Demographic factors such as gender, age, ethnicity and education level may have an effect on presence as well. Youngblut (2002) found a negative relation between education level and presence. The effect of age on presence is inconclusive so far. Van Schaik (2004) found a negative relation between age and presence, but Schuemie et al. (2005) found a positive correlation. The participants' game playing experience was also tested. The

results from previous studies on the relationship between game playing experience and presence are mixed; some studies found a positive relationship (Romano & Brna, 2001; Youngblut, 2002), but Usoh (1999) found a negative relationship.

Previous studies found that display technology also affected feelings of presence (Juan & Perez, 2009; Krijn et al., 2004). Presence was higher for content rendered stereoscopically than for content rendered non-stereoscopically. The latter was especially true for more dynamic content. Whether stereoscopy also increases feelings of presence in a more static virtual environment is evaluated in our current study.

Hence, based on literature we hypothesize that some individual characteristics are predictive to experienced presence in a virtual environment representing the public speaking domain. Since for one condition the virtual environment is rendered stereoscopically, individuals with good stereovision might see more depth and experience higher levels of presence than individuals with poor stereovision. Therefore, we expect a relationship between presence and stereo acuity. Furthermore, we also expect a relationship between presence and ITQ since ITQ was originally designed to measure individual's tendency of experiencing presence. Because the relation of presence with other individual characteristics is non-conclusive in literature, we may hypothesize that these effects are smaller.

1.2 Cybersickness and presence

One of the negative side effects caused by an immersion in a virtual environment is cybersickness. Stanney and Kennedy (2009) reported that about 80–95% of individuals interacting with a HMD simulator reported some level of cybersickness, with 5–50% experiencing symptoms severe enough to end participation. Stanney et al. (1998) found that these symptoms could be explained by task characteristics, such as the speed of movements, the degree of control the user has on the immersion, the amount and type of images shown in peripheral vision, etc. Considering that the speed of the participants' movements is relatively low in the virtual public speaking world, experienced cybersickness symptoms should be related more to visual discomfort issues in the current study.

The reported results about the relationship between presence and cybersickness are controversial. Witmer and Singer (1998) found a significant negative correlation between cybersickness and presence, whereas Slater, Steed, and Usoh (1993), Liu (2011) and Busscher, de Vliegheer, Ling, and Brinkman (2011) found a positive correlation between presence and

cybersickness. Since both presence and cybersickness are factors related to increased dropout rate in virtual reality exposure therapy, it would be helpful to clarify the relationship between presence and cybersickness. Hence, we want to understand under which circumstances the feeling of presence leads to cybersickness, and whether the individual characteristics that affect presence also have an effect on cybersickness.

2 Method

2.1 Participants

Based on a power analysis, a sample size of 84 participants was needed to find at least medium size relationships ($r = .3$) with an 80% chance as classified by Cohen (2009). To cope with potential missing data, 88 students and staff from the Delft University of Technology were actually included in the experiment (35 females, 53 males). The participants were recruited by advertisements on the university campus. Since we were interested in the impact of individual characteristics on feelings of presence, no exclusion criteria were used. The participants' age ranged from 18 to 70 years old with the mean being 28 ($SD = 6.3$) years. About half (47, 53.4%) of the participants were Asian and the other half of the participants were European. Each participant received a small gift for their participation. The experiment was approved by the University's Ethics Committee and done according to Dutch Law and the Declaration of Helsinki.

It should be noted that the participants of this experiment were not socially phobic. There have been different reports on how presence is experienced by phobic and non-phobic people. For example, Robillard, Bouchard, Fournier, and Renaud (2003) reported that phobic participants experienced a higher level of presence, while Busscher et al. (2011) found the opposite result, namely that non-phobic participants scored significantly higher on presence than phobic participants. Still non-phobic individuals do experience presence in a virtual environment (Wiederhold & Wiederhold, 2005). Therefore the sample used in this study is considered sufficiently valid to provide insight into the relationship between individual characteristics and experienced presence.

2.2 Apparatus

The virtual environments were presented via a Z800 helmet with a resolution of 800*600 (horizontal*vertical) pixels. It had a visual field in diagonal of 40 degrees, and had a built-in 3-degrees of freedom tracker which measured the movement of the user's head with a 125Hz update speed. The field of view and accommodation of the Z800 helmet were comparable to the field of view and accommodation of a 105-inch display viewed at 3.66 meters. Participants wore their prescribed glasses for the experiment. Sounds were played through speakers on the desk in front of the observer. The virtual worlds were all made using WorldViz's Vizard 3.0.

Participants were exposed to two virtual environments: a virtual neutral world and a virtual public speaking environment (Figure 1). In the virtual neutral world, there was a small room with a table and a TV showing a documentary about wildlife (Busscher et al., 2011). In the virtual public speaking environment, there were five animated avatars (two women and three men) dressed in a casual style around a table. Hall (1996) showed that social distance between people is correlated with physical distance, and the physical distance used for public speaking ranges from 3.7 to 7.6 meters. Therefore, the distance between the avatars (displayed in life size) and the observer was specifically set to a distance typical for public speaking, i.e. the avatars were sitting 6.6-6.8 meters away from the participant. One of the avatars gave instructions at the beginning and at the end to the participant. We manipulated the avatars' attitude to elicit emotional engagement (Slater, Pertaub, & Steed, 1999), and thereby enhancing perceived presence. The attitude of the avatars changed over time from a positive attitude, where all the avatars showed interest in the talk by looking at the participant, to a neutral attitude, where some of the avatars were interested in the talk while others were not, and finally to a negative attitude, where all the avatars showed no interest in the talk by looking away, stretching their arms, talking amongst each other or falling asleep. A validation test, in which 16 participants were asked to rate the attitude of the virtual audience from 0 (negative) to 100 (positive) showed that the attitudes of the avatars were perceived as what we intended ($F(2,14) = 38.72, p < 0.001$). The negative attitude was significantly lower than the neutral ($t(15) = 5.33, p < 0.001$) and positive ($t(15) = 7.29, p < 0.001$) attitudes. The mean and standard deviation of the scores on the positive, neutral and negative attitude were $M = 57.19, SD = 5.08$; $M = 50, SD = 7.01$; $M = 20, SD = 4.52$ respectively.

2.3 Presence and cybersickness measures

To measure the presence level the participants experienced in the virtual environments, two questionnaires which were designed to measure the sense of presence in virtual environments were used, namely the Igroup Presence Questionnaire (IPQ) (Schubert, Friedmann, & Regenbrecht, 2001) and the Slater-Usoh-Steed (SUS) questionnaire (Slater, Usoh, & Steed, 1994). The IPQ consists of 14 items rated on a seven-point Likert Scale. The scores on the 14 IPQ items are mapped onto three subscales, namely Involvement (the awareness devoted to the virtual environment), Spatial Presence (the relation between the virtual environment and the physical real world), and experienced Realism (the sense of reality attributed to the virtual environment). It also contains one general item (G1), which assesses the general feeling of being in the virtual environment.



Figure 1: Left, virtual neutral world. Right, virtual public speaking world

The Slater-Usoh-Steed (SUS) (Slater et al., 1994) questionnaire consists of six questions and is based on variations of three themes: 1) the sense of being in the virtual environment, 2) the extent to which the virtual environment becomes the dominant reality, and 3) the extent to which the virtual environment is remembered as a place. Participants score each of the six questions on a seven-point Likert Scale. The overall score of SUS is obtained by counting the number of questions whose score is 6 or 7.

To investigate whether the participants experienced cybersickness symptoms from viewing the virtual environments, cybersickness was measured using the Simulator Sickness Questionnaire (SSQ) developed by Kennedy et al. (1993). This questionnaire is commonly used to measure cybersickness in many different contexts, including stereoscopic rendering (Bouchard, Côté, & Richard, 2006; Bruck & Watters, 2009; Busscher et al., 2011; Hale &

Stanney, 2006; Kim, Kim, Kim, Ko, & Kim, 2005; Liu, 2011; Obrist, Wurhofer, Meneweger, Grill, & Tscheligi, 2012; Sharples et al., 2008; Wiederhold & Wiederhold, 2005). It is composed of three subscales: nausea, oculomotor effects and disorientation. Each item is scored on a 4-point scale (0-‘doesn’t feel anything’, 1-‘a little’, 2-‘medium’, 3-‘a lot’). The total SSQ score is an aggregate score of the three components and ranges from 0 to 235.62.

2.4 Measurements of the individual characteristics

Visual acuity was measured using ‘Freiburg Visual Acuity Test’ at a distance of 3 metres (Bach, 1996). Stereo vision ability was measured both by the TNO stereo test and the Randot stereo test (Cooper, Feldman, & Medlin, 1979). Eye dominance was determined in two different ways: 1) sighting test, 2) binocular rivalry. Strabismus and phoria were tested using cover tests and the Maddox wing test. Pupil distance, colour vision and ability to see “magic eye stereograms” were also tested (Howard & Rogers, 2002; Ishihara, 1979; Nefs, O'Hare, & Harris, 2010; Wilmer & Backus, 2008).

The Immersive Tendency Questionnaire is designed to measure differences in the tendencies of individuals to experience presence in an immersive virtual environment (Witmer & Singer, 1998). It is an 18-item measure and consists of three subscales: Focus, Involvement and Games. The Focus items are related to mental alertness, participants’ ability to concentrate on enjoyable activities and block out distractions. Involvement items are related to the participants’ tendency to get involved in some activities. Items related to the Games subscale ask about how frequently the participants play games and whether they get involved to the extent that they feel like they are inside the games.

The Tellegen absorption scale is a self-report questionnaire designed to measure absorption (Tellegen & Atkinson, 1974). It comprises 34 items in which participants indicate whether each item is ‘True’ or ‘False’ with regards to their own experience, and the total score is the number of items to which they respond ‘True’. Its score ranges from 0 to 34.

The Locus of Control questionnaire is a 29-items measure of peoples’ attribution styles (Rotter, 1966). Each item is comprised of two statements (one is an external attribution, and another one is an internal attribution), and the participants are requested to choose the one with which they agree more. Each external attribution that is chosen receives 1 point. The score ranges from 0 to 23, with high scores indicating that the participant has an external locus of control and low scores indicating that he or she has an internal locus of control.

Empathy was measured with a set of items associated with the responses of one individual to the experience of another (Davis, 1994). It involves the ability to have compassion towards other beings. Empathy was measured with Davis' Interpersonal Reactivity Index (Davis, 1980). It consists of four seven-item subscales, each of which measures a separate aspect of empathy. The "Perspective-taking" scale contains items 'which assess spontaneous attempts to adopt the perspectives of other people and see things from their point of view'. The "Fantasy" scale measures the tendency to identify with characters in movies, novels, plays and other fictional situations. The "Concern" scale inquires about ones' feelings of warmth, compassion, and concern for others, while the "Personal distress" scale measures the feelings of anxiety and discomfort that result from observing another's negative experience.

Spatial intelligence was measured by the mental rotation test, which measures the ability to mentally rotate three dimensional objects (Jansen & Heil, 2010). In the current study, participants were presented with a series of pairs of perspective line drawings, and were asked to press the keyboard as soon as they determined whether the two drawings depicted the same objects or mirrored ones. The test had pairs of objects which were rotated a specific amount of degrees (e.g. 0°, 60°, 120° or 180°). Half of the pairs were the same objects rotated, and the other half of the pairs were a mirrored version of the same objects. The stimuli were shown in random order to the participants. The participants were judged on how accurately and rapidly they could distinguish the mirrored pairs from the non-mirrored ones. The scores were the total number of correct responses in 5 minutes, and the d' of their responses was also calculated.

A questionnaire regarding gender, age, education level, nationality, game playing experience and personal experience in computer technology was also used.

2.5 Procedure

Each participant was provided with an information sheet prior to the experiment. The whole procedure was explained to them and they were asked to complete an informed consent form. At the beginning of the experiment, the participants were asked to fill in an information questionnaire about their current physical state. Their personal characteristics were measured before they were exposed to the virtual environments. They were first immersed in a non-stereoscopic virtual neutral world, and then in a virtual public speaking

world twice: once with stereoscopic rendering and once without stereoscopic rendering in the virtual environment, in counterbalanced order. In the virtual neutral world, the participants were told to watch a documentary of wildlife. However, in the virtual public speaking world, the participants were asked to give a 5-min talk in each virtual public speaking world without any slides or props. The presence and cybersickness measurements were administered after each exposure to the virtual environment. During the talk physiological data such as heart rate and skin conductance were also recorded. The content of the presentation was recorded using a web camera². The experimenter left the experimental room when the experiment started. Finally there was a debriefing session, in which the experimenter explained full details of the experiment to participants and answered all the questions from the participants. The whole experiment took about 90 minutes for each participant.

3 Results

Means and standard deviations for the questionnaires and the vision tests are presented in Table 1. The units of the measurements are given in bracket. Note that the unit of spatial intelligence is in the number of correct responses. For some variables such as personality traits and some demographic data, there were missing values for three participants.

Table 1 Mean and standard deviation for individual characteristic measurements

Variable (unit)	N	Minimum	Maximum	Mean	Std. Deviation
Age (year)	88	18.00	65.00	28.30	6.78
Years of education ³ (year)	85	14.00	25.00	20.19	2.54
Spatial Intelligence	85	6	53	19.26	8.89
Spatial Intelligence (d ³)	85	-1.48	4.65	2.22	1.34
3m Vision-Left eye (Snellen fraction)	88	0.17	1.87	0.99	0.43
3m Vision-Right eye (Snellen fraction)	88	0.18	1.95	0.97	0.42
3m Vision-Both eyes (Snellen fraction)	88	0.29	2.00	1.23	0.44
3m Vision-dominant eye ⁴ (Snellen fraction)	88	0.20	2.00	1.09	0.43

² Focus of this paper will only be on subjectively reported measurements. Part of the results from this study are also published in Ling et al. (2012).

³ Years of education is calculated according to participants' education level. We give 14, 18, 21, 25 years of education for people who have finished their high school, bachelor, master and PhD respectively.

Stereo vision-Randot test (arc sec)	88	40	200	50.23	34.37
Stereo vision-TNO test (arc sec)	88	30	480	138.41	145.59
Inter-pupillary distance (cm)	88	5.30	7.20	6.36	0.35
Phoria Horizontal (prism diopters)	88	0.00	22.00	4.25	4.475
Immersive Tendencies	85	41	120	78.67	14.44
Immersive Tendencies-Focus	85	19	46	31.21	5.60
Immersive Tendencies-Involvement	85	14	49	30.72	7.93
Immersive Tendencies-Games	85	2	14	7.90	2.98
Absorption	85	1	31	17.72	7.32
Locus of Control	85	3	20	11.14	3.79
Empathy- Fantasy	85	8	27	20.86	2.76
Empathy- Perspective	85	7	27	19.56	2.90
Empathy- Concern	85	12	35	25.36	4.60
Empathy- Distress	85	3	33	19.79	4.96

All participants scored within normal range on the immersive tendencies questionnaire. The mean of immersive tendencies was 78.67 in our study and 76.66 in Witmer and Singer (1998), and no significant difference was found between these two studies with an independent-samples *t*-test. The level of absorption in our study was 17.72, which was lower than the mean absorption level (21.84) in Murray et al. (2007) ($t(144) = 3.71, p < 0.001$). The mean empathy fantasy in the current study was 20.86 which was also lower than the mean (23.54) reported in Wallach et al. (2010) ($t(132) = 4.45, p < 0.001$). Locus of control, on the other hand, was 11.14 in our study, which was significantly higher than the mean value (4.94) reported by Wallach et al. (2010) ($t(141) = 12.75, p < 0.001$), and lower than the mean value (12.81) reported by Murray et al. (2007) ($t(122) = 2.40, p < 0.01$). The results indicate that participants in our sample tended to be more external, less absorbed and less empathic. Since there were some similar items in the ITQ, absorption and empathy questionnaires, we tested correlations between these variables, and their subscales. We only found a significant correlation between ITQ and absorption ($r = .35, p < 0.01$), and between ITQ and the empathy subscale concern ($r = .23, p < 0.05$). No significant correlation between absorption and empathy was found. The mean of the pupil distances was 6.36 centimetres in our study, which was quite close to the mean 6.34 centimetres reported in Dodgson (2004).

⁴ Half of the participants ($N = 44$) have left dominant eyes and the other half have right dominant eyes.

Means and standard deviations for the presence measurements SUS and the four IPQ subscales are shown in Table 2. Correlation analyses between IPQ total score and SUS found significant correlations for non-stereoscopic neutral world ($r = .59, p < 0.001$), non-stereoscopic public speaking world ($r = .68, p < 0.001$) and stereoscopic public speaking world ($r = .68, p < 0.001$) individually. Because these were not perfect correlations, we continued analyzing SUS and IPQ separately.

To get a general idea about the presence level in the current experiment, the IPQ presence subscales were compared with an online IPQ dataset⁵. Presence in the non-stereoscopic virtual environments including the neutral and public speaking world was compared to the online data obtained with a mono HMD by using an independent-samples *t*-test. The results showed that no significant difference was found for any of the IPQ subscales. Presence in the stereoscopic virtual public speaking world was compared with the online data obtained with a stereo HMD. These results showed that involvement ($t(121) = 2.20, p = 0.03$) and realism ($t(121) = 2.24, p = 0.027$) were significantly higher in our data set than in the online dataset ($M = 2.96, SD = 0.93; M = 2.23, SD = 0.91$). No significant difference was found for G1 and spatial presence.

To test the effect of stereoscopic rendering on presence, paired-samples *t*-tests were performed using the IPQ subscales and SUS presence scores in the non-stereoscopic and stereoscopic virtual public speaking worlds as paired variables. A significant main effect of stereoscopy on spatial presence ($t(87) = 2.67, p = 0.009, d = 0.29$) and SUS presence ($t(87) = 2.23, p = 0.028, d = 0.24$) was found, however, no significant improvement in IPQ involvement and realism was found (Ling et al., 2012).

Task is known to have an effect on presence (Ijsselsteijn et al., 2000; Witmer, Jerome, & Singer, 2005). The paired-samples *t*-tests on the IPQ subscales and SUS illustrated that only involvement was significantly higher ($t(87) = 2.35, p = 0.021, d = 0.38$) in the non-stereoscopic public speaking world than in the non-stereoscopic neutral environment. Considering Cohen's classification (Cohen, 1992), the differences were statistically small with effect sizes all below medium classification of 0.5.

⁵ Download on March 21th, 2012. For comparison data see <http://www.igroup.org/pq/ipq/data.php>

Table 2 Mean and standard deviation for presence measurements

	G1	Spatial Presence	Involvement	Realism	SUS
Non-stereoscopic Neutral world	3.49(1.52)	3.24(1.23)	3.00(1.35)	2.78(0.96)	1.36(1.50)
Non-stereoscopic Public Speaking World	3.39(1.83)	3.34(1.48)	3.37(1.52)	2.65(1.34)	1.58(2.17)
Stereoscopic Public Speaking World	3.61(1.64)	3.59(1.39)	3.56(1.48)	2.73(1.18)	1.89(2.17)

3.1 Relationship between individual characteristics and presence

We initially examined the average presence scores across the three virtual worlds. So, to test the relationship between individual characteristics and presence, a series of correlation analyses were conducted, using the individual characteristics and the average value of presence experienced across all the three virtual environments as variables (Table 3). Note that in total 105 correlations were examined without adjusting alpha level. Only variables that were found to be significantly correlated with presence are presented in Table 3. Most of the individual characteristics that were correlated were positively correlated with reported presence, only age and years of education were negatively correlated with involvement.

To test whether significant correlations between presence averaged across the three virtual worlds and individual characteristics still exist per virtual environment, the correlation analyses were repeated for each virtual environment separately. Only immersive tendency and vision acuity of the right eye were consistently correlated with spatial presence in all these three virtual environments (Table 4). A significant correlation was also found between the visual acuity of participants' dominant eye and averaged spatial presence (Table 3), but no consistent significant correlation was found for each virtual environment. Therefore, we did not use visual acuity of the dominant eye in the following multiple regression analysis.

Other individual characteristics data such as computer experience, TV watching and game playing experience were not significantly correlated with averaged presence.

In addition to a linear relationship between individual characteristics and presence, we also tested several non-linear relationships, such as a logarithmic, inverse, quadratic, cubic, compound, power, S, growth, exponential and logistic functional behaviour. A series of paired *t*-tests were conducted, but no significant difference was found in the squared

prediction error between linear and non-linear prediction for the relation of averaged presence scores with the individual variables.

Table 3 Correlations between users' characteristics and presence averaged across the three virtual environments

Variable	G1	Spatial	Involvement	Realism	SUS
Presence					
Age	-.13	-.14	-.24*	-.11	-.006
Years of education	-.13	-.15	-.25*	-.074	-.099
3m Vision-Left eye	.20	.20	.21	.17	.22*
3m Vision-Right eye	.21	.28**	.17	.25*	.20
3m Vision-Both eyes	.17	.23*	.16	.19	.19
3m Vision-dominant eye	.20	.23*	.16	.21*	.21
Immersive Tendencies	.29**	.26*	.14	.087	.23*
Immersive Tendencies-Focus	.25*	.24*	.10	.033	.25*
Immersive Tendencies-Involvement	.24*	.21	.12	.13	.13
Immersive Tendencies-Games	.25*	.26*	.096	.12	.092
Absorption	.16	.18	.12	.22*	.10
Empathy- Concern	.15	.13	.23*	.062	.27*

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Table 4 Consistent correlations between individual variables and spatial presence in the three virtual environments

Variable	Spatial Presence		
	Neutral non-stereoscopic	Public Speaking non-stereoscopic	Public Speaking stereoscopic
3m Vision-Right eye	.22*	.26*	.24*
Immersive Tendencies	.21*	.22*	.24*

* . Correlation is significant at the 0.05 level (2-tailed).

Since only ITQ and visual acuity of the right eye correlated consistently with presence in each of the three virtual environments, the next step was to conduct multiple regression analyses to test whether the combination of these two variables could have a better overall

prediction of spatial presence. The regression analyses were done using visual acuity (right eye) and ITQ as independent variables and averaged spatial presence as dependent variable. The independent variables were entered in the order of their correlation value, which means the one with highest correlation was entered first. As expected, the regression models were all significant in both steps; $F(1, 86) = 7.25, p < 0.01$ and $F(2, 82) = 9.08, p < 0.001$ for step1 and step2 individually (Table 5). The combination of visual acuity (right eye) and ITQ raised the correlation to 0.43.

Table 5 Regression analysis (ENTER) predicting level of Spatial Presence

Step	Variable	B	SE B	β	ΔR^2	ΔF
1	3m Vision-Right eye	0.787	0.292	0.279**	0.078	7.251
2	3m Vision-Right eye	0.955	0.285	0.336**	0.181	9.083
	Immersive Tendencies	0.023	0.008	0.282**		

Note: ** $p < 0.01$.

A series of independent-samples *t*-tests were done to analyse the difference in presence between people with different gender, origin (Asian vs. European), colour vision ability, eye dominance, eye problem history, ability to see “magic eye stereograms” and stereoscopic acuity groups. No significant difference was found in reported averaged presence among the three virtual environments.

The relationships between individual characteristics and presence differences caused by stereoscopic rendering and task were also tested. The presence differences were obtained by subtracting the presence scores for one virtual environment (e.g. non-stereoscopic virtual public speaking world) from the presence scores for the other virtual environment (e.g. stereoscopic virtual public speaking world). Correlation analyses were done between individual characteristics and the difference in IPQ subscales and SUS caused by stereoscopic rendering, but none of the results was significant. Similarly, correlation analyses between individual characteristics and difference in presence measurements caused by task were conducted, but no significant result was found.

To analyse the difference in presence improvement (by rendering stereoscopy and different task requirements) between people with different gender, origin (Asian vs. European), colour vision ability, eye dominance, eye problem history and ability to see “magic eye stereograms”, a series of independent-samples *t*-tests were done. Non-Asian participants reported a higher realism difference between the stereoscopic public speaking

world and the non-stereoscopic public speaking world than Asian participants ($t(86) = 3.18$, $p < 0.01$). Related to task, participants with left dominant eyes reported higher realism difference between the public speaking world and the neutral world than participants with right dominant eyes ($t(86) = 2.49$, $p < 0.05$). A higher involvement difference was also found in non-Asian participants than Asian participants ($t(86) = 2.40$, $p < 0.05$).

3.2 Relationship of presence between different virtual environments

Although the combination of visual acuity (right eye) and ITQ raised prediction of spatial presence in the current study, it is not clear whether participants who experienced higher level of presence in one virtual environment would also report higher level of presence in another one. We therefore conducted correlation analyses of presence between different virtual worlds to examine this (Table 6). The results indicate that the participants tended to score higher presence in the public speaking environment if they scored higher in the neutral world.

Table 6 Correlations of presence scores between the three virtual environments

	2D Neutral vs. 2D public speaking	2D Neutral vs. 3D public speaking	2D public speaking vs. 3D public speaking
G1	.43**	.44**	.76**
Spatial Presence	.49**	.50**	.82**
Involvement	.49**	.45**	.77**
Realism	.43**	.44**	.73**
SUS	.55**	.56**	.82**

** Correlation is significant at the 0.01 level (2-tailed).

Note: 2D Neutral: Non-stereoscopic Neutral world; 2D public speaking: Non-stereoscopic Public Speaking World; 3D public speaking: Stereoscopic Public Speaking World.

3.3 Relationship between individual characteristics and cybersickness

Similar to relationship between individual characteristics and presence, data analyses were performed for cybersickness measured with the Simulator Sickness Questionnaire. The mean and standard deviation of the post SSQ scores in the non-stereoscopic neutral world, the non-stereoscopic public speaking world and the stereoscopic public speaking world were: $M = 23.76$, $SD = 2.45$, $M = 24.61$, $SD = 2.76$ and $M = 24.78$, $SD = 2.65$ respectively. Paired-samples t -tests were performed among the three worlds, but no significant difference was found between any of these three worlds for SSQ.

Correlation analyses were conducted between individual characteristics and averaged SSQ first. ITQ ($r = .28, p < 0.05$), ITQ-Involvement ($r = .42, p < 0.001$), ITQ-Games ($r = .22, p < 0.05$), and empathy-Distress ($r = .24, p < 0.05$) were found to be significantly correlated with SSQ. ITQ and ITQ-Involvement were also found to repeatedly impact cybersickness in all the three virtual environments separately (Table 7). The results show that participants who could easily get immersed or involved in the virtual environments reported more cybersickness.

To test whether the combination of ITQ and ITQ-Involvement could result in a better prediction of cybersickness, regression analyses were conducted using ITQ and ITQ-Involvement as independent variables and averaged cybersickness as dependent variable. The independent variables were entered in the order of their correlation value. The regression models were significant in both steps; $F(1, 83) = 17.76, p < 0.001$ and $F(2, 82) = 10.49, p < 0.001$ for step 1 and step 2 individually. The combination of ITQ-Involvement and ITQ only raised the correlation from 0.42 to 0.45.

A series of independent-samples *t*-tests were done to analyse the difference of averaged SSQ between people with different gender, origin, colour vision ability, eye dominance, eye problem history, and ability to see “magic eye stereograms”. No significant difference was found in reported averaged SSQ among the three virtual environments.

Table 7 Consistent correlations between ITQ and SSQ in the three virtual environments

Variable	Simulator Sickness Questionnaire		
	Neutral non-stereoscopic	Public Speaking non-stereoscopic	Public Speaking stereoscopic
Immersive Tendencies	.28**	.24*	.25*
Immersive Tendencies-Involvement	.40**	.37**	.41**

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

3.4 Relationship between immersive tendencies, presence and cybersickness

The results above suggest that people who are more easily immersed in a virtual environment have a higher level of spatial presence, but also experience more cybersickness. Hence, we also conducted a correlation analysis between averaged spatial presence and

averaged SSQ, but no significant correlation was found. The existing relationships between ITQ, spatial presence and SSQ are shown in figure 2.

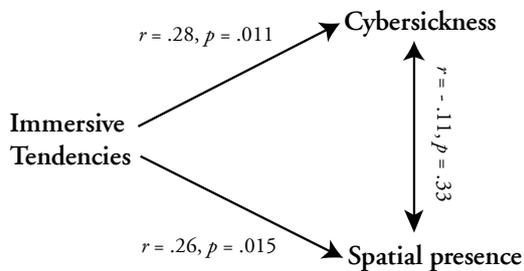


Figure 2: Relationship between immersive tendencies, averaged presence and averaged cybersickness

To get the relationship between ITQ and presence controlling ITQ for the effect of SSQ on ITQ, a series of semi-partial correlation analyses were done, and significant correlations were found for each of the three worlds separately as shown in Table 8. Semi-partial correlation analyses between ITQ and SSQ were done, after controlling ITQ for spatial presence. Again significant correlations were found for all the three worlds (Table 9). Hence, the results show that even after controlling for simulator sickness, people who have a higher tendency to get involved in a virtual environment tend to have a higher level of presence. As such, presence and cybersickness are partly explained by different parts of the immersive tendency. In addition, presence can not predict whether the participants will experience more cybersickness or not.

Table 8 Semi-partial correlations between ITQ and spatial presence controlling ITQ for SSQ in the three virtual environments

Variable	Immersive Tendencies		
	Neutral non-stereoscopic	Public Speaking non-stereoscopic	Public Speaking stereoscopic
Spatial Presence	.25*	.26*	.27*

*. Correlation is significant at the 0.05 level (2-tailed).

Table 9 Semi-partial correlations between ITQ and cybersickness controlling ITQ for spatial presence in the three virtual environments

Variable	Immersive Tendencies		
	Neutral non-stereoscopic	Public Speaking non-stereoscopic	Public Speaking stereoscopic
Cybersickness	.31**	.27*	.28*

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4 Discussion

People experience different levels of presence even when they are confronted with the same media technology and facing the same experimental task. In the current study, participants' immersive tendency and visual acuity of the right eye were positively correlated with that of spatial presence repeatedly among three virtual worlds, i.e. a non-stereoscopic neutral world, a non-stereoscopic public speaking world, and a stereoscopic public speaking world. The combination of ITQ and visual acuity of the right eye raised the correlation with averaged spatial presence of the three virtual worlds. However, no effects of locus of control, stereovision, computer experience or game playing experience on presence measures were found in any of the three virtual worlds. The effect of individual characteristics on cybersickness in the virtual environments was also tested. The ITQ and its subscale involvement were positively correlated with cybersickness. The results of semi-partial correlation analyses showed that cybersickness and presence were explained by different parts of the immersive tendency, and we did not find a significant relationship between presence and cybersickness.

It is not surprising that we found a correlation between ITQ and presence. Witmer and Singer's (1998) immersive tendencies questionnaire (ITQ) was developed to identify those persons who would be more likely to experience a sense of presence in virtual environments and they obtained a positive correlation between ITQ and presence ($r = .24, p < 0.01$). This finding was replicated in the current study repeatedly in all the three worlds. ITQ was also found to be correlated with cybersickness repeatedly in the three worlds. The results suggest that individuals who score high on ITQ would experience higher levels of presence and more cybersickness when they are exposed to virtual environments. However, there is a

concern that the Simulator Sickness Questionnaire is not 'purely' measuring cybersickness, but that it is confounded with feelings of anxiety (Bouchard, Robillard, Renaud, & Bernier, 2011). It is possible that participants still felt anxiety even when they were in the neutral environment, as some (Brinkman, Hattangadi, Meziane, & Pul, 2011; Busscher et al., 2011) have even found a decrease in SSQ from pre- to post measurement. A new cybersickness measurement seems required to limit the bias of anxiety in reporting cybersickness.

Although a significant correlation between ITQ and cybersickness was found, the reported cybersickness symptoms were low and we had no dropout during the experiment. Reported means of SSQ ranged from 23.76 to 24.78 across the three worlds, which were rather low compared to the total SSQ score which ranged from 0 to 235.62. Bouchard et al. (2011) suggested that if a user experiences sickness symptoms severe enough, the session should be terminated. However, it is not clear to what extent the total SSQ score should raise to be severe enough. It also does not become clear from the current study whether ITQ is still correlated with SSQ when the patients are exposed to virtual environments that can easily cause sickness symptoms, because our worlds did not lead to severe cybersickness as compared to the report in Stanney and Kennedy (2009).

Individuals who have lower visual acuity reported lower presence. A significant correlation between visual acuity of the right eye and averaged spatial presence and a significant correlation between the visual acuity of participants' dominant eye and averaged spatial presence were found. These results indicate that visual acuity has an effect on presence and people with better visual acuity can experience higher levels of presence than people with worse visual acuity. As such, this finding raises the question whether for people with poor visual acuity, the efficacy of VRET applications can be improved by improving their visual acuity.

Contradictory to our hypothesis, we found no significant relationship between averaged presence and stereoscopic acuity. No significant relationship between the presence increase induced by stereoscopic rendering and stereoscopic acuity was found either. Apparently, the ability of stereoscopic vision did not affect the individual's feelings of presence, not even in the stereoscopically rendered virtual environments. The little effect of stereoscopic acuity on presence may be explained by the relatively small statistical effect size of stereoscopic rendering on presence in the virtual public speaking world (Ling et al., 2012). Maybe the task of speaking in public has drawn participants' attention away from what was being presented

in the virtual environment. Motion parallax and the relatively large physical distance between the user and the virtual audience may have been two other reasons for the small difference in presence between the stereoscopic and non-stereoscopic rendering conditions. Therefore, stereo acuity may have an effect on presence in conditions where the effect size of stereoscopic rendering on presence is larger, which still needs to be confirmed in additional experiments.

We hypothesized that people with high spatial intelligence were better at orienting themselves in the virtual three-dimensional environment, might interact more easily and got involved in the task more quickly; as a result, they would report higher presence. It was also reported that students with higher spatial intelligence tended to feel more presence in tested anxiety environments (Alsina-Jurnet & Gutierrez-Maldonado, 2010). In our study, however, we found no significant relationship between presence and spatial intelligence. It is possible that spatial intelligence could play a more important role to elicit presence in experimental settings where searching and navigation in complicated three-dimensional spaces is essential.

No significant correlation between locus of control and presence was found in the current study. Compared to the studies of Murray et al. (2007) and Wallach et al. (2010), which found significant relationships between locus of control and presence, in our study participants had less control over the virtual environment. In our experiment, participants mostly focused on their talk facing a virtual audience, while in the experiments of Murray et al. (2007) and Wallach et al. (2010), the participants could explore the virtual environment as much as they wanted during the virtual reality exposure. Therefore, it seems that the effect of locus of control on presence is dependent on the task, and locus of control may have an effect on presence under the condition that participants have more control options over the displayed virtual environments.

It is reported in the literature that aspects of empathy like perspective, concern and distress could become more relevant in virtual environments including virtual characters (Nicovich et al., 2005; Wallach et al., 2010). As such, we expected to find a significant correlation between aspects of empathy and presence. We indeed found significant correlations between concern and averaged presence measurements such as involvement and SUS score. The results show that feelings of warmth, compassion, and concern for others can affect feelings of presence in virtual environments with avatars in it.

Absorption was found to be significantly correlated with the averaged realism subscale, but not with averaged spatial presence, nor with averaged involvement or averaged SUS. Murray et al. (2007) also found no correlation between absorption and presence. In contrast, there are studies which found that people who were more absorbed experienced higher level of presence (Baños, 1999; Sas, 2004). Murray et al. (2007) used an immersive virtual environment with HMD, while Sas (2004) used a non-immersive virtual environment with desktop. All these results suggest that the role of absorption may be larger in less immersive virtual environments.

No relationship was found between presence and computer experience, and no relationship between presence and game playing was found either. These results are in line with Alsina-Jurnet and Gutierrez-Maldonado (2010) and Schuemie et al. (2005). People who have little experience with computers may have problems with the interface and may pay less attention to the content of the virtual environment. As a result, they may experience less presence. However, participants in our study did not have much control over the virtual environment and the participants could easily focus on their task in the public speaking world. Since all participants were students and staff from the university with at least some computer experience, this could be another reason for the insignificant relationship between presence and computer experience.

Among all tested individual characteristics, only ITQ and visual acuity were repeatedly correlated with presence in all three virtual worlds. These results indicate that ITQ and visual acuity could be more valid and reliable than the other individual characteristics in predicting the sense of presence. This applies not only to the virtual public speaking world independent of stereoscopic rendering, but also to the virtual neutral world. Whether ITQ and visual acuity also predict the level of presence in other virtual reality applications needs to be investigated.

Participants tend to score presence similarly across different virtual environments. They reported higher levels of presence in the public speaking environments if they scored higher presence in the neutral world. The correlation between presence in the neutral world and presence in the public speaking worlds were comparable to the result of the combination of ITQ and visual acuity of the right eye, and even about twice the result of ITQ. Hence, under the condition that a virtual reality system is available, a virtual neutral world can be used as a screening tool to predict presence.

This study has some limitations. First, the measurement of presence used in this study was self-reported presence which is prone to well-known demand characteristics. Participants may guess what the researchers examine and which outcome they expect, and then answer accordingly or contradictory to these expectations (von der Pütten et al., 2012). More objective measures in combination with self-reported presence may provide a more accurate view of the experienced presence. Second, there are many other virtual reality applications such as VRET for treating other mental disorders, training and entertainment. It is worthwhile to investigate the effect of individual characteristics like visual acuity and ITQ in these applications as well. Finally, we still need to realize that both ITQ and visual acuity only predict part of the presence variance caused by individual differences. There must be other factors that affect presence, but they still need to be identified in future research work.

5 Conclusion

In this study, significant correlations between ITQ and spatial presence and also between visual acuity and spatial presence were found repeatedly in a non-stereoscopic neutral world, a non-stereoscopic public speaking world, and stereoscopic public speaking world. Significant correlations between ITQ-Involvement and cybersickness, and between ITQ and cybersickness were also found repeatedly in the three virtual worlds. Participants tended to report higher presence in the virtual public speaking world if they scored higher presence in the virtual neutral world.

The results in the current study may help to explain why different individuals experience different levels of presence, although they are exposed to the same settings of a virtual environment. These results may also help to identify people who are better able to experience presence in a virtual public speaking environment, and as such, can benefit more from virtual reality applications for public speaking. To successfully complete a virtual reality exposure therapy, the patient should experience high levels of presence without any severe cybersickness symptoms. It is possible to use the virtual neutral world as a screening tool if a virtual reality system is easily available. An alternative way is that the therapist can give patients the ITQ questionnaire and a vision test as input of an intake, and based on the outcome decide whether virtual reality exposure therapy might be suitable for them. For example, if the patients score high in ITQ, it is likely that they will experience higher feeling

of presence and cybersickness in the virtual environment. The latter seems negligible as the virtual public speaking worlds did not induce severe cybersickness in people. The findings in this study can also potentially help to reduce the dropout rate during virtual reality exposure therapy, and help to avoid overloading the patients with other irrelevant questionnaires during the initial intake. In spite of limitations of this study and the need for further research, our results suggest that individual characteristics can explain part of both experienced presence and cybersickness for virtual reality exposure therapy in the public speaking domain.

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