Bachelorthesis

The Relationship between Human Factors and Presence experienced in Virtual Environments (VEs)

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Abstract

In recent years significant technological progress has been made with regard to *Virtual Reality (VR)*. As a consequence, VR became relevant to the domain of psychology. When one examines VR from a psychological perspective, the construct of *presence* is of particular interest. The degree of presence one experiences in a *Virtual Environment (VE)* differs from person to person, so there seem to be specific human factors that are related to presence. However, these factors are not assuredly identified yet. Therefore this study focused on detecting the human factors that act as predictors of presence. More specifically, the associations between presence and the human factors *age, openness*, *introversion*, *empathy* and *computer experience* were examined. This was done by conducting a correlational research, in which 80 respondents were exposed to a VE with the aid of a Google Cardboard. In the process the five human factors and the construct of presence were quantified with several questionnaires. The obtained data were then analysed with a *multiple regression analysis*, in which the five human factors served as the independent variables and presence as the dependent variable. The results of this analysis revealed that the human factors age, introversion and empathy were not significantly related to presence. However, there were still some human factors that acted as predictors of presence, because the factor openness showed a negative and the factor computer experience a meaningful positive association with presence. Although these results must be interpreted with caution due to some research limitations, this study nevertheless laid the foundation for further research on the topic. Such research could then generate additional knowledge about the relationship between human factors and presence, which could have valuable practical implications for the development of new VR-technologies.

Introduction

Over the last decades huge progress has been made in the development of new *technologies*, especially with regard to *computer soft- and hardware*. This has directly and indirectly affected our everyday lives in countless ways, of which some are generally thought to be more positive than others. For example, twenty years ago mobile phones were still a rarity, whilst nowadays nearly every person owns a modern smartphone (Rushton, 2012). One of the often mentioned advantages of this trend is that everybody is contactable most of the time, while one of the downsides is that people are more prone to adopting unhealthy body postures (Lee, Lee, Choi, Seo & Shim, 2013). So there naturally are upsides and downsides that come with every new technology.

The same applies to one of the newest developments in the sector of computer technology, namely the rise of *Virtual Reality (VR)*. After its introduction to the public in the early 1990s, a lot of progress has been made and the invention of new technologies has ultimately led to renewed interest in VR (Sherman & Craig, 2002). As a consequence, VR has nowadays reached the mainstream market: a growing number of more affordable and convenient *VR-devices*, like for instance the *Oculus Rift*, are now available to the public and with the introduction of the *Google Cardboard* it even became possible to use your own smartphone as a VR-device (MacIsaac, 2015). The term Virtual Reality is thereby generally defined as a "medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation" (Sherman & Craig, 2002, p. 13). Thus the purpose of using a VR-device is to get immersed into a *Virtual Environment (VE)* and to be able to interact with it, for example by looking around. The term Virtual Environment thereby refers to "the corresponding environment represented and stored in a computer" (Loomis, Blascovich & Beall, 1999, p. 557) that is "perceived when a user wears or inhabits an appropriate apparatus" (Wang, 2002, p. 234). Because the VE is the environment that the person using a VR-device eventually interacts with, it is thought to be most influential. Therefore the term VE is used throughout this report to refer to the environment created by a VR-device, while the term VR is referring to the overarching concept describing the technology in general.

Just as the rise of smartphones has faced some criticism, the substantial progress made in VR is also evaluated critically by some people, which are for example concerned about the possible social consequences of this trend (Cline, 2005). But despite these critiques the huge potential of VR cannot be denied and therefore it is essential to get to know more about the effects of VR and the possible *applications* for this new technology. Thereby it becomes apparent that the usage of VR is not only limited to the technological or entertainment sectors, but can also be used in other areas that do not immediately come to mind when one thinks about technological inventions. One of those areas is the domain of *psychology*.

In the domain of psychology there are a lot of potential advantages linked to the use of technology and VR specifically. One general advantage is, for example, that VR provides one with the

opportunity to create safe and naturalistic environments in which all stimuli can be controlled (Schultheis & Rizzo, 2001). This characteristic of VR in turn opens up new possibilities with regard to the *clinical practice* of psychology. For instance, it would seem possible to enhance the psychological well-being and reduce the stress of patients by exposing them to relaxing VEs that are specifically designed for the individual. Furthermore psychologists might regularly make use of VR-devices to create VEs that can be actively used in therapy sessions to treat the psychological complaints of patients with specific disorders (Schultheis & Rizzo, 2001). The implementation of this kind of VR-usage in clinical practice becomes more and more realistic as the quality of the VR-technology gets better and the acceptance of VR grows. There are already a lot of encouraging examples to be found in the scientific literature, giving a first outlook on what might be possible with VR. For instance, there are a lot of studies that provide evidence for the effectiveness of VR as a *therapeutic tool*. Especially with the treatment of *phobias* the use of VEs works as well as or even better than traditional *in vivo exposure* (see for example Emmelkamp, Bruynzeel, Drost & Van der Mast, 2001; Parsons & Rizzo, 2008). But also with regard to the treatment of *Post-Traumatic Stress Disorder (PTSD)* (see for example Rothbaum, Hodges, Ready & Alarcon, 2001) and *eating disorders* (see for example Perpiñá, Botella & Baños, 2003) research with VR has yielded promising results.

Besides the clinical research mentioned above, researchers have also focused on more basic research to get to know more about the *psychological mechanisms* that are at work when an individual is exposed to VEs. Such knowledge about VR could be used to develop more effective VR-devices and new applications for VR in general (Earnshaw, 2014). In line with these previous studies, the focus of this particular research also lies on certain psychological variables and their relation with VR.

Presence

A psychological construct that is particularly relevant when investigating VR from a psychological perspective is the construct of *presence* (Thornson, Goldiez & Le, 2009). Presence can be defined as "a psychological state or subjective perception in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience" (Thornson et al., 2009, p. 62). This construct of presence plays such a vital role in VR-research, because it is established in the scientific literature that it is a pivotal *indicator* for the effect that a VE ultimately has on a person (Slater & Wilbur, 1997). For instance, Bowman and McMahan (2007) found that at least a certain degree of presence must be experienced by the VR-user for a VE to have a significant effect. In some other cases, as described for example by Vora and her colleagues (2002), the effectiveness of a training for aircraft inspection executed with VEs was directly dependent on the degree of presence felt by the people using the VR-device. So it can be inferred that people who more easily experience a higher degree of presence when using VR-devices also have a higher chance of being affected significantly by VEs (Sacau, Laarni & Hartmann, 2008). Or in other words, by attaining knowledge about the type of persons that feel a deeper sense of presence more easily, knowledge is

also attained about the type of persons that benefit the most from VEs that are designed to positively affect the user.

When focusing on the psychological side of presence, as is the case here, the following statement made by Thornson and her colleagues (2009) must be taken into account in addition to the aforementioned definition: "Presence is a *psychological phenomenon* that occurs in the human mind and not in the specific technology" (p. 63). Therefore, although the technology influences presence significantly, the construct of presence ultimately is not a property of the technology, but a property of the individual varying across people and time (Thornson et al., 2009). This notion is further substantiated by Heeter's conception of presence. Heeter (1992) namely proposes that presence is a multidimensional psychological construct. Thus it must be noticed that the degree of presence one experiences is *subjective* and can differ from person to person.

Aim of this Study

As a consequence, it seems to be a logical next step to examine the individual psychological factors that might be related to the construct of presence. However, until now most research has focused on the influence of *technical aspects* on presence, for example by experimenting with different VR-devices (see among others Krijn et al., 2004) and specifying technical requirements such as graphics and resolution that ensure that users can experience a high degree of presence (Alsina-Jurnet & Gutiérrez-Maldonado, 2010). But as Thornson and her colleagues (2009) state, the *individual difference human factors* that are related to presence must also not be ignored. These include, for example, psychological and demographic variables that are linked to each person individually. Knowledge about these human factors is essential, because it can have substantial practical implications for the development and utilisation of VR-technologies (Thornson et al., 2009). Furthermore such knowledge could also prove to be useful for improving the usage of VR in the psychological practice. Therefore the concrete *aim* of this research is to identify the human factors that are related to the different degrees of presence experienced by people using the same VR-device. To achieve this specific aim, a research design is applied that is guided by the following research question: *Which human factors are significantly related to the degree of presence experienced by individuals in VEs?* To answer this question not only the presence experienced by the VR-users, but also the most relevant human factors that are believed to be related to presence are measured. The human factors that are taken into account in this research are the demographic variable *age*, the personality traits *openness*, *introversion* and *empathy* and lastly the *level of computer experience*. All of these variables are reported by the scientific literature to be related to the construct of presence in one way or another (see for example Alsina-Jurnet & Gutiérrez-Maldonado, 2010; Lessiter, Freeman, Keogh & Davidoff, 2001; Thornson et al., 2009) and are therefore included in this research.

With regard to the first human factor, namely the demographic variable age, it can be stated that several researchers have found a significant negative correlation between age and the construct of presence (see for example Schaik, Turnbull, Wersch & Drummond, 2004; Bangay & Preston, 1998).

According to Sacau and her colleagues (2008), the reason for this negative relation could be that elder people have more usability problems when working with computers and need more time to learn using computers than younger people. This is the case because young people's information processing ability is generally higher than that of elder people: for example, older people have fewer processing resources available and perform more slowly in a variety of tasks than younger people (Salthouse, 1996). This age-related changes may also have an effect on the ability of a person to allocate attentional resources. Thus in the context of presence it is proposed that age negatively affects the degree of presence experienced by a person, because older people have more problems to concentrate their attention on the essential aspects of a VE (Sacau et al., 2008). Therefore the following hypothesis is formulated with regard to the variable age: *Age shows a significant negative association with presence.*

The second and third human factors are the two *personality traits* openness and introversion. Personality traits are assumed to be possible human factors that are associated with presence, because they are stable traits that discriminate between individuals and also influence the cognitive processes of a person (Thornson et al., 2009). The two traits investigated here are part of two dimensions, namely the *openness to experience* and the *extraversion-introversion* dimension, belonging to the *five factor model of personality* also known as the *Big Five* (John & Srivastava, 1999). Regarding the second human factor openness it can be said that a person high on openness to experience is imaginative, creative, inquiring and open for new experiences, while a person low on that dimension is more conservative and does not show much interest in new experiences (Rammstedt, Kemper, Céline, Klein & Kovaleva, 2013). In the literature it is proposed that the characteristics of a more open person are positively related to the construct of presence (Sas & O'Hare, 2003; Thornson et al., 2009). The notion behind this assumption is that "being open to new experiences might be related to one's ability and willingness to suspend disbelief and imagine themselves as part of a virtual or augmented world" (Thornson et al., 2009, p. 68). Furthermore it is also stated that people who are less open and experience anxiety more frequently in new situations may be less able to focus their attention on the VE, which can disrupt their sense of presence (Sacau et al., 2008). Thus the following hypothesis is constructed with respect to the factor openness: *Openness shows a significant positive association with presence.*

With regard to the third factor, namely introversion, it has been found that introvert people are generally reflective in nature, reserved and oriented towards their inner world (Thornson et al., 2009). This stands in contrast to more extravert people who are considered to be more active, outgoing, talkative and sociable, but also more impulsive (Rammstedt et al., 2013). The characteristics of people high in introversion are believed to be positively linked to the degree of presence one experiences in VEs. In other words, introversion is believed to be related positively to presence. This has been proposed because a narrower range of attention allows introvert people to suppress conflicting sensory informations, such as for example the stimuli of the VR-device, which are thought to disturb the

experience of presence (Thornson et al., 2009). This ability of introverts to suppress conflicting stimuli and to allocate their attention to the virtual stimuli instead is therefore thought to be related to the degree of presence one experiences. Indeed there is evidence in the scientific literature that introvert people experience a deeper sense of presence (Sas, O'Hare & Reilly, 2004). As a consequence, the following hypothesis is formulated with regard to the factor introversion: *Introversion shows a significant positive association with presence.*

The fourth human factor is another personality trait, namely empathetic ability or just empathy. According to Sas (2004), empathy "involves the ability to engage in the cognitive process of adopting another's psychological point of view, together with the capacity to experience affective reactions to the observed experience of others" (p. 1022). Thus an empathetic person is characterised by a high ability to detect the emotions of other people and to feel for them. This is also believed to be a characteristic that is positively related to presence: it gives a person the capacity to feel for virtual characters in a VE, which makes the experience more emotional and increases the extent to which a person experiences presence (Thornson et al., 2009). Scientific studies are supporting this notion, having found that people higher in empathy experienced a higher degree of presence (see for example Sas & O'Hare, 2003; Sas et al., 2004). Thus, with regard to the human factor empathy, the following hypothesis is formulated: *Empathy shows a significant positive association with presence.*

In contrast to the four already mentioned human factors, no hypothesis is constructed for the last human factor, namely the level of computer experience one has. This is because there is no conclusive evidence of a relation between this factor and the construct of presence in the scientific literature (Thornson et al., 2009). Many researchers argue that theoretically there should be a positive link between the two variables. Sacau and her colleagues (2008), for instance, assume that "people who have little experience with computers may have problems with the interface, and as a result, they may pay less attention to the content of the media presentation" (p. 2257). Related to this, it is believed that the more experience a person has with computers, the higher is the ability of this person to understand the task information and to perform well in a VE (Thornson et al., 2009). However, the *empirical research* conducted until now has not been able to confirm such a link between the level of computer experience one has and the degree of presence one experiences (Thornson et al., 2009). So at the moment there is only inconclusive evidence with regard to a possible relationship between these two variables. Therefore the human factor level of computer experience is not hypothesised, but just measured as an *additional variable* in this study. The focus of this research thus mainly lies on finding an answer to the aforementioned research question by testing the four respective hypotheses about the human factors age, openness, introversion and empathy listed above.

Methods

Respondents

In this study the process of recruiting the respondents was guided by five different criteria, namely by three *inclusion criteria* and two *exclusion criteria*. The first two inclusion criteria implicated that the respondents should be able to speak German and to understand German and English, because some parts of the experiment were conducted in English. The third inclusion criterion stated that the respondents had to be 18 years or older at the time of the research. The two exclusion criteria additionally implicated that respondents with serious hearing or visual impairments and respondents receiving psychological treatment were not allowed to participate. Because of the Google Cardboard not being compatible with glasses, participants normally wearing glasses were asked to not wear them, but their contact lenses instead. Thus if the respondents did not have contact lenses and indicated that they were visually too impaired without their glasses or if they did not meet one of the other criteria, they were excluded from the research beforehand.

In total 80 participants were recruited for this research. All of them started and finished the entire data collection process, thus the response rate amounted to 100%. The respondents were recruited by asking relatives, friends, colleagues and other people if they would like to participate in a research project over VR, so the research sample can be described as a *convenience sample*. The detailed demographic data of the recruited respondents are shown in *Table 1*.

Table 1. *Demographic Data of the Recruited Respondents*

Demographic Variable	**Distribution in Research Sample**	
	N	**%**
Gender		
Female	43	53.7
Male	37	46.3
Nationality		
German	78	97.4
Dutch	1	1.3
Other Nationality	1	1.3
Education		
Lowest High School Degree (Hauptschulabschluss)	1	1.3
Normal High School Degree (Realschulabschluss)	9	11.2
Specialised High School Degree (Fachabitur)	5	6.2
Highest High School Degree (Abitur)	44	55.0
Bachelor	8	10.0
Master	3	3.8
Other Degree	10	12.5
Profession		
Student	41	51.3
Employee	26	32.4
Self-Employed	3	3.8
Apprentice	3	3.8
Other Profession	7	8.7

In general it can be said that nearly all of the 80 respondents were German, with only two people coming from other countries. Furthermore there were approximately as many male as there were female participants in the research sample. In addition, the majority of the respondents was highly educated, with most of them having earned at least the highest German high school degree or a degree from a university. Moreover it was noticeable that most of the respondents were either students or employees. In line with that, the mean of the respondents' age in years was 33.25 with a standard deviation of 15.33. Thereby the youngest person was 19, while the oldest person was 78 years old.

Materials

For the conduction of the data collection and for the measurement of the various psychological variables different materials, like for example questionnaires and technological devices, were needed. Those materials are described in detail hereafter.

Materials for the Experiment

First of all, a correctly assembled Google Cardboard was needed for the conduction of the experiment. A Google Cardboard is a simple VR-device developed by *Google*, which is worn like a pair of glasses and can be used together with a smartphone to create a VE (MacIsaac, 2015). Thus it was also necessary that the researcher had his smartphone available. On the smartphone the App *Perfect Beach* developed by *nDreams LTD* had to be installed, because this App displayed the VE and also contained the audio instructions of the *Guided Meditation* used during the experiment. The settings in the App also had to be adjusted beforehand: the gender of the avatar was matched with the gender of the respondent, the volume was set to a convenient level and the beach environment was adjusted so that it was filled with daylight and the avatar lay on the beach. To create a better sound experience the headphones were connected to the smartphone and used by the participant while he was exposed to the VE or listened to the Guided Meditation. The headphones were also provided by the researcher. Furthermore, because the questionnaires were filled in digitally, a laptop or computer was needed on which an online survey could be displayed. This survey had been created with the software *Qualtrics* and contained all the relevant questionnaires. In addition to the aforementioned materials, the following instruments were needed: a device to track the time (e.g. a watch), a printed version of the *informed consent* and a printed version of the *researcher instructions*.

Measuring Instruments

In contrast to the first human factor age, which was measured together with other demographic variables like *gender*, *nationality*, *education* and *profession* by simply asking the respondents about them, all the other human factors and the construct of presence were measured with the aid of several questionnaires.

The sense of presence felt by the participants, for instance, was measured with the German version of the *Igroup Presence Questionnaire (IPQ)*. The IPQ is a short questionnaire consisting of 14

items that was specifically designed to be used in studies with VEs. One item for example reads *"I felt present in the virtual space"*. The IPQ thus measures the degree of presence experienced by the users of VR-devices. Furthermore the questionnaire consists of three subscales measuring different aspects of presence, namely the *spatial presence*, *involvement* and *realness* subscales (Schubert, Friedmann & Regenbrecht, 2001). In this case the total score of all 14 IPQ-items was used as an indicator for the general amount of presence experienced by the respondents. Each of the 14 items was thereby answered on a *7-point-scale (1-7)* with several different anchors, such as for example "strongly disagree – strongly agree" or "not real at all – totally real". As a result, total scores between 7 and 98 were possible, with higher scores representing a higher degree of presence felt by the participants. Other research indicates that the IPQ has sufficient psychometric qualities (Price, Mehta, Tone & Anderson, 2011). In this study *Cronbach's Alpha* took on the value of $\alpha = .87$, which is thus indeed an indication that the IPQ is a reliable questionnaire.

The human factors openness and introversion were also measured with the aid of a questionnaire, namely with the German *Big-Five-Persönlichkeitstest (B5T)*. The B5T is an elaborate personality questionnaire based on the five factor model of personality (Satow, 2011). It was designed to measure the five personality dimensions of that model, namely the neuroticism, conscientiousness, agreeableness, openness to experience and extraversion-introversion dimensions (John & Srivastava, 1999). In total the questionnaire consists of 72 items, which were all answered on a *4-point-scale (1-4)* ranging from "strongly disagree" to "strongly agree". Research has shown that the B5T is a reliable and valid questionnaire (Satow, 2011). Furthermore the B5T is composed of nine different subscales. However, only two of these subscales, each consisting of 10 different items whose total score could range between 10 and 40, were used during this study. More specifically, to measure the human factor openness, the openness to experience subscale of the B5T was used. As the name indicates, this scale specifically examines the personality dimension of openness to experience (Satow, 2011). One of the items, for instance, states the following: *"I always want to try new things"*. The total score of all the items of this subscale was used as a measure for the openness of the respondents, with higher scores indicating a higher level of openness (Satow, 2011). Thereby the openness to experience subscale was found to be a reliable scale in this study ($\alpha = .82$). The second subscale, namely a *modified version* of the extraversion-introversion subscale of the B5T, was used to quantify the human factor introversion. The normal extraversion-introversion subscale measures the personality dimension of extraversion-introversion and consists of such items like *"I enjoy being around other people"*. Normally higher scores on that scale indicate a higher level of extraversion. In this case, however, it was decided to modify the subscale by recoding it, so that it would directly measure the level of introversion and thus make the interpretation of the scores more straightforward. This adjustment could be undertaken without further problems, because extraversion and introversion are essentially part of one dimension (John & Srivastava, 1999; Satow, 2011). So the total score of all the items of the modified extraversion-introversion subscale was used as a measure for the introversion of the respondents.

Similar to the openness to experience subscale, the modified extraversion-introversion subscale also turned out to have sufficient internal consistency (α = .79).

The fourth human factor, namely empathy, was measured with the German version of the *Interpersonal Reactivity Index (IRI)*, which is also known by its German name *Saarbrücker Persönlichkeitsfragebogen (SPF)* (Paulus, 2009). The SPF consists of 16 items, like for instance the item *"I have warm-hearted feelings towards people who are worse off than me"*, and measures the empathetic ability of a person. Each of the 16 items was thereby answered on a *5-point-scale (1-5)*, with answers ranging from "never" to "always". In this case however, only the 12 items belonging to the three subscales named *empathic concern*, *perspective taking* and *fantasy scale* were used as an indicator for the empathetic ability of the respondents. This was done because it was found that the items of the fourth subscale of the SPF, namely the *personal distress* subscale, act too inconsistent in relation to the overall empathy-score (Paulus, 2012). Thus the used total score could vary between 12 and 60, with higher scores representing a higher level of empathetic ability (Paulus, 2012). In general, research has shown that the SPF has good psychometric properties (Paulus, 2009). This also seemed to be the case in this study (α = .78).

The last human factor, namely the level of computer experience, was not hypothesised, but tested nonetheless by using five *self-formulated German items* (see *Appendix A*). These items were formulated with the aim of creating a short questionnaire that measures the level of the computer experience of the respondents. At first eight items were phrased, but after a review three items were removed and the others were revised, leaving five items in the final version of the questionnaire. One of these items for example reads *"I feel comfortable when using a computer"*. A *5-point-scale (1-5)* with answering options ranging from "do not agree at all" to "totally agree" was assigned to each of the items. The total score of the five self-formulated items was used as an indicator for the level of the computer experience of the participants. This total score could vary between 5 and 25, with higher total scores representing a higher level of computer experience. Cronbach's Alpha again indicated that the reliability of the questionnaire was good (α = .91). Because the self-formulated questionnaire had not been validated before, an additional factor analysis was conducted. The *scree plot* obtained during that analysis showed that the first factor explained 72.95% of the total variance and had an *Eigenvalue* of 3.65, while the other factors all had Eigenvalues smaller than 1 (see *Appendix B*). This made the conclusion that the questionnaire had only one underlying factor consequential (Field, 2009). Because it had been assumed beforehand that the variable computer experience would be unidimensional, the results of the factor analysis are an indication of good factorial validity. The psychometric properties of the self-formulated questionnaire thus seemed to be decent.

Procedure

The data collection process followed a standardised procedure, which was specified in a research protocol that had been compiled beforehand by the four researchers associated with the research program. The first step was to *randomly* allot the participants to an *experimental condition* and a

control condition, so that there were 40 respondents in each research condition. The reason for this was that this particular study was part of an overarching research program that dealt with the psychological effects of VR and it was necessary for some of the other studies that different conditions were implemented during the data collection. The two conditions were thus not relevant to this particular research, but because of their procedure differing in some points they are outlined separately later on.

Before the beginning of each experiment that was conducted during the month-long data collection period, an adequate and standardised *testing environment* had to be created. For instance, the researcher had to make sure that nobody entered the room during the experiment and that there was a desk with a revolving chair in which the participant could comfortably sit. Most of the time the library of the *University of Twente* or the home of the respondents served as a proper setting. After the testing environment had been prepared, the actual experiment began with the welcoming of the respondent and a short introduction about the survey. Then the participant was seated in front of a table upon which the laptop was placed. On the laptop the Qualtrics survey with the different questionnaires was opened, so that the respondent could fill them in if asked to. Next the respondent was asked to fill in the informed consent. After that the further conduction of the experiment differed depending on the condition to which the respondent was allocated to (see *Appendix C*).

In the experimental condition the respondent started with disclosing some demographic information and filling in the two subscales from the B5T, the self-formulated questionnaire about computer experience, the SPF, and some other questionnaires not relevant to this particular study. Next, the participant was given the Google Cardboard with the smartphone and the headphones attached to it. On the smartphone the Perfect Beach App was opened and the audio instructions of the Guided Meditation were started. The participant was instructed to sit back, put on the cardboard and the headphones, freely look around in the VE and try to relax while listening to the Guided Meditation. This exposure to the VE and the audio instructions of the Guided Meditation lasted approximately 12 minutes. Afterwards the cardboard was taken back from the participant and he was instructed to fill in the IPQ and some other questionnaires not relevant to this particular study. At the end a short *debriefing* was conducted to clarify the background of the experiment, to answer the questions of the respondent and to thank him once again for taking part in the study.

In the control condition on the other hand, the procedure differed a bit. In the beginning the respondent also disclosed the demographic information and filled in the two subscales from the B5T, the self-formulated questionnaire about computer experience, the SPF, and some other questionnaires not relevant to this particular study. Thereafter however, the respondent was only given the headphones and he was instructed to close his eyes and relax while listening to the same 12 minute long audio instructions of the Guided Meditation used in the experimental condition. Next, the participant filled in some more questionnaires that were also not relevant to this particular study. Subsequently the respondent received the Google Cardboard with the smartphone and the headphones

attached to it. On the smartphone the Perfect Beach App was opened, but the audio instructions of the Guided Meditation were not started. Instead only the background noises of the beach environment came out of the headphones. The participant was then instructed to sit back, put on the cardboard and the headphones, freely look around in the VE and try to relax. In this case however, the respondent only had to stay in the VE for 5 to 10 minutes. When the participant then had the feeling that he had seen everything, he could signal this to the researcher and the cardboard was removed. Afterwards the respondent was instructed to fill in the IPQ and one additional questionnaire not relevant to this particular study. As was the case in the experimental condition, a short debriefing was conducted at the end and the participant was thanked once again for his participation.

Ethics

Several actions were taken to guarantee that this research met the common ethical standards. For example, each respondent was informed before the start of the data collection about the procedure of the experiment and that the participation in the study was voluntary and anonymous. Furthermore the collected data were kept confidential at all times and they were not passed on to third parties. In addition, several criteria were determined to guide the recruitment process and to protect unsuited respondents, such as underage people or people receiving psychological treatment, from taking part in the study (see paragraph *Respondents*). Therefore the research was approved by the *Ethics Commission* of the University of Twente.

Data Analysis and Research Design

The statistical analyses were conducted with the aid of the statistics software *SPSS*. Because a *correlational research design* was utilised during this study, the focus lay on testing the hypotheses by identifying possible associations between the scores derived from the different questionnaires. This was done with the aid of a *multiple regression analysis*.

Before the results of that regression analysis were further investigated however, it was tested if the assumptions for a multiple regression analysis were met. The first assumption, the assumption of *no perfect multicollinearity*, was tested using the *Variance Inflation Factor (VIF)*. In this case all VIF-values were significantly smaller than 10 and thus not a cause for concern, so the assumption of no perfect multicollinearity was fulfilled (Field, 2009). The next two assumptions, namely the assumptions of *homoscedasticity* and *linearity*, were both checked with the aid of a graph contrasting the regression standardised residuals and the regression standardised predicted values. Because this graph showed a random array of data points without any noticeable pattern or spreading to it, both assumptions were said to be met (Field, 2009). The assumption of *independent errors* was controlled with the *Durbin-Watson Test*. Because this test revealed a score of 1.93, the assumption of independent errors was also fulfilled (Field, 2009). The last assumption of *normally distributed errors* was checked with the aid of a histogram showing the distribution of the regression standardised residuals. This distribution did not reveal a significant deviation from the normal distribution, so the

assumption of normally distributed errors was also met (Field, 2009). Besides these general assumptions it was also checked if there were any outliers that could have significantly distorted the results of the regression analysis. This was done by looking at the regression standardised residuals of each respondent. However, all of these standardised residuals were lower than 3, so no outliers were detected and all scores remained in the dataset (Field, 2009). Thus the statistical analyses could be further conducted without any difficulties, because no outliers or problems with the assumptions had been identified.

Before conducting the multiple regression analysis however, first a *simple regression analysis* with presence as the *dependent* variable and the categorical variable research condition as the *independent* variable was carried out. This was done because there were several differences between the two conditions that could have had significant effects on the presence experienced by the respondents. So it was controlled with the aid of the simple regression analysis if these differences indeed led to the type of research condition having a significant influence on presence, which could have distorted the associations between the five human factors and the construct of presence.

Subsequently the main analysis, namely a multiple regression analysis with presence being defined as the dependent variable and the five human factors being classified as the independent variables, was conducted. Thereby the significance level was set at 0.05 and for the analysis a *forced entry method* was chosen, so that the independent variables were all selected into the regression model simultaneously (Field, 2009). If the categorical variable research condition had been found to be a significant predictor of presence in the simple regression analysis, that variable was also included in the multiple regression analysis as an additional sixth independent variable. This was done to control and correct for the possible distortion that the variable caused with regard to the associations between the five human factors and presence. However, if the type of research condition was not found to be significantly related to presence, the variable research condition was not included in the multiple regression analysis, which was then run with only the five human factors as the independent variables. This was done to stop the statistical power of the analysis from becoming too small, because if as many as six independent variables were included in the regression analysis a sample size of at least 100 respondents would have been necessary (Field, 2009).

Results

The data of all 80 respondents were present in the customised dataset, indicating that there were no missing values. As can be seen in *Table 2*, the descriptive statistics with regard to the different scores derived from the respective questionnaires and subscales did not reveal any apparent irregularities. The *presence*, *openness*, *introversion*, *empathy* and *computer experience scores* all had means that were neither particularly high nor low. In line with that, the corresponding standard deviations and the

ranges of the scores also did not reveal any cause for concern, thus a further analysis of the data was deemed possible.

Table 2. *Descriptive Statistics of the Psychological Variables*

Variable		Mean (SD)	Range	
			Lowest	Highest
Presence	(7 - 98)	59.08 (13.25)	21	94
Openness	(10 - 40)	28.71 (4.92)	18	40
Introversion	(10 - 40)	20.00 (4.07)	12	29
Empathy	(12 - 60)	43.19 (5.30)	30	56
Computer Experience	(5 - 25)	18.40 (4.52)	5	25

The results of the simple regression analysis with the variable research condition as the independent variable showed that the used regression model explained only negligible 0.6% of the total variance. The corresponding F-ratio was thus not significant ($F(1, 78) = 0.45$, $p = .503$), indicating that the model did not fit the data. In addition, the regression analysis revealed that the type of research condition was not significantly associated with the presence scores obtained by the respondents (b = -2.00; $t(78) = -.67$, $p = .503$). Because the type of condition did not have a significant effect on the presence experienced by the respondents, the variable research condition was not included in the following multiple regression analysis.

The regression model of the multiple regression analysis explained a higher proportion of the total variance than the first model (13.1%), but was also just a marginally more significant predictor than the simple mean of the presence scores ($F(5, 74) = 2.24$, $p = .059$). With regard to the four hypotheses the regression analysis yielded varying results (see *Table 3*). Between the demographic variable age and the presence scores no meaningful regression was found, because the corresponding regression coefficient of $b = -.03$ did not significantly differ from zero. Therefore the hypothesis that age shows a significant negative association with presence was discarded. With respect to the second hypothesis it could be said that a significant regression between the openness scores and the presence scores was found. This regression, however, was not oriented in the positive direction as predicted, but displayed a negative regression coefficient of $b = -1.04$. The formulated hypothesis stating that openness is positively related to presence thus had to be rejected, because the opposite was the case. No significant regression was detected between the introversion scores and the presence scores ($b = -.42$). As a consequence, the hypothesis that introversion shows a significant positive association with presence was disproved. There was also no significant regression between the empathy scores and the presence scores ($b = .40$). Thus the hypothesis stating that empathy displays a significant positive association with presence was discarded. Although not hypothesised, the association between the computer experience scores and the presence scores was also analysed. Thereby a positive regression coefficient of $b = .77$ was found that was marginally significant, but fell just above the boundary value ($t(74) = 1.96$, $p = .054$). However, the questionnaire used to measure computer

experience had shown decent psychometric properties and the statistical power of the multiple regression analysis was quiet low, which could lead to significant associations incorrectly being labelled as not significant. Thus although the regression between the computer experience scores and the presence scores was strictly speaking not significant, the association between the level of computer experience and presence was classified as meaningful nonetheless.

Table 3. *Regression Coefficients of the Human Factors*

Human Factor	**B**	**SE (B)**	**β**	**t**	**Sig.**
Age	-0.03	0.11	-0.04	-0.30	0.766
Openness	-1.04	0.36	-0.39	-2.89	0.005
Introversion	-0.42	0.41	-0.13	-1.03	0.308
Empathy	0.40	0.29	0.16	1.38	0.173
Computer Experience	0.77	0.39	0.26	1.96	0.054

Discussion

The main aim of this research was to identify the human factors that are directly related to the different degrees of presence experienced by people who all use the same VR-device. After investigating the results of the statistical analysis however, it became clear that not many of such factors had been found. The research results namely indicated that, with regard to the human factors and presence, only a few associations had been found and these even differed from what had been anticipated. In fact, all the hypotheses that had been formulated beforehand had to be disproved.

Research Results

With regard to the first hypothesis, which predicted a negative association between the demographic variable age and presence, no affirmative evidence was found. In other words, young and old respondents did not differ with respect to their sense of being present in the VE. This might seem contradictory to what would be expected, because it is generally assumed that elder people have fewer information processing resources available and therefore need more time to get used to computer related technologies, which would negatively influence their sense of presence (Sacau et al., 2008; Salthouse, 1996). However, there have also been cases in which age had been positively related to presence (Schuemie, Abel, Van der Mast, Krijn & Emmelkamp, 2005). In general it seems that the more complex the VR-device, the more influential the age of the VR-users is (Thornson et al., 2009). So it might seem possible that in this study the age of the respondents had no influence on presence, because of the Google Cardboard being one of the simpler VR-devices on the market.

The second hypothesis, which stated that the personality trait openness shows a positive association with presence, also had to be discarded. Nevertheless a significant link between openness

and presence had been found, but that link turned out to be negative and not positive as had been predicted beforehand. Thus in this case people who were more conservative and less open to new experiences were found to experience a higher degree of presence, which is contrary to the assumptions made in the scientific literature (see for example Thornson et al., 2009). It could be speculated that this had to do with the calming, safe and stable beach environment that was used as the VE during the experiment. As described earlier, the participants had to look through the Cardboard for a long time period without anything happening in the VE. Therefore it could be possible that participants with higher openness to experience were bored after a while, because those people are said to be more fond of changing environments (John & Srivastava, 1999). Participants with lower openness to experience on the other hand maybe found the VE to be more appealing, because they were not overwhelmed with sudden changes and thus could take their time to develop a sense of being present in the VE. This would also explain why a positive association between openness and presence was found in earlier studies that implemented changing and interactive VEs (see for example Sas & O'Hare, 2003), while the opposite relation was detected in this study, in which a very stable VE had been utilised.

The third hypothesis, which predicted a positive association between the personality trait introversion and presence, also had to be rejected. This finding is again contrary to the scientific literature (Thornson et al., 2009). One possible explanation for why no positive association between the variables was found in this particular study could be that the more introvert people were more affected by the Guided Meditation, which played before or during their exposure to the VE. It might namely be possible that the introvert respondents reacted to the Meditation by trying to focus more on their inner selves, while the more extravert participants might have ignored the Meditation and instead paid more attention to the characteristics of the VE. This could have given the extravert respondents a better sense of space that balanced out their inferior capacity to suppress irrelevant sensory information, resulting in a similar degree of presence experienced by both introvert and extravert participants.

With regard to the last hypothesis, which positively linked the human factor empathy to the construct of presence, again no affirmative evidence was found. This implies that empathetic ability was not related to presence, which is contrary to the findings of scientific studies that have shown that people higher in empathy experience a higher degree of presence (see for example Sas & O'Hare, 2003). However, the lack of an association between empathy and presence in this case could also be related to the fact that there were no other virtual characters present in the VE besides the own avatar. Indeed empathy mainly involves experiencing the emotions observed in others and adopting another person’s perspective (Thornson et al., 2009), so when there is no interaction with other people empathy seems to become less relevant. So maybe if other human avatars would have been implemented in the VE, the respondents with a higher empathetic ability would then have experienced a higher degree of presence than the respondents with less empathetic ability.

With respect to the last human factor, namely the level of computer experience, a positive association with presence was detected. This study was thus one of the first to find empirical evidence for the theoretical notion that computer experience and presence should be related (Thornson et al., 2009). Although the found association between these two variables was only marginally significant, it was considered meaningful nonetheless due to the low statistical power of the analysis. Therefore it was concluded that people with a higher level of computer experience felt a higher sense of presence. This finding thus supports the idea that more computer experience enables one to solely focus on the task at hand and to interact more effectively with VR-technologies, which in turn results in a higher degree of presence (Sacau et al., 2008; Thornson et al., 2009). So with regard to this last human factor this study indeed affirms some of the assumptions made in the scientific literature.

Taken altogether, the research question formulated at the beginning of the research could thus be answered as follows: The human factors age, introversion and empathy were not significantly related to the degree of presence experienced by the respondents in the VE. The factor openness, however, showed a significant negative association with presence and the level of the computer experience of the respondents was also meaningfully related to presence. So nevertheless there were some human factors that acted as predictors of presence in this study.

Limitations and Strong Aspects of the Research

The fact that the results of this study were not consistent with the findings of other scientific literature maybe also had to do with some limitations and weaknesses of this research, which could have distorted the obtained results. For example, one of these limitations was that, despite the utilisation of a detailed research protocol, there were some problems during the collection of the data. For instance, some participants came across technical problems with the VE during the experiment. Some respondents for example stated that the latency between their own motion and the representation of that motion in the VE was too long, while others said that the VE had moved slightly to the left or right without them having turned their heads. Scientific studies have shown that such technical errors can negatively influence the degree of presence experienced by the users of VR-devices (see for example Brooks, 1999; Pallavicini et al., 2013). So it is possible that these software problems could also have distorted the obtained results in this study. In addition, some of the participants reported that the Google Cardboard was quite uncomfortable and that this had disturbed their experience of the VE. So this might have also been an inadvertent factor that could have influenced the research results.

Another weakness of this study was the fact that the research sample was a convenience sample. This resulted in the sample not being as representative for the normal German population as had been intended. For instance, an unproportionally high number of respondents were highly educated, students and less than 30 years old. Although one could make the point that the demographic background of the respondents should not make a significant difference when investigating the relations between human factors and presence, such an unrepresentative sample could still pose a problem for the external validity of the research results. For example, it might be possible that a

different relation between age and presence would have been found if the older generation had not been so underrepresented in the research sample. So these kind of implications must be kept in mind when generalising the obtained results.

On the other hand there were also some strong aspects that made this research scientifically valuable. For example, one positive aspect of this study was that until now not much research with a focus on the human factors related to presence had been conducted. Therefore this study could be seen as a notable first step that provides a foundation for possible future research on the topic. For instance, this study identified some possible problems that can occur when conducting research on the relations between human factors and presence, so other researchers now should be more alert about these difficulties and can avoid them in their own research. They might, for example, choose a more comfortable VR-device, use a better research sample and carefully plan the data collection process in order to prevent some of the problems that arose during this study.

Another strong point lay in the methodological aspects of this research. For example, a sophisticated research design had been implemented on the basis of a detailed research protocol. Furthermore the psychometric properties of the used questionnaires, subscales and the self-formulated questionnaire all were sufficient. This ensured that the results of the statistical analysis were accurate and, at least to a certain degree, valid.

Suggestions for further Research

One of the reasons behind this research was to further shed light on the human factors that are associated with the construct of presence. Although only a few of these factors were identified in this research, the study nonetheless revealed some new information that might be focused on during further research in the future. For instance, it could be tested if the results obtained during this research, which were quite contrary to the assumptions made in the scientific literature, can be replicated in similar research that avoids the shortcomings of this study. For example, there were some concerns with the statistical power of the regression analysis in this study. This was because 90 respondents would have been needed for the analysis to have sufficient statistical power, but in this case only a sample of 80 respondents was available (Field, 2009, p. 223). Thus in future research it could be tested if still no significant associations can be detected, even when a large enough sample is being used.

Besides simply trying to replicate the results of this study, further research could also investigate if there are other human factors that are significantly associated with presence, but have not been examined in scientific research yet. In this study it was namely found that the regression model of the multiple regression analysis did not fit the data well, indicating that the five examined human factors taken together were not capable of reliably predicting the degree of presence experienced by the respondents. So it seems plausible that there are other factors related to the construct of presence that are not identified yet. These could be other demographic variables, like for example gender, or different psychological variables, such as neuroticism or intelligence, that have barely been examined

in the context of VR until now (Sacau et al., 2008).

Another suggestion for further research would be to not only examine the associations between the human factors and presence, but also the association between presence and the effectiveness of a VE in a training situation or in a *psychological intervention* (see for example Vora et al., 2002). This would be particularly relevant if the VE is used as a therapeutic tool to enhance a positive psychological variable or to reduce a negative psychological variable. In that case it might be of interest to investigate the role of presence as a mediator between the human factors and the effectiveness of the VE, because this could yield novel theoretical knowledge about the role that the construct of presence plays in the interaction between humans and VEs.

Another proposal for further research could be to test if the associations between the human factors and presence depend on the characteristics of the used medium. According to Sacau and her colleagues (2008), distinct human factors might be related to presence when a highly immersive medium, such as a sophisticated VR-device, is used in contrast to when a less immersive medium, such as a normal TV, is utilised. Therefore it might be worthwhile to identify and compare the human factors that are influential when highly immersive VR-devices are used with those that are relevant when one makes use of less immersive VR-devices.

A last suggestion for future research on the topic could be based on some of the comments made by the respondents during the experiment. For instance, some of the respondents would have liked the VEs to be more customisable and interactive. Taking this as a starting point, one could for example investigate whether the respondents would experience a higher degree of presence if a VE would be chosen that allows a greater *depth of interaction* (Zeltzer, 1992). Thus in general it can be said that there are still plenty of unclear aspects regarding VR that need to be examined in the future.

Practical Implications

With the aid of this study new knowledge about the relationship between human factors and the construct of presence was gained. Although this knowledge must be evaluated with caution due to some limitations of this study, it still has some valuable practical implications. For example, knowing that age does not seem to be a predictor of presence can exert an influence on how VR is applied in practice, because it indicates that old people can benefit from VR in the same way as young people do. Thus not just the members of the younger generations, but people from all ages should be encouraged to try out VR-devices and benefit from its many advantages.

Furthermore the gained knowledge about the associations between specific human factors and presence could prove beneficial when developing new VR-devices and creating new VEs. This is because knowing which human factors are relevant during the VR-experience can help in inventing VR-devices and VEs that are more user friendly and have features that increase the chance of every user to experience a high degree of presence. For example, it was found in this study that people who are less open to new experiences feel a higher degree of presence when being exposed to a VE than people who are more open to new experiences. However, it was assumed that this was mainly due to

the more open people getting bored after a while by the calming and unchanging VE used in this case. Thus in practice it seems to be reasonable to design VEs that strike a good balance between a too stable and a too cluttered environment, so that both more open and less open people would get the chance to experience a high degree of presence. In line with that, one could even go a step further and develop VEs that can be personalised by the VR-users according to their preferences. For instance, it might be reasonable to offer users with little computer experience the option to choose a clearer and simpler *VR-interface*, because this could increase their chances of experiencing a degree of presence as high as that experienced by users with more computer experience.

Another possible way to apply the knowledge gained from this research would be to use it for the identification of people who are most likely to feel a deep sense of presence and thus would get the most out of VEs (Sacau et al., 2008). Theoretically this could be done by simply measuring the computer experience of the people, because according to this study the level of computer experience one has predicts the degree of presence one experiences in VEs. However, it is strongly recommended to wait for more scientific evidence to emerge before carrying out such selection procedures in the psychological practice.

References

Alsina-Jurnet, I., & Gutiérrez-Maldonado, J. (2010). Influence of personality and individual abilities on the sense of presence experienced in anxiety triggering virtual environments. *International journal of human-computer studies*, *68*(10), 788-801.

Bangay, S., & Preston, L. (1998). An investigation into factors influencing immersion in interactive virtual reality environments. *Studies in health technology and informatics*, 43-51.

Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: how much immersion is enough?. *Computer*, *40*(7), 36-43.

Brooks Jr, F. P. (1999). What's real about virtual reality?. *Computer Graphics and Applications, IEEE*, *19*(6), 16-27.

Cline, M. S. (2005). *Power, madness, and immortality: The future of virtual reality*. Mychilo Cline.

Earnshaw, R. A. (Ed.). (2014). *Virtual reality systems*. Academic press.

Emmelkamp, P. M., Bruynzeel, M., Drost, L., & van der Mast, C. A. G. (2001). Virtual reality treatment in acrophobia: a comparison with exposure in vivo. *CyberPsychology & Behavior*, *4*(3), 335-339.

Field, A. (2009). *Discovering statistics using SPSS*. Sage publications.

Heeter, C. (1992). Being there: The subjective experience of presence. *Presence: Teleoperators & Virtual Environments*, *1*(2), 262-271.

John, O. P., & Srivastava, S. (1999). The Big Five trait taxonomy: History, measurement, and theoretical perspectives. *Handbook of personality: Theory and research*, *2*(1999), 102-138.

Krijn, M., Emmelkamp, P. M., Biemond, R., de Ligny, C. D. W., Schuemie, M. J., & van der Mast, C. A. (2004). Treatment of acrophobia in virtual reality: The role of immersion and presence. *Behaviour research and therapy*, *42*(2), 229-239.

Lee, H., Lee, S., Choi, Y. S., Seo, Y., & Shim, E. (2013, January). A new posture monitoring system for preventing physical illness of smartphone users. In *Consumer Communications and Networking Conference (CCNC), 2013 IEEE* (pp. 713-716). IEEE.

Lessiter, J., Freeman, J., Keogh, E., & Davidoff, J. (2001). A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. *Presence*,*10*(3), 282-297.

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in psychology. *Behavior Research Methods, Instruments, & Computers*, *31*(4), 557-564.

MacIsaac, D. (2015). Google Cardboard: A virtual reality headset for $10?. *The Physics Teacher*, *53*(2), 125-125.

Pallavicini, F., Cipresso, P., Raspelli, S., Grassi, A., Serino, S., Vigna, C., ... & Riva, G. (2013). Is virtual reality always an effective stressors for exposure treatments? Some insights from a controlled trial. *BMC psychiatry*,*13*(1), 1.

Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of behavior therapy and experimental psychiatry*, *39*(3), 250-261.

Paulus, C. (2009). Der Saarbrücker Persönlichkeitsfragebogen SPF (IRI) zur Messung von Empathie: Psychometrische Evaluation der deutschen Version des Interpersonal Reactivity Index.

Paulus, C. (2012). Ist die Bildung eines Empathiescores in der deutschen Fassung des IRI sinnvoll?.

Perpiñá, C., Botella, C., & Baños, R. M. (2003). Virtual reality in eating disorders. *European Eating Disorders Review*, *11*(3), 261-278.

Price, M., Mehta, N., Tone, E. B., & Anderson, P. L. (2011). Does engagement with exposure yield better outcomes? Components of presence as a predictor of treatment response for virtual reality exposure therapy for social phobia. *Journal of anxiety disorders*, *25*(6), 763-770.

Rammstedt, B., Kemper, C. J., Céline, M., Klein, C. B., & Kovaleva, A. (2013). Eine kurze Skala zur Messung der fünf Dimensionen der Persönlichkeit. *Methoden, Daten, Analysen*, *7*, 233-249.

Rothbaum, B. O., Hodges, L. F., Ready, D., & Alarcon, R. D. (2001). Virtual reality exposure therapy for Vietnam veterans with posttraumatic stress disorder. *The Journal of clinical psychiatry*, *62*(8), 1-478.

Rushton, K. (2012). Number of smartphones tops one billion. *The telegraph*, *17*.

Sacau, A., Laarni, J., & Hartmann, T. (2008). Influence of individual factors on presence. *Computers in Human Behavior*, *24*(5), 2255-2273.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological review*, *103*(3), 403.

Sas, C. (2004). Individual differences in virtual environments. In *Computational Science-ICCS 2004* (pp. 1017-1024). Springer Berlin Heidelberg.

Sas, C., & O'Hare, G. M. P. (2003). Impact of cognitive style upon sense of presence.

Sas, C., O'Hare, G. M., & Reilly, R. (2004). Presence and task performance: an approach in the light of cognitive style. *Cognition, Technology & Work*,*6*(1), 53-56.

Satow, L. (2011). B5T. Psychomeda Big-Five-Persönlichkeitstest. Skalendokumentation und Normen sowie Fragebogen mit Instruktion [PSYNDEX Tests-Nr. 9006357]. *Leibniz-Zentrum für Psychologische Information und Dokumentation (ZPID)(Hrsg.), Elektronisches Testarchiv. Available at: http://www.zpid.de*.

Schaik, P. V., Turnbull, T., Wersch, A. V., & Drummond, S. (2004). Presence within a mixed reality environment. *CyberPsychology & Behavior*,*7*(5), 540-552.

Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence*, *10*(3), 266-281.

Schuemie, M. J., Abel, B., van der Mast, C. A. P. G., Krijn, M., & Emmelkamp, P. M. G. (2005). The effect of locomotion technique on presence, fear and usability in a virtual environment. In *EUROMEDIA* (Vol. 2005, p. 11th).

Schultheis, M. T., & Rizzo, A. A. (2001). The application of virtual reality technology in rehabilitation. *Rehabilitation psychology*, *46*(3), 296.

Sherman, W. R., & Craig, A. B. (2002). *Understanding virtual reality: Interface, application, and design*. Elsevier.

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments (FIVE): Speculations on the role of presence in virtual environments. *Presence: Teleoperators and virtual environments*, *6*(6), 603-616.

Thornson, C. A., Goldiez, B. F., & Le, H. (2009). Predicting presence: Constructing the tendency toward presence inventory. *International Journal of Human-Computer Studies*, *67*(1), 62-78.

Vora, J., Nair, S., Gramopadhye, A. K., Duchowski, A. T., Melloy, B. J., & Kanki, B. (2002). Using virtual reality technology for aircraft visual inspection training: presence and comparison studies. *Applied Ergonomics*, *33*(6), 559-570.

Wang, G. G. (2002). Definition and review of virtual prototyping. *J. Comput. Inf. Sci. Eng.*, *2*(3), 232-236.

Zeltzer, D. (1992). Autonomy, interaction, and presence. *Presence: Teleoperators & Virtual Environments*, *1*(1), 127-132.

Appendices

Appendix A

German and English Version of the Self-formulated Questionnaire

Self-formulated Items to measure the Variable "Level of Computer Experience"

These five items were formulated to measure the level of computer experience of the respondents. The items are answered on a 5-point Likert-Scale. The total scores of the respondents can be calculated by simply adding up the scores of the five separate items. This total score is then thought to give an indication of the level of computer experience of the respective respondent.

English Version (provided for other interested researchers):

In the following you will read five statements about computer experience (PC/Laptop). Please indicate for every statement how much you agree with it by using the 5-Point-Scale. The higher the score you give, the higher your agreement. There are no right or wrong answers. If you are not sure how to answer a question, chose the answer that applies best to you. Please answer spontaneously, without thinking to long about each question.

To what extent do you agree with the following statement?

1.) I would consider myself a person that is handy with computers. [Not at all] 1 -2-3-4- 5 [Totally]

2.) I often use a computer in my free time. [Not at all] 1 -2-3-4- 5 [Totally]

3.) I feel comfortable when using a computer. [Not at all] 1 -2-3-4- 5 [Totally]

4.) I would consider myself an experienced user of computers. [Not at all] 1 -2-3-4- 5 [Totally]

5.) I have regularly used computers in the past 5 years. [Not at all] 1 -2-3-4- 5 [Totally]

German Version (used during this research):

Der folgende Fragebogen umfasst fünf Aussagen über Erfahrung mit Computern (PCs/Laptops). Bitte geben Sie für jede Aussage an inwiefern diese auf Sie zutrifft, indem Sie Gebrauch von der 5-Punkte-Skala machen. Je höher die Zahl, desto höher die Zustimmung. Es gibt dabei keine richtigen oder falschen Antworten. Wenn Sie sich bei einer Aussage unsicher bezüglich Ihrer Antwort sind, dann wählen Sie jene Antwortmöglichkeit die am ehesten auf Sie zutrifft. Bitte antworten Sie dabei spontan, ohne zu lange über die einzelnen Fragen nachzudenken.

Inwieweit treffen die folgenden Aussagen auf Sie zu?

1.) Ich würde mich als jemanden bezeichnen der gut mit Computern umgehen kann. [Trifft gar nicht zu] 1 -2-3-4- 5 [Trifft genau zu]

2.) Ich mache in meiner Freizeit oft Gebrauch von Computern. [Trifft gar nicht zu] 1 -2-3-4- 5 [Trifft genau zu]

3.) Ich fühle mich wohl wenn ich einen Computer bediene. [Trifft gar nicht zu] 1 -2-3-4- 5 [Trifft genau zu]

4.) Ich würde mich als jemanden bezeichnen der erfahren ist im Umgang mit Computern. [Trifft gar nicht zu] 1 -2-3-4- 5 [Trifft genau zu]

5.) Ich habe in den vergangenen 5 Jahren regelmäßig Gebrauch von Computern gemacht. [Trifft gar nicht zu] 1 -2-3-4- 5 [Trifft genau zu]

Appendix B

Additional Information about the Factor Analysis

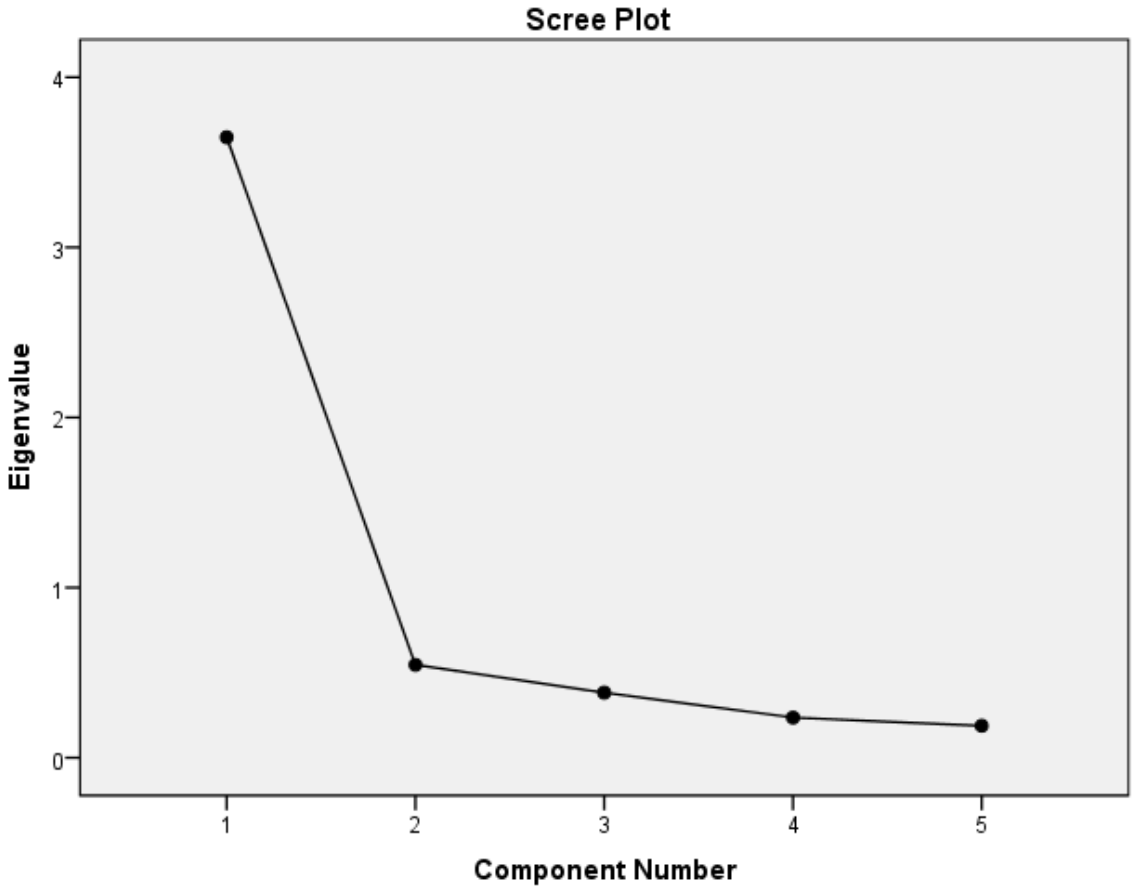

Figure B1. Scree Plot

Appendix C

Additional Information about the Research Procedure

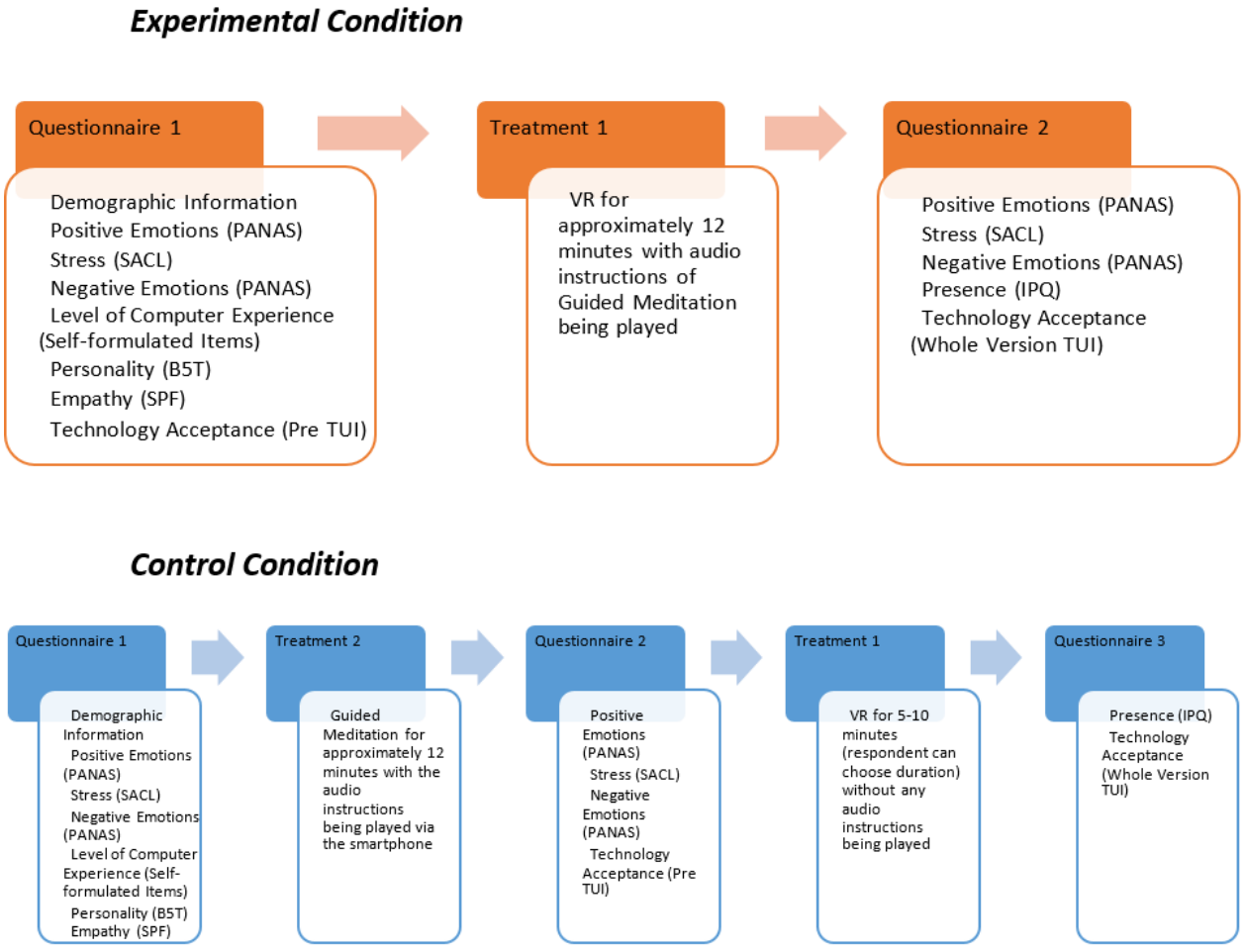

Figure C1. Graphical Overview of the Research Procedure