Master thesis

INFLUENCE OF

PERSONALITY TRAITS

AND EMOTIONAL CONTENT

ON THE SENSE OF PRESENCE IN

A VR APPLICATION

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I've been working on this thesis for over half a year. Especially in the beginning I had a hard time finding direction and a specific topic, since there are many topics on virtual reality uninvestigated. I have always been fascinated by psychology; therefore a combination of the latter with an educational purpose was my preferred topic. This is how I decided to work with personality traits. The article of Weibel et al. (2010) on these traits inspired me the most, and made me curious about the usage of their findings in virtual reality. This thesis became more and more something I really enjoyed working on and therefore I would like to thank some people. First, my first supervisor Dr. Bas Kollöffel, who helped me finding my way when I was lost in all the available information. Thank you for taking the time to read my thesis and granted me with helpful feedback. Second, I want to thank my second supervisor Dr. Ilona Friso-van den Bos for being critical and her useful feedback. Next, I want to thank my friends and family for supporting me and having the faith that I would bring this thesis to a good end. Special thanks to my sister, for her unending patience and helping me with my academical skills. This journey has really been a blast and I am proud to say that I have studied Educational Science and Technology on the University of Twente, where I have learned much about academic research and met so many new people.

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Kirsten olde Heuvel
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Abstract

Virtual Reality (VR) could be a promising medium in education. It is proven to be effective in training and higher education. Sense of presence, the sense of being captivated in the virtual environment, is an important aspect of an effective VR training. People can experience different levels of sense of presence when exposed to the same mediated environment. This difference could be attributed to user characteristics as well as the characteristics of the VR environment. The current study examined whether emotional content and individual differences could influence the extent of sense of presence in a VR environment. A mixed-method study, with a quasi-experimental within-subjects design, gave insight in the relation between the experienced sense of presence when exposed to negative or positive emotional content and whether this relationship could be moderated by the personality traits Neuroticism, Extraversion and Openness to Experience. Insights in the personality traits of the participants were gathered through an online questionnaire, even as the extent of sense of presence. A semi-structured interview gave insight into the overall experience of the VR experiment. Research main findings showed that there is a strong relation between sense of presence when exposed to negative emotional content and positive emotional content. However, results showed that the personality traits Neuroticism, Extraversion and Openness to Experience do not moderate this relation. The latter is presumably due to the type of mediated environment. These findings contribute in several ways to the understanding of the concept sense of presence and provide a basis for future research on the determinants that can influence sense of presence.

Keywords: virtual reality, sense of presence, personality traits, emotional content

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1. Project description

1.1 Rationale

Virtual reality (VR) is an emerging technology in the current society. Virtual Reality can be defined as a three-dimensional multi-sensory environment in which a person is immersed through wearing a head-mounted display (HMD). People can step inside a virtual world and the computer-simulated environment presents the user real life scenarios, with the opportunity to be replayed (Bricken & Byrnes, 1993; Pantelidis, 2010). Users are provided with the illusion that they are moving through and are surrounded by a three-dimensional world (Slater, 2009). Which can result, that the user has a feeling of being part of that world (Riva et al., 2007). Nowadays, the use of VR for educational purposes is rising. For instance, VR has the opportunity to present the user multiple perspectives (e.g. peripheral and bird-eye) to map different aspects of the situation. It allows students to examine objects extremely close, from a distance, from inside, and from top or bottom (Pantelidis, 2010). This is an added value in comparison to two-dimensional learning technologies (Bailenson et al., 2008). The latter makes it easier for high school students to understand complex and abstract materials (Dede, Salzman, & Loftin, 1996). Moreover, Pantelidis (2010) argued that for students it is more exciting to use a VR system, as it allows them to walk around in a virtual world and interact with it. VR systems have become less costly, more user-friendly, and more accessible (Parsons & Rizzo, 2008). These reasons make it attractive for educational purposes.

To enhance learning outcomes and utilize the potential that VR offers, feeling a sense of presence is essential. Sense of presence is defined as the feeling of actually being in the virtual environment (Mestre & Fuchs, 2006). A well-designed, three-dimensional and multisensory (auditory, visual, and haptic) virtual environment can cause a high sense of presence and thus induces the users to concentrate more and spend more time on task (Salzman, Dede, Loftin, & Chen, 1999). For learners to benefit the most from VR, a deeper understanding of the determinants of presence is needed.

Roughly, the sense of presence encountered in a VR environment could be attributed to two things, the characteristics of the VR and user characteristics (Lessiter, Freeman, Keogh, & Davidoff, 2001; Ling, Nefs, Brinkman, Qu & Heynderickx, 2013; Lombard & Ditton, 1997; Psotka & Davison, 1993; Wallach, Safir & Samana, 2010; Witmer & Singer, 1998). First, the characteristics of the VR define the *technical aspects*, *media form,* and *media content*. *Technical aspects* enclose the stimuli a VR system provides to the user (e.g. auditory,

visual, and haptic). *Media form* refers to the objective properties of a display medium (e.g. image motion, interaction, screen size) (Baños et al., 2004; Jurnet et al., 2005; Lessiter et al., 2001), and *media content* characterize the events represented by the medium (Baños et al., 2004; Lessiter et al., 2001; Lombard and Ditton, 1997). Lombard and Ditton (1997) suggest that different media content could provoke a different emotional response in the user. Presence could be enhanced by the emotions that a VR environment is able to provoke in the user.

Second, user characteristics enclose the individual differences, ranging from age, cognitive abilities, willingness to suspend disbelief, spatial intelligence, and personality traits (Baños et al., 2004; Jurnet et al., 2005; Macedonio, Parsons, Digiuseppe, Weiderhold, & Rizzo, 2007). Users can experience different levels of presence when exposed to the same media content (Lombard & Ditton, 1997). Weibel et al. (2010), suggest considering personality traits as covariates when examining the concept sense of presence. Moreover, research into the moderating influence of personality traits on sense of presence is of value because it may increase the number of people that can benefit from VR training (Jurnet et al., 2005).

This study aims to investigate the relation between the characteristics of the VR and the user characteristics, with a focus on the influence of emotional content and personality traits on the sense of presence in a VR application.

2. Theoretical framework

2.1 Virtual reality and education

Previously, VR was especially used in the entertainment industry (e.g. gaming) (Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Now, a broadened interest is seen in the use of virtual reality in higher education (Merchant et al., 2014). The rapid change in technology and the reduction of costs makes the use of VR in educational settings more feasible (Abulrub, Attridge, & Williams, 2011; Merchant et al., 2014). The use of three-dimensional technologies over two-dimensional learning technologies is preferred because it aids experiential learning (Chee, 2001). Moreover, users are provided with the opportunity to create and design their virtual objects (Merchant et al., 2014) and have autonomy over their own learning experience. An advantage of VR is that it provides the user with immediate feedback on their actions made (Chee, 2001). For instance, engineering students can create and manipulate objects in a safe environment (Abulrub et al., 2011). Decisions that could have serious consequences in real life can be made with impunity in a VR environment (Ferry et al., 2004). Previous research has established that the use of VR in education is highly motivating (Freina & Ott, 2015). It is an alternative method for presenting material and holds the attention of students, which makes it a great way to teach certain objectives (Freina & Ott, 2015; Pantelidis, 2010). Learning environments can be adapted based on research into the features of VR that provide the most leverage for enhancing understanding (Salzman et al., 1999). Immersion and feeling a sense a presence are examples of those features.

2.2 Immersion and sense of presence

Immersion and sense of presence are both common terms in virtual reality research. Many authors interchangeably use the terms immersion and sense of presence. However, a clear distinction should be made.

Sense of presence. Many researchers attempted to define the term sense of presence (Bystrom, Barfield, & Hendrix, 1999; Slater & Wilbur, 1997; Welch, Blackmon, Liu, Mellers, & Stark, 1996). However, lacking a universal definition regarding sense of presence. For instance, Lessiter et al. (2001) describe presence as the "users' experience of mediated presentations" (p. 283). Slater and Usoh (1994), and Steuer (1992) relate presence to the perception of a user's body being in the virtual world rather than the real world, whereas Lombard and Ditton (1997) describe it as a "perceptual illusion of nonmediation" (para. 2). In which, perceptual refers to the continuous responses of the human sensory and illusion of

nonmediation indicates that the user is not aware of the medium providing the information, resulting in a real response as if the medium was not there. Slater and Wilbur (1997) claim that sense of presence aims for the more cognitive aspect. The latter can also be described as the human response to the system. While, Witmer and Singer (1998) define presence as: "the subjective experience of being in one place or environment, even when one is physically situated in another" (pp. 225). Overall, a more general interpretation of presence is the sense of "being there". The perception of being somewhere else, other than in the real world, mediated by the virtual environment (Lessiter et al., 2001, Slater & Usoh, 1994; Steuer, 1992). Prerequisite for sense of presence is the feeling that the movements of the virtual body in the VR environment can be identified with the movements of the participant in real life (Slater & Wilbur, 1997). A person who feels highly present in a VR environment describes the environment as visited rather than as the images seen (Slater, Linakis, Usoh, & Kooper, 1996; Slater & Wilbur, 1997). Numerous studies examined the construct of sense of presence and identified three dimensions that may contribute to it (for example, Baños et al., 2004; Internation Society for Presence Research, 2000; Lessiter et al., 2001). They argued that sense of presence could be explained by the following constructs: Spatial Presence, Involvement, and Experienced Realism.

The first is Spatial Presence, which can be defined as the possibility to interact with and in the VR environment (Lessiter et al., 2001; Schubert, Friedmann, & Regenbrecht, 2001). It is the user's perception that his/her body is in the virtual world rather than in the physical world (International Society for Presence Research, 2000). Lessiter et al. (2001) describe it as: "the sense of being located within a spatially contiguous physical environment" (pp. 293). Spatial Presence is related to media form, meaning users experience a higher sense of Spatial Presence when high fidelity presentations are provided by the VR system (Lessiter et al., 2001).

Involvement appears when users' attention is directed towards virtual objects and stimuli provided by the VR system, rather than the objects in the physical world (e.g. furniture, other people) (International Society for Presence Research, 2000; Lessiter et al., 2001; Schubert et al., 2001; Witmer, Jerome, & Singer, 2005). Lessiter et al. (2001) describe it as the users' evaluation of the media experience. Furthermore, they suggest that Involvement is related to the variables media form, media content and user characteristics. The level of Involvement could be increased when the user participates in activities that engage and challenge them cognitively, emotionally or physically (Witmer et al., 2005).

Experienced Realism refers to the extent to which a VR environment feels natural and consistent with reality (International Society for Presence Research, 2000; Lessiter et al., 2001; Witmer et al., 2005). It can be described as the users' reality judgement (Schubert et al., 2001). Experienced Realism is also related to media form according to Lessiter et al. (2001). It could be enhanced when the sensory characteristics of the virtual environment correspond to those in the physical world (International Society for Presence Research, 2000; Lessiter et al., 2001). Important to note, it is about the perception of the user rather than the actual correspondence with the physical world. This applies also for the constructs Spatial Presence and Involvement.

The importance of feeling a sense of presence is highly stressed in literature (Riva et al., 2007; Schrader, 2013; Slater & Wilbur, 1997). Some evidence suggests that there is a relation between sense of presence and task performance (Bricken & Byrnes, 1993; Sas, O'Hare, & Reilly, 2004). It is still inconclusive whether sense of presence can enhance task performance (Nash, Edwards, Thompson, & Barfield, 2000; Slater et al., 1996). Notwithstanding, that behaviour in the VR environment matches the real-world behaviour more closely when users experience a high sense of presence (Slater, 2009; Slater et al., 1996). This results in the transfer of skills, which are acquired in the virtual world, to real-world performance (Bricken & Byrnes, 1993; Coelho, Tichon, Hine, Wallis, & Riva, 2006; Sas et al., 2004). Utilization of a VR application could be enhanced when there is more similarity in performance between the VR world and reality (Sanchez-Vives & Slater, 2005). For instance, this applies to the training of fire fighters or surgeons (Slater et al., 1996). These people can train real-life situations in VR, without further negative consequences.

Immersion. Immersion entails the technical aspects of a virtual reality system. It refers to which extent the system produces an extensive, surrounding, vivid, and matching environment. Some researchers define it as an objective description of what a VR system can provide (Slater et al., 1996). A VR system is immersive when it provides high-fidelity stimuli that create a realistic experience for the user (Bowman & McMahan, 2007; Slater & Wilbur, 1997). On the contrary, Witmer and Singer (1998) refer to immersion as a psychological state of the user. If an individual interacts naturally with the VR environment, he or she is likely to become immersed in that environment. Immersion provides the possibility to interact with the virtual environment, which generally results in a high sense of presence. In many VR systems, an HMD is worn; this excludes sensations not acquiring from the VR system. This so-called isolation from the real world is an important aspect of an immersive VR system (Witmer & Singer, 1998).

While there is some inconsistency among researchers regarding the distinction between the terms sense of presence and immersion there is a consensus among social scientists that they are related (Slater & Wilbur, 1997; Weibel et al., 2010; Witmer & Singer, 1998). Both imply the extent to which a user feels isolated from the real world. So whether this isolation is accomplished by a psychological state (Witmer & Singer, 1998) or by the system (Slater & Wilbur, 1997), a greater feeling of presence is likely to be produced (Bowman & McMahan, 2007; Slater & Wilbur, 1997; Witmer & Singer, 1998).

2.3 Determinants of sense of presence

Factors determining the extent of sense of presence in a VR environment are important to examine. Baños et al. (2004) claim that other factors need to be taken into account and that immersion and sense of presence is not a one-to-one relationship. Besides the technical aspects of a system, user experience, media content and individual differences are important variables to enhance presence. According to Coelho et al. (2006), the experienced sense of presence depends on the stimuli a VR environment offers and how the user interprets this. Hoffman, Prothero, Wells, and Groen (1998) suggest that paying more attention to virtual environmental stimuli results in a higher extent of presence. Thus, in order to feel present, it is important to focus on the virtual reality environment rather than the real environment (Darken, Bernatovich, Lawson, & Peterson, 1999).

Emotional content. The media content provided by the VR application is also a predictor for sense of presence. Baños et al. (2004), Jurnet, Beciu, and Maldonado (2005), Riva et al. (2007) and Västfjäll (2003) argue that presence could be enhanced when using emotional content. Västfjäll (2003) states that emotion is a component of sense of presence. Likewise, Baños et al. (2004) suggest that emotions are a predictor for sense of presence. An environment that evokes emotions like pleasure, sadness or anxiety promises to elicit a higher sense of presence (Baños et al., 2004; Jurnet et al., 2005). Freeman, Lessiter, Pugh, and Keogh (2005) reported that emotions and presence are related only for arousing stimuli. No relation was found between a neutral VR environment and sense of presence. In the same way, Weibel et al. (2010) found that *immersive tendency* is among others determined by *emotional involvement*. Here, immersive tendency refers to how easily someone experiences presence. Next, emotional involvement refers to emotional reactions toward media exposure, which could be either negative or positive. In other words, if a user's emotional involvement increases, he or she is likely to experience a higher sense of presence. In summary, the emotional content provided by the mediated environment can lead to an emotional response.

One can assume that emotional response and sense of presence are related, this implies that users who are exposed to emotional content are more likely to experience sense of presence than those exposed to neutral content. Important to note is that individuals experience emotions differently. To illustrate, individuals who are more susceptible to negative stimuli, experience a heightened level of emotional distress when faced with negative life events compared to people who show more positive characteristics (Winter & Kuiper, 1997). Furthermore, people react differently to media exposure, depending on their personality. Some feel more immersed when reading a book or watching a scary movie than others (Weibel et al., 2010). This closely relates to the degree of sense of presence an individual experience while being confronted with virtual reality environments (Weibel et al., 2010). In an investigation into the relation between the Big Five personality traits and immersive tendency in mediated environments, Weibel et al. (2010) found that emotional involvement is influenced by the personality traits Neuroticism, Extraversion and Openness to Experience (Weibel et al., 2010). Consequently, individuals who score high on one of these dimensions are more likely to be immersed and feel a sense of presence when exposed to media in comparison with people scoring low on one of these dimensions (Weibel et al., 2010). Therefore only these three traits are taken into account in this study.

Neuroticism. Neuroticism closely relates to emotional stability. Several distinctive facets of neuroticism include anxiety, depression, vulnerability resentfulness, angry hostility and alienation (Jacques, Garger, Brown, & Deale, 2009; John & Srivastava, 1999; Larsen & Ketelaar, 1989; Weibel et al., 2010). People who score high on Neuroticism experience negative emotions more strongly. Therefore, according to Weibel et al. (2010), it seems reasonable that people who score high on Neuroticism experience a higher sense of presence when exposed to negative media content, such as violent computer games, negative news or murder mysteries.

Extraversion. Extravert people tend to identify events as challenges rather than threats (Carver & Connor-Smith, 2010). Furthermore, they are assertive, high in energy (Carver & Connor-Smith, 2010) and they are more susceptible to positive emotions (Carver & Connor-Smith, 2010; Larsen & Ketelaar, 1989). Positive emotions are associated with reward orientation. People, who score high on Extraversion, are therefore more sensitive for rewards than the other personality traits. (Shiota, Keltner & John, 2006).

Openness to Experience. People who score high on Openness to Experience are adventurous, inventive and interested in new experiences (Weibel et al., 2010). Because they are naturally curious, they experience less anxiety when working with new media, such as VR

(Jacques et al., 2009; Sacau, Laarni, & Hartmann, 2008). According to Weibel et al. (2010), presence is positively associated with creative imagination and willingness to be transported into a (imaginary) world, which are corresponding characteristics of Openness to Experience (John & Srivastava, 1999). Moreover, such individuals experience a higher sense of presence when exposed to VR rather than conventional media (Weibel et al., 2010).

In conclusion, Extraversion and Neuroticism relate more strongly to positive or negative mood inductions than the other personality traits (Costa & McCrae, 1980). A negative stimulus provokes more anxiety according to Pertaub, Slater, and Barker (2002). People who score high on Neuroticism tend to be more affected by negative stimuli (Eysenck, 1985) and are more apprehensive. Extravert people tend to be more affected by positive stimuli (Eysenck, 1985). Assuming that emotional response is an important component of feeling a sense of presence, it is expected that people who score high on Neuroticism experience a higher sense of presence when exposed to negative emotional and people who score high on Extraversion experience a higher sense of presence when exposed to positive emotional content. Regarding the trait Openness to Experience, it is expected that people who score high on Openness to Experience, experience a high sense of presence when exposed to negative emotional content and a high sense of presence when exposed to positive emotional content. People scoring high on Openness to Experience appear to be affected by both negative and positive content (Costa and McCrae, 1984). Most likely the use of a VR environment satisfies the curiosity of such people, resulting in a higher sense of presence overall. In contrast to people scoring low on Openness to Experience, like people who are more conventional and close-minded (Burke & Witt, 2002), are expected to experience more anxiety when working with new media (Jacques et al., 2009; Sacau et al., 2008). Negative emotional content most likely increases this feeling and because anxiety is related with higher levels of presence (Jurnet et al., 2005; Robillard, Bouchard, Fournier, & Renaud, 2003), it is expected that people scoring low on Openness to Experience encounter a higher sense of presence when exposed to negative emotional content.

Hence, sense of presence can be influenced by personality traits and the emotional content a VR environment provides. The combination of these three has not yet been investigated. This research focuses on the moderating influence of personality on the relation between emotional content and sense of presence.

3. Research question and model

Based on the theoretical framework above this study examined the relation between the emotional content provided by the virtual reality environment and the experienced sense of presence. Next, it was investigated if this relationship could be moderated by the personality traits Neuroticism, Extraversion, and Openness to Experience. Through questionnaires and a semi-structured interview, this study aimed to find an answer to the following research question:

> *What is the relation between the emotional content provided by a virtual reality environment and the experienced sense of presence and could this be moderated by personality traits such as Neuroticism, Extraversion, and Openness to Experience?*

3.1 Hypotheses

The following hypotheses were drawn, deriving from the theoretical framework.

Hypothesis 1: There is a relation between experienced sense of presence negative emotional content and experienced sense of presence positive emotional content.

Hypothesis 2: The relation between experienced sense of presence negative emotional content and positive emotional content is moderated by the personality traits Neuroticism, Extraversion, and Openness to Experience.

Hypothesis 2a: There is an interaction effect between emotional content and Neuroticism on the extent of sense of presence. People scoring high on Neuroticism experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content in comparison with people scoring low on Neuroticism, who are expected to experience a higher sense of presence when exposed to positive emotional content and a lower sense of presence when exposed to negative emotional content.

Hypothesis 2b: There is an interaction effect between emotional content and Extraversion on the extent of sense of presence. People scoring high on Extraversion experience a higher sense of presence when exposed to positive emotional content and a lower sense of presence when exposed to negative emotional content in comparison with people scoring low on Extraversion, who are expected to experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content.

Hypothesis 2c: There is an interaction effect between emotional content and Openness to Experience on the extent of sense of presence. People scoring high on Openness to

Experience encounter a high sense of presence in both emotional content situations. People scoring low on Openness to Experience are expected to experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content.

3. Research design and methods

3.1 Research design

To answer the main research question, a quasi-experimental within-subject design was conducted. An experiment was held at the University of Twente and the researcher controlled the independent variable. In this experiment participants were gathered through convenience sampling, forming one group with a within-subject design. Participants were exposed to two conditions. To prevent that the order of those conditions could be an influential factor, counterbalancing was applied. This study is mainly quantitative as data was gathered through surveys. A semi-structured interview at the end of the experiment was held to provide more insight into the overall VR experience of the participants. The latter makes this study a mixed-method design.

3.2 Respondents

A total of 46 respondents participated in this study. Thirty-four female participants and 12 male participants participated in the experiment, with a mean age of 23.41 years (*SD* = 3.99, range 18 to 34 years old). The sample included participants from higher education and participants were gathered based on convenience sampling and their willingness to participate. No exclusion criteria were used, apart from being 18 years or older.

3.3 Procedure

At first, permission was asked for conducting this experiment to the ethics committee of the University of Twente. The participants were asked for consent, before participating (Appendix A). To investigate the relation between the emotional content and the extent of sense of presence, an experiment was held at the BMS lab at the University of Twente. Before participating all participants were informed about the purpose of the study through e-mail. They were asked to prepare a short presentation (max. 5 minutes) about their topic of choice, before attending the experiment. Besides, the e-mail contained a link to an online questionnaire to determine their personality, based on the Big Five Inventory (BFI) (John & Srivastava, 1999). Participants were asked to fill in this questionnaire before using the VR environment. When signing up for the study, two groups of presenters were randomly formed. Participants were either assigned a D (disengaged) or E (engaged). During the experiment, participants presented one time for a disengaged virtual public and one time for an engaged virtual public using the VR speech application, with a small break in between. Participants

with a D first presented to the disengaged public, and participants with an E first presented to the engaged public, to apply counterbalancing. On the day of the experiment, each participant was exposed to the virtual environment to get familiarized with the technology before starting his or her presentation. Next, they were asked to give the first 5-minute presentation for the virtual public, without using any props or slides. The participants did not receive any feedback during or after their talks. Furthermore, the researcher was unaware of the participants' BFI score. After each presentation participants were asked to fill in a questionnaire about their experienced sense of presence, based on the Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001). The presentations were audio and video recorded. The level of engagement of the virtual public was at the discretion of the researcher. For the public who was fully engaged, the engagement was set at 100%, hereinafter referred to as the *engaged public.* For the public who was disengaged, the engagement was set at 0%, hereinafter referred to as the *disengaged public*. To equalize the experience across participants in the experiment, a mobile phone rang in the virtual environment at 2 min 30 when presenting for the disengaged public. The public applauded only when the participants finished their presentation for the engaged public to emphasize the positive ambiance. For ethical reasons, participants who presented for the disengaged public the second time were debriefed and told that the negative reaction from the audience was not due to their talk. At the end of the second and final presentation, a semi-structured interview was taken by the researcher to gain more insight into the overall VR experience of the participant. The overall experiment lasted 60 minutes for each participant. Figure 1 shows the procedure schematically.

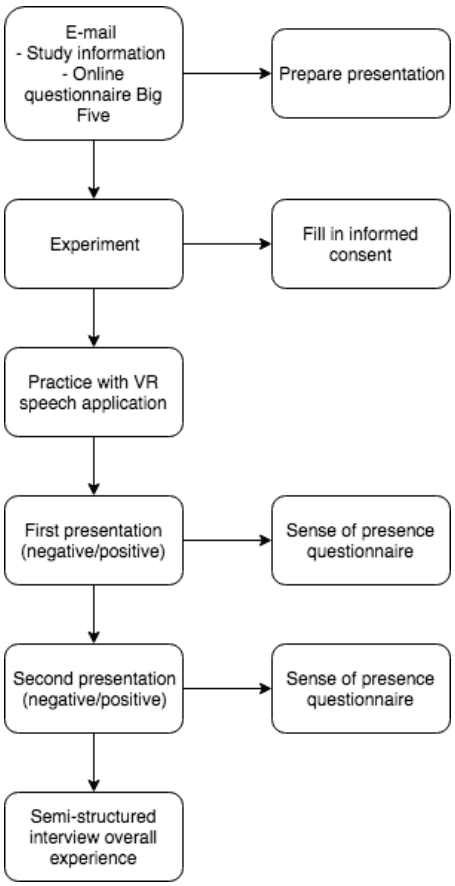

Figure 1. Flowchart procedure

3.4 Instrumentation

3.4.1 Hardware

An HTC Vive VR System was used to display the virtual environment. Corresponding handheld controllers functioned as virtual hands in the VR environment. Participants hold a handheld controller in each hand. This also counteracts motion sickness, as the movement in the virtual world matches the movement of the body in the real world (Slater & Usoh 1994). Meaning, hand motion in the real world results in synchronous motion in the virtual environment.

3.4.2 Software

To investigate the relation between sense of presence and the emotional content a virtual environment provides, the VR Speech application, developed by Brainstud was used in the experiment (Brainstud, n.d.). With this application, users can practice their presentation skills in front of a virtual public. For this study, the theatre stage was used. Users can stand on a virtual podium and the public is sitting in front of them (see Figure 2).

Figure 2. Screenshot of a person standing on the stage in front of the virtual public. Adapted from Brainstud, n.d.

The engagement of the public can be modified to either engaged or disengaged, ranging from 0% (*disengaged*) to 100% (*engaged*). In this study, the engagement of the virtual public represents the emotional content and can be varied by the experimenter. The reaction of the disengaged public represented the negative emotional content and the reaction of the engaged public represented the positive emotional content. When the engagement was at its lowest, the virtual public looked down, talked among each other and seemed uninterested. When the virtual public was fully engaged they nodded a few times and showed interest in the talk by looking at the participant. In the application, there is also a possibility to let a phone ring (see Figure 3) or let the virtual public applaud (see Figure 4).

Figure 3. Screenshot of the phone ringing during presentation disengaged public. Adapted from Brainstud, n.d.

Figure 4. Screenshot of the public applauding after presentation engaged public. Adapted from Brainstud, n.d.

3.4.3 Questionnaires

This study made use of two questionnaires to gather information about the participants. And a semi-structured interview was held afterward.

Personality traits. The Big Five Inventory (BFI) was used to gain insight into the personality traits of the participants (John & Srivastava, 1999) (Appendix B). The BFI is a Likert scale survey, ranging from 1 (*disagree*) to 5 (*agree*). This instrument is used, and its validity has been confirmed by many others including, Shiota et al. (2006), Srivastava, Chandra, and Shirish (2015), and Weibel et al. (2010). The subset used in this research contained 26 questions about the characteristics of the participant, focusing on Neuroticism (e.g., "Is depressed, blue"), Extraversion (e.g., "Is talkative"), and Openness to Experience (e.g., "Is curious about many different things).

Sense of presence. The Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001) assessed the extent of sense of presence (Appendix C). The IPQ is a combined questionnaire constructed from previous published validated questionnaires among which those of Witmer and Singer (1998) and Slater, Usoh, and Steed (1994) (Schuemie, Van Der Straaten, Krijn, & Van Der Mast, 2001). The subset used in this research contained 14 items about the extent of sense of presence a participant experiences when standing inside the virtual environment. Participants rated each item on a seven-point Likert scale. Several other studies also used the IPQ to measure sense of presence, including Jurnet et al. (2005); Price, Mehta, Tone, and Anderson (2011); Schuemie et al. (2001). The IPQ measures several constructs of presence: Spatial Presence (SP) (e.g., "I had a sense of acting in the virtual space, rather than operating something from outside"), Involvement (INV) (e.g., "I was not aware of my real environment"), Experienced Realism (REAL) (e.g., "How real did the virtual world seem to

you?"), and one general item measuring presence, called General Presence (GP) (e.g., "In the computer-generated world I had a sense of 'being there' ").

Semi-structured interview. After completing the two questionnaires a semi-structured interview gave insight into the overall VR experience. For example, "How aware were you of us being in the room?" and "Did you notice any difference in the type of public?".

3.5 Data analysis

The data yielded from the two questionnaires consisted of quantitative Likert scale responses. First, negative items were reverse coded. Second, the average scores of the four constructs (SP, INV, REAL, GP) of the IPQ were combined and computed into a new variable. A new variable was computed for the IPQ scores obtained when presenting for the disengaged public (hereinafter referred to as *IPQ disengaged public*) and for the IPQ scores obtained when presenting for the engaged public (hereinafter referred to as *IPQ engaged public).* Second, the average scores of the three constructs of the BFI were combined and computed into a new variable. Resulting in three new variables: Neuroticism, Extraversion and Openness to Experience. Third, a Shapiro Wilk test of normality pointed out that the scores of the IPQ disengaged public, IPQ engaged public, and the scores of the BFI questionnaire were normally distributed. Therefore, Pearson's correlation was used to determine the association between the IPQ engaged public and IPQ disengaged public. Moreover, a paired-samples t test was conducted to determine if there was a difference in scores between the IPQ disengaged and IPQ engaged public. To compare the four constructs of the IPQ disengaged public and IPQ engaged public, repeated measures ANOVA with Bonferroni correction was carried out. To examine the possible moderated influence of the personality traits Neuroticism, Extraversion, and Openness to Experience on the relation between sense of presence positive and negative emotional content, repeated measures ANOVA and repeated measures ANCOVA were both conducted for each personality trait independently. The independent variable in this research is the emotional content represented by the reaction of the virtual public, which could be either disengaged (negative) or engaged (positive). The dependent variables were the mean scores resulting from the IPQ questionnaires. The scores on the subscales of the BFI questionnaire, Neuroticism, Extraversion and Openness to Experience, would be a possible moderator and was measured at scale level. Statistical significance was interpreted at the $p < .05$ level.

3.5.1 Big Five Inventory

First, the internal consistency coefficient of the constructs Neuroticism, Extraversion, and Openness to Experience were calculated to analyse the reliability of the BFI instrument. After analysing the internal consistency coefficient of all the subscales, one item was removed from the subscale Openness to Experience to increase Cronbach's alpha. Outputs are shown in Table 1.

Table 1

Internal Consistency of the Personality Traits

Construct	Number of items	Cronbach's alpha
Extraversion	8	.86
Neuroticism	8	.80
Openness to Experience	9	.65

Factor analysis for the BFI was conducted to reduce the items into a fixed factor of three solutions. Principal axis factoring with oblique rotation was used so the factors were allowed to correlate. The three-factor solutions correspond with those from the original BFI: Extraversion, Neuroticism, and Openness to Experience. Cronbach's alpha regarding Openness to Experience is slightly lower than .7. This is in line with research from John & Srivastava (1999) who also reported that Openness to Experience tended to be less reliable in comparison to the other constructs. Nevertheless, because the BFI is frequently used and validated by others it is considered reliable and used for further analysis.

3.5.2 Igroup Presence Questionnaire

A reliability check was carried out to measure the internal consistency coefficient of the IPQ. The seven-item scale showed adequate internal reliability with a Cronbach's alpha of .78 for the results of the IPQ disengaged public and .79 for the results of the IPQ engaged public. Factor analysis for the IPQ was conducted to reduce the items into a fixed factor of four solutions. Principal axis factoring with oblique rotation revealed four factors: Spatial Presence (SP), Involvement (INV), Experienced Realism (REAL), and General Presence (GP). These are in line with the dimensions from the IPQ. All subscales were considered reliable and were used for further analyses.

4. Results

This part displays the results for the main research question. Results are presented for each hypothesis.

4.1 Results data analysis

Hypothesis 1: There is a relation between experienced sense of presence negative emotional content and experienced sense of presence positive emotional content.

To test the hypothesis that there is a relation between sense of presence negative emotional content and sense of presence positive emotional content, a Pearson's correlation was conducted between IPQ disengaged public and IPQ engaged public (Table 2). Results showed a strong positive correlation between sense of presence, disengaged public and sense of presence engaged public ($r = .72$, $p < .001$).

Table 2

Results Pearson's Correlation between the Measured Variables

	IPQ	
	Disengaged	Engaged
IPQ		
Disengaged	-	
Engaged	.72**	-

** $p < .01$, two-tailed.

The next step was to conduct a linear regression analysis to test whether presence scores could be predicted based on previous presence scores. Mean scores resulting from the IPQ engaged public were inserted once as the independent variable and once as the dependent variable. The same was applicable for the IPQ disengaged public. In the regression model performed to predict the score of the IPQ disengaged public, the mean scores resulting from the IPQ engaged public were included in the regression equation. There was a significant model $R^2 = .51$, $F\ (1,44) = 46.15$, $p < .001$. With the results from the engaged IPQ ($\beta = .72$, $p < .001$) being a significant predictor. In the regression model performed to predict the score of the IPQ engaged public, the mean scores resulting from the IPQ disengaged public were included in the regression equation. There was a significant model $R^2 = .51$, $F\ (1,44) = 46.15$,

$p < .001$. It was found that results from the IPQ disengaged public significantly predicted results from the IPQ engaged public ($\beta = .72$, $p < .001$). An overview of the results is presented in Table 3.

Table 3

Results Multiple Linear Regression for the Sense of Presence Score Disengaged Public and Engaged Public

Outcome	Predictor	R^2	F	p	β	t	p
IPQ disengaged public	IPQ engaged public	.51	46.15	< .001	.72	6.79	< .001
IPQ engaged public	IPQ disengaged public	.51	46.15	< .001	.72	6.79	< .001

Finally, a paired-samples t test was carried out to test compare the mean scores resulting from the IPQ disengaged public and IPQ engaged public. Results from the paired-samples t test showed that there was no statistically significant difference between the experienced sense of presence when presenting in front of an engaged public (M= 4.74, SD= .68), and the extent of sense of presence when presenting in front of a disengaged public (M= 4.60, SD= .79) (t (45) = 1.78, p = .08). Furthermore, four paired-samples t tests were performed to make post-hoc comparisons ($p < 0.05$ with Bonferroni correction) between the two conditions, with the subscales of the IPQ taken into consideration. Results indicated that Experienced Realism engaged public (M= 4.16, SD= .98) was significantly higher from the mean score for Experienced Realism disengaged public (M= 3.93, SD= .99), (t (45) = -2.66, p = .01). No significant differences were found within the subscales Spatial Presence, Involvement, and General Presence. Table 4 shows a schematic overview of the results of the pairwise comparisons.

Table 4

Pairwise Comparisons of the Subscales of the IPQ

		Paired differences					
		M	*SD*	*SE*	*t*	*df*	*p*
Pair 1	IPQ disengaged SP – IPQ engaged SP	-.16	.63	.09	-1.74	45	.09
Pair 2	IPQ disengaged INV – IPQ engaged INV	-.05	1.18	.17	-.28	45	.78
Pair 3	IPQ disengaged REAL – IPQ engaged REAL	-.23	.59	.09	-2.66	45	.01*
Pair 4	IPQ disengaged GP – IPQ engaged GP	-.15	.82	.12	-1.27	45	.21

Note. SP = Spatial Presence; INV = Involvement; REAL = Experienced Realism; GP = General Presence.
* $p < .05$ with Bonferroni correction.

Hypothesis 2: The relation between sense of presence negative emotional content and sense of presence positive emotional content is moderated by the personality traits Neuroticism, Extraversion, and Openness to Experience.

Hypothesis 2 was split up in three sub-hypotheses to investigate the moderating influence of the personality traits Neuroticism, Extraversion, and Openness to Experience on the extent of sense of presence. Results are described below.

Hypothesis 2a: There is an interaction effect between emotional content and Neuroticism on the extent of sense of presence. People scoring high on Neuroticism experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content in comparison with people scoring low on Neuroticism, who are expected to experience a higher sense of presence when exposed to positive emotional content and a lower sense of presence when exposed to negative emotional content.

First, repeated measures ANOVA was carried out to examine the interaction effect between emotional content and Neuroticism on the experienced sense of presence. A dichotomous variable, using median split, was computed to classify high and low scores on Neuroticism.

For Neuroticism, 63% (29 participants) had an equal or lower score than *Mdn* = 3.63 and 37% (17 participants) had a higher score than *Mdn* = 3.63. The new dichotomous variable of Neuroticism was inserted as a between-subjects factor in the repeated measures ANOVA. Analysis of the plots showed that people scoring high on Neuroticism, experienced a lower sense of presence when exposed to negative emotional content in comparison with people scoring low on Neuroticism. The difference is even larger when exposed to positive emotional content, while people scoring low on Neuroticism experienced a higher sense of presence in comparison with people scoring high on Neuroticism. However, the repeated measures ANOVA showed that the interaction was not significant, $F(1, 44) = 1.06$, $p = .31$. To further analyse the moderation effect of Neuroticism, repeated measures ANCOVA was carried out with the continuous variable of Neuroticism inserted as the covariate and the IPQ disengaged public and IPQ engaged public as within-subjects variables. Data analysis showed that the effect of emotional content on the sense of presence was not significant $F(1,44) = 1.79$, $p = .19$, and the interaction between emotional content and Neuroticism was not significant, $F(1, 44) = .91$, $p = .35$, hereby rejecting hypothesis 2a.

Hypothesis 2b: There is an interaction effect between emotional content and Extraversion on the extent of sense of presence. People scoring high on Extraversion experience a higher sense of presence when exposed to positive emotional content and a lower sense of presence when exposed to negative emotional content in comparison with people scoring low on Extraversion, who are expected to experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content.

Repeated measures ANOVA was carried out to examine the interaction effect between emotional content and Extraversion on the experienced sense of presence. First, a dichotomous variable of the construct Extraversion was computed. A median split was used to classify high Extraversion and low Extraversion. For Extraversion, 52.2% (24 participants) had an equal or lower score than *Mdn* = 3.63 and 47.8% (22 participants) had a higher score than *Mdn* = 3.63. The dichotomous variable was inserted as the between-groups variable in repeated measures ANOVA. Examination of the plots revealed that people scoring high on Extraversion experienced a higher sense of presence when exposed to positive emotional content and a higher sense of presence when exposed to negative emotional content in comparison with people scoring low on Extraversion. Though, this effect appeared not to be significant, $F(1, 44) = .32$, $p = .57$. To further analyse the moderation effect of Extraversion, repeated measures ANCOVA was carried out with the continuous variable of Extraversion

inserted as the covariate and the IPQ disengaged public and IPQ engaged public as within-subjects variables. Data analysis showed that the effect of emotional content on the sense of presence was not significant $F(1,44) = .77$, $p = .39$ and no statistically significant interaction between Extraversion and emotional content, $F(1, 44) = 1.57$, $p = .22$. So, hypothesis 2b could not be supported.

Hypothesis 2c: There is an interaction effect between emotional content and Openness to Experience on the extent of sense of presence. People scoring high on Openness to Experience encounter a high sense of presence in both emotional content situations. People scoring low on Openness to Experience are expected to experience a higher sense of presence when exposed to negative emotional content and a lower sense of presence when exposed to positive emotional content.

First, a dichotomous variable of the construct Openness to Experience was computed. A median split was used to classify high scores on Openness to Experience and low scores on Openness to Experience. For Openness to Experience, 52.2% (24 participants) had an equal or lower score than *Mdn* = 3.78 and 47.8% (22 participants) had a higher score than *Mdn* = 3.78. The dichotomous variable was inserted as the between-groups variable in repeated measures ANOVA. When examining the plots, the graph showed an interaction effect of Openness to Experience on the relation between emotional content and sense of presence. Plots revealed that people scoring high on Openness to Experience reported a higher sense of presence when exposed to negative emotional content in comparison with people scoring low on openness experience. When exposed to positive emotional content, people scoring high on Openness to Experience reported a lower sense of presence in comparison with people scoring low on Openness to Experience. However, the repeated measures ANOVA showed that the interaction effect was not statistically significant, $F(1, 44) = .27$, $p = .61$. To further examine the moderation, repeated measures ANCOVA was carried out with the continuous variable Openness to Experience inserted as the covariate and the IPQ disengaged public and IPQ engaged public as within-subjects variables. Data analysis showed that the effect of emotional content on the sense of presence was not significant $F(1,44) = 1.64$, $p = .21$. Moreover, there was no statistically significant interaction effect between Openness to Experience and emotional content, $F(1, 44) = 1.17$, $p = .29$, hereby rejecting hypothesis 2c.

4.2 Results interview

After completing the second talk a semi-structured interview was held to gain more insight into the overall experience. Despite the fact that the participants were facing a virtual

audience, they stated that they felt it was more real than expected (e.g. “Although it didn’t seem real, I was fully captivated in the virtual world”). The majority (38) of the participants indicated that they were unaware that the researcher was in the (same) room (e.g. “I completely forgot my environment”). Eight participants stated that they were only the first time aware that the researcher was in the (same) room. Forty-five participants were able to successfully distinct the disengaged public from the engaged public, one participant only failed to recognize a difference in the type of public. A summary of the reactions can be found below.

4.2.1 Disengaged public comments

The reactions on the speeches for the disengaged public were inconsistent. Twelve participants indicated that the disengaged public distracted them. Many reported feelings of confusion and a tendency to forget what they wanted to say. Moreover, one participant stated: “I felt insecure because they seemed bored.” Different from some participants who argued that the disengaged audience did not influence them, what made it easier to give the presentation, for instance: “I felt less nervous because they didn’t seem to care. You can make mistakes as they would not notice it”, and “The public didn’t look, that makes it easier. You are less distracted.”

A further finding was that 12 participants felt like talking to a wall. One participant recalled: “After a while, I tended to say that if they don’t want to listen, they rather go.” And another one stated that he was just going to finish the 5 minutes without paying attention to the public. Participants described the disengaged public as ‘demotivating’, and ‘uncomfortable’.

4.2.2 Engaged public comments

Participants’ reactions regarding the presentation for the engaged public were in contrast to the disengaged public more consentient. Twenty-one of the participants indicated that speaking in front of the engaged public was more motivating than speaking in front of the disengaged public. One participant commented: “For the second one (engaged) I felt the time moved on faster”, and “For the second one (engaged) I didn’t have to concentrate that much, because I had the engagement of the audience, so it was easier.” “In the second presentation (engaged) I used more body language and I was more into it.” Another indicated: “And also people looking at me, I felt better”. Though, there were some idiosyncratic reactions amongst the participants. Nine participants argued that the engaged public was making weird gestures with their hands. One stated that he had a hard time interpreting the engaged public and one

participant recalled: “I found the second (engaged) public annoying. You are watching them and they are making gestures which don’t make sense.”

5. Discussion and conclusion

5.1 Discussion

This study aimed to investigate the moderating influence of personality traits on the relation between emotional content and the extent of sense of presence in a VR environment. First, it was hypothesized in this study that there is a relation between the sense of presence when exposed to negative emotional content and the sense of presence when exposed to positive emotional content. This hypothesis was confirmed, and analysis revealed a strong positive relation between the two conditions. Results of this study indicated that participants who experienced a high sense of presence when presenting in front of the engaged public also reported a high sense of presence when presenting in front of the disengaged public. Hence, presence can predict presence. Meaning, if an individual experience a high sense of presence when exposed to positive content it is likely that this individual also experiences a high sense of presence when exposed to negative content and vice versa. Surprisingly, no statistically significant differences were found between the sense of presence when presenting in front of an engaged public and disengaged public. Although no main difference was found between the two conditions, further analysis revealed that there was a significant difference in sense of presence regarding the subscale Experienced Realism. Participants scored significantly higher on the subscale Experienced Realism when presenting in front of an engaged public. This is probably due to the users' reality judgement of the virtual audiences (Schubert et al., 2001). In the current study the disengaged public, in contrast to the engaged public, did not look at the participants at all. It is highly unlikely that the characters from the disengaged public acted like real people would act when attending a presentation. Previous research has established that enhanced realism and socially realistic experiences improve sense of presence (Lombard & Ditton, 1997; Tinwell, Grimshaw, Nabi, & Williams, 2011) and that Experienced Realism could be enhanced when the appearance of the virtual environment is concurrent with the physical world (International Society for Presence Research, 2000; Lessiter et al., 2001). Therefore, it can be assumed that the engaged public was perceived as a more realistic representation of the real world.

Second, it was expected that the relation between sense of presence negative emotional content and sense of presence positive emotional content is moderated by the personality traits Neuroticism, Extraversion, and Openness to Experience. With respect to the second hypothesis, it was found that the sense of presence in a VR environment could not

directly be attributed to personality traits according to this current study. These results are discordant with those found by Weibel et al. (2010) who suggest that sense of presence is influenced by the three personality traits Extraversion, Neuroticism and Openness to Experience. This discrepancy could be attributed to the type of mediated environment. Weibel et al. (2010) studied the influence of personality traits on sense of presence when exposed to conventional media (e.g. book, TV). In contrast to the current study, which examined sense of presence in a VR environment.

Next, it was hypothesized that there is an interaction effect between emotional content and Neuroticism on the extent of sense of presence. People who score high on Neuroticism were expected to experience a higher sense of presence when exposed to negative emotional content in comparison with people scoring low on Neuroticism. While, a negative stimulus provokes more anxiety (Pertaub et al., 2002) and people who score high on Neuroticism are more affected by this. No significant results were found regarding the moderating influence of the personality trait Neuroticism on the relation between the extent of sense of presence negative and positive emotional content. A possible explanation for this might be that VR environments that elicit strong emotions (pleasure, anxiety) evoke greater feelings of presence (Baños et al., 2004). Notwithstanding, it is more difficult for a VR environment to induce anxiety than other moods (Baños et al., 2004). Presumably, the disengaged public did not evoke anxiety in the participants who scored high on Neuroticism. This also explains the inconsistency in participants' experiences concerning the disengaged public. As for some participants it was easier to present in front of the disengaged public (e.g. "I felt less nervous because they didn't seem to care. You can make mistakes as they would not notice it"), while others indicated to be more disturbed by the disengaged public. Moreover, it seems reasonable that some participants did not notice the disengaged and disinterested public as they focused mainly on their talk. Consequently, they were not affected by the negative stimuli of the virtual environment.

Furthermore, the hypothesis that people scoring high on Extraversion experience a higher sense of presence when exposed to positive emotional content in comparison with people scoring low on Extraversion was invalidated by the results. Research findings showed that Extraversion did not have a significant interaction effect on the relation between experienced sense of presence negative and positive emotional content. This unexpected result may be partly explained by findings from Freeman et al. (2005). Their research suggests that emotions and presence are related only when there are arousing stimuli. Some participants indicated that they could not interpret the engaged public and were distracted by

the hand gestures of the engaged audience. Even though, results from the semi-structured interview revealed that the reaction of the engaged public did have a positive influence on the emotional state of the participants. Some recalled that the engagement of the public was motivating and gave them a better feeling. These results are in accord with studies indicating that people who score high on Extraversion are more likely to experience positive emotions when exposed to positive emotional stimuli (Carver & Connor-Smith, 2010; Larsen & Ketelaar, 1989). Considering inconsistency in reactions amongst the participants and lack of statistically significant results, the reaction of the engaged public was presumably a non-arousing stimulus or at least did not provoke a strong emotional reaction to influence the experienced sense of presence.

Lastly, it was expected that there would be an interaction effect between Openness to Experience and emotional content on the extent of sense of presence. Research findings showed that Openness to Experience did not have a moderating influence on the relation between the experienced sense of presence negative and positive emotional content. This unexpected outcome can be explained by the relation between sense of presence and absorption. Weibel et al. (2010) argue that people who score high on Openness to Experience have an increased tendency to get absorbed in mediated environments. In accordance with the present results, previous studies failed to acknowledge a relation between absorption and sense of presence (Murray, Fox, & Pettifer, 2007; Ling et al., 2013). This in contrast to Sas et al. (2004) and Weibel et al. (2010) who found that people who were more absorbed experienced a higher degree of sense of presence. Interestingly, those studies used less immersive environments (e.g. desktop, movie), while the current study used a VR environment with HMD. Hence, Openness to Experience and the extent of sense presence is probably related to less immersive mediated environments, like a movie or playing a video game on a desktop.

5.2 Limitations

Important to note are the limitations this study entails. First of all, measuring presence is difficult and hard to evaluate (Jurnet et al., 2005). In this study, the subjective measurement of the IPQ questionnaire was used, as feeling a sense of presence is a subjective experience (IJsselsteijn, De Ridder, Freeman, & Avons, 2000). This type of measurement could create limitations, because of their subjective nature. Although the instrument in the current study was found to be reliable, the accuracy of these measures is debatable. Therefore objective measurements (e.g. postural, physiological responses) should also be considered for further

research. Physiological responses occur, in general, unconscious, creating a reliable representation of the participants' emotional response to the virtual environment (IJsselsteijn et al., 2000).

Second, it is unfortunate that the measurement of emotional response was not included in this study. Although emotion is a component of sense of presence, emotions affect behaviours and therefore could influence the interactions between the participant and the VR environment (Huang & Alessi, 1999). Moreover, it was found in several studies that emotional response and presence are related in certain contexts (e.g. Jurnet et al., 2005; Riva et al., 2007; Västfjäll, 2003), but it is unclear whether this is a causal relationship. In the first place, this study assumed that presence and emotional responses are related. Because emotional response was not measured in this study, this could not be confirmed. When the emotional response of the participants pointed out to be significantly different among the conditions it could be suggested that presence and emotional responses are not related. This would be in line with research from Slater (2003), who argues that presence and emotional reponse are orthogonal. In other words, if someone feels highly present in a situation this could not directly be attributed to emotional content. If an individual feels present in a VR environment it signifies that the emotional response would be similar in the real world (Slater, 2003). In future studies, it is important to assess both emotional responses and sense of presence.

Third, participants were required to leave the VR environment to complete the IPQ questionnaire. This could have caused a so-called "break-in-presence (BIP)" (Slater & Steed, 2000). Participants are re-entering the real world, which could disturb their reported sense of presence in the VR world. For example, talking to the researcher (who is not part of the VR environment) could have caused a BIP. One way to avoid this phenomenon is to survey participants whilst they are in the VR environment (Schwind, Knierim, Haas, & Henze, 2019). Further studies, which take this type of measurement into account, will need to be undertaken.

Fourth, the instruments used in this study were provided in English, not being the native language of the majority of the participants. Unfamiliarity with the term presence could have caused inconsistencies in scores across different participants since the definition of presence was not explained beforehand. Concepts could easily be misinterpreted among different individuals, and should, therefore, be discussed between participants and researchers to agree on the intended meaning of the concept (Suessbrick, Schober, & Conrad, 2000).

Fifth, being able to manipulate objects in the virtual world could increase the level of sense of presence according to Sheridan (1992). Unfortunately, this was not possible for the participants in the VR speech application, which could have influenced their experienced sense of presence. According to Freeman et al. (2005), presence could be defined as a user's "perceived ability to act within the experience" (p. 218). In the current study, participants were not required to move through the virtual space. Even though they had the opportunity to walk back and forth on the stage, they did not utilize this. Hence, resulting in a lower sense of presence.

Finally, concerning the sample, this study's participants were from higher education and between 18 and 34 years old. Schuemie, Abel, Van Der Mast, Krijn, and Emmelkamp (2005) found that age correlates positively with presence, meaning that older people experience a higher sense of presence than younger people. Therefore, outcomes could be different when investigating older participants. This study's sample covered only a limited part of the Dutch society, thus it is hard to generalize the results. Even though the number of men and women was not equally distributed, previous research has established that gender does not influence presence (Sas, 2004; Schuemie et al., 2005).

5.3 Theoretical & practical implications

To benefit the most from a VR application or training a feeling of a sense of presence is needed to transfer acquired skills in VR, from virtual to real-world performance. There is still a lot unknown about the determinants that predict sense of presence in VR (Jurnet et al., 2005; Lombard & Ditton, 1997; Weibel et al., 2010). Research into the relation between sense of presence, emotional content and personality traits could be of value when designing VR training. Although this research did not point out any significant interaction effect of personality traits on the relation between emotional content and sense of presence, this is a promising outcome for educational training purposes. According to this study, no prior assessment of personality traits is needed to conduct an effective VR training. Moreover, it was found that participants reported similar presence scores under different conditions. This is a practical contribution to VR therapy or training. For instance, a neutral VR environment can be used as a screening tool to identify participants who would experience the most presence and therefore can benefit the most from the VR training. This could also limit dropout rates in VR therapy or training.

For one thing, this study's results indicated that sense of presence, regarding the subscale, Experienced Realism, was higher for an engaged public. This is probably because

the engaged public was looking at the participant, thus seeing facial expressions. It is therefore suggested that a more realistic VR environment provokes a higher sense of presence. Consequently, for effective VR training, designers should create a VR environment that matches the real world more closely.

5.4 Future research

The results of this study could initiate future research. First of all, one should consider objective measurements, like physiological reactions (e.g. heart rate and skin temperature), to corroborate subjective measures of presence (IJsselsteijn et al., 2000). Moreover, to avoid a BIP, scoring sense of presence in the VR environment should be taken into account in future studies (Schwind et al., 2019).

Additionally, a greater focus on the association between emotional response and sense of presence could produce interesting findings that account for the variability in presence scores among individuals. Whether the emotional response changes and not sense of presence (Slater, 2003) when exposed to emotional content in VR, would be an interesting topic for further research. To develop a full picture of the moderating influence of personality traits on the extent of sense of presence, additional studies will be needed with a focus on the use of arousing content. According to Freeman et al. (2005) the ability to act within the VR environment is a determinant for an arousing stimulus. This should be taken into account when investigating other applications.

5.5 Conclusion

In this study, determinants of sense of presence were investigated in a VR environment. The extent of sense of presence was investigated with regard to emotional content and personality traits since no previous research has examined the combination of those three. This study has identified that sense of presence, regarding the subscale Experienced Realism, was influenced by emotional content. The average score on the subscale Experienced Realism was significantly higher when exposed to positive emotional content. One of the more significant findings to emerge from this study is that there was a strong positive relation between experienced sense of presence negative and positive emotional content. Meaning, participants tended to report a high sense of presence when exposed to negative emotional content if they experienced a high sense of presence when exposed to positive emotional content. Despite this promising outcome, not all hypotheses could be confirmed. Specifically, the relation between sense of presence negative and positive emotional content was not moderated by the personality traits Neuroticism, Extraversion, and

Openness to Experience. Possible explanations for research' unexpected outcomes are; the emotional content provided, both negative and positive, were presumably non-arousing stimuli, which could have resulted in a low sense of presence. Emotional response and sense of presence are orthogonal, meaning emotional response could be influenced by emotional content not the sense of presence (Slater, 2003). Additionally, variances in the sense of presence could also be explained by individual differences in spatial intelligence, demographic factors, visual ability, and locus of control (Ling et al., 2013). However, this was not the focus of this study.

To answer the main research question: *What is the relation between the emotional content provided by a virtual reality environment and the experienced sense of presence and could this be moderated by personality traits such as Neuroticism, Extraversion, and Openness to Experience?* This study has identified that the scores on the subscale Experienced Realism were higher when exposed to positive emotional content and that participants tended to report a higher sense of presence when exposed to negative emotional content if they scored higher when exposed to positive emotional content. However, the relation between sense of presence when exposed to negative and positive emotional is not moderated by the personality traits Neuroticism, Extraversion, and Openness to Experience.

Finally, there is still inconclusive research on the determinants of presence in VR environments and how to measure presence. Therefore, this study contributed to the understanding of the concept of presence and makes the knowledge gap a little bit smaller.

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Appendix

Appendix A. Informed Consent

Participant code/SONA ID: _____

Consent Form for Public Speaking in Virtual Reality

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	□	□
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	□	□
I understand that taking part in the study involves a questionnaire, an interview and is video recorded. Audio and video recordings will not be transcribed but will be used for observation measures. Additionally, all recordings will be destroyed after 6 months from the end date of this study.	□	□
Use of the information in the study		
I understand that information I provide will be used for a master thesis	□	□
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	□	□
I agree that my information can be quoted in research outputs	□	□
I agree to be audio/video recorded.	□	□
Future use and reuse of the information by others		
I give permission for the survey database that I provide to be archived in SPSS so it can be used for future research and learning.	□	□
I agree that my information may be shared with other researchers for future research studies that may be similar to this study or may be completely different. The information shared with other researchers will not include any information that can	□	□

directly identify me. Researchers will not contact me for additional permission to use this information.

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

_____	_____	_____
Researcher name	Signature	Date

Study contact details for further information:

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Appendix B. Subset Big Five questionnaire

Instruction

Below you find 26 statements. For each statement, circle the response that best characterize how you feel about that statement, where 1 = Disagree, 2 = Slightly Disagree, 3 = Neutral, 4 = Slightly Agree and 5 = Agree, in the box to the left of it.

I see myself as someone who...	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree
1. Is talkative	1	2	3	4	5
2. Is depressed, blue	1	2	3	4	5
3. Is original, comes up with new ideas	1	2	3	4	5
4. Is reserved	1	2	3	4	5
5. Is relaxed, handles stress well	1	2	3	4	5
6. Is curious about many different things	1	2	3	4	5
7. Is full of energy	1	2	3	4	5
8. Can be tense	1	2	3	4	5
9. Is ingenious, a deep thinker	1	2	3	4	5
10. Generates a lot of enthusiasm	1	2	3	4	5
11. Worries a lot	1	2	3	4	5
12. Has an active imagination	1	2	3	4	5
13. Tends to be quiet	1	2	3	4	5
14. Is emotionally stable, not easily upset	1	2	3	4	5
15. Is inventive	1	2	3	4	5
16. Has an assertive personality	1	2	3	4	5
17. Can be moody	1	2	3	4	5

18. Values artistic, aesthetic experiences	1	2	3	4	5
19. Is sometimes shy, inhibited	1	2	3	4	5
20. Remains calm in tense situations	1	2	3	4	5
21. Prefers work that is routine	1	2	3	4	5
22. Is outgoing, sociable	1	2	3	4	5
23. Gets nervous easily	1	2	3	4	5
24. Likes to reflect, play with ideas	1	2	3	4	5
25. Has few artistic interests	1	2	3	4	5
26. Is sophisticated in art, music, or literature	1	2	3	4	5

BFI scale scoring ("R" denotes reverse-scored items)

Neuroticism: 4, 9R, 14, 19, 24R, 29, 34R, 39

Extraversion: 1, 6R, 11, 16, 21R, 26, 31R, 36

Openness to Experience: 5, 10, 15, 20, 25, 30, 35R, 40, 41R, 44

Appendix C. Subset sense of presence questionnaire

Question	Did not felt present		Moderately felt present			Felt present	
1. I did not feel present in the virtual space	1	2	3	4	5	6	7
Question	Not aware at all		Moderately aware			Extremely aware	
2. How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)?	1	2	3	4	5	6	7
Question	Not real at all		Moderately real			Completely real	
3. How real did the virtual world seem to you?	1	2	3	4	5	6	7
Question	Fully disagree		Moderately agree				Fully agree
4. I had a sense of acting in the virtual space, rather than operating something from outside.	1	2	3	4	5	6	7
Question	Not consistent		Moderately consistent			Very consistent	

5. How much did your experience in the virtual environment seem consistent with your real world experience?	1	2	3	4	5	6	7
Question	About as real as an imagined world					Indistinguishable from the real world	
6. How real did the virtual world seem to you?	1	2	3	4	5	6	7
Question	Fully disagree		Moderately agree			Fully agree	
7. I was not aware of my real environment.	1	2	3	4	5	6	7
Question	Not at all		Somewhat			Very much	
8. In the computer generated world I had a sense of "being there"	1	2	3	4	5	6	7
Question	Fully disagree		Somewhat agree			Fully agree	
9. Somehow I felt that the virtual world surrounded me.	1	2	3	4	5	6	7
10. I felt present in the virtual space.	1	2	3	4	5	6	7
11. I still paid attention to the real environment.	1	2	3	4	5	6	7
12. The virtual world seemed	1	2	3	4	5	6	7

more realistic than the real world.							
13. I felt like I was just perceiving pictures.	1	2	3	4	5	6	7
14. I was completely captivated by the virtual world.	1	2	3	4	5	6	7

Sense of presence scale scoring ("R" denotes reverse-scored items)

Spatial Presence (SP): 1, 4, 9, 10, 13R

Involvement (INV): 2R, 7, 11R, 14

Experienced Realism (REAL): 3, 5, 6, 12

General Presence (GP): 8