Factors influencing Sense of Presence in a Virtual Reality intervention targeting Obsessive-Compulsive Disorder

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Table of contents

Abstract

Cognitive behavioral therapy (CBT) with Exposure and Response Prevention (ERP) in virtual reality (VR) is a promising new approach to treat Obsessive-Compulsive Disorder (OCD) as it has potential to tackle the existing treatment gap by overcoming treatment barriers on both the patient's and the therapist's side. The efficiency of VR interventions is highly dependent on the participants to feel as though they are ''in'' the virtual environment, a mechanism commonly referred to as *sense of presence*. The aim of this study is to investigate factors influencing sense of presence in an ERP for VR intervention targeting OCD. 40 participants experiencing contamination or checking compulsion were screened for their sense of presence upon completion of an intervention which took place in two separate and customized virtual environments. We expected participants experiencing contamination compulsions to display a higher sense of presence than participants experiencing checking compulsions, as well as males to experience a higher sense of presence than females. Finally, we expected to see a negative relationship between cybersickness and sense of presence and for this relationship to be more pronounced in the older population. No significant group differences were found for the main hypotheses. As sense of presence was low to moderate across the sample, technical improvements such as advanced graphics and additional sensory cues might be needed to ensure an immersive experience for participants and allow appropriate group comparisons. Subscale analyses revealed participants experiencing checking compulsions feeling a significantly higher sense of involvement, calling for tailored future VR interventions.

Keywords: Sense of presence, Virtual Reality, Obsessive-Compulsive Disorder, Age, Gender, Cybersickness

1. Theoretical Background

1.1 Introduction

Obsessive-compulsive disorder (OCD) is the fourth most common psychiatric disorder and affects estimately 1-3% of the world's population (Grant, 2014). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V; American Psychiatric Association, 2013) it is characterized by obsessive thoughts and/or compulsive actions. Compared to healthy individuals, individuals with OCD usually experience significantly lower quality of life across all domains (Subramaniam et al., 2013). Despite this and due to various factors, a majority of individuals with OCD do not receive adequate treatment (Kohn et al., 2004). In recent years, Cognitive behavioral therapy (CBT) with Exposure and Response Prevention (ERP) in virtual reality (VR) has gained popularity as it has proven to be a successful approach in the treatment of several psychiatric disorders (Krijn et al, 2004) and demonstrates potential in closing the treatment gap in individuals with OCD. In order for ERP in VR to be successfully implemented, patients need to feel as though they are 'in' the virtual environment, a feeling which is referred to as sense of presence (Schubert, 2003). This study aims to investigate sense of presence and influencing factors in OCD patients taking part in an ERP in VR intervention.

1.2 Obsessive-Compulsive Disorder

1.2.1 Symptoms and Prevalence.

According to the DSM-V, OCD is characterized by recurrent and persistent thoughts (obsessions), repetitive behaviors or mental acts (compulsions) or both (American Psychiatric Association, 2013). Individuals with OCD act out compulsions to neutralize or suppress the discomfort caused by their obsessions (Grant, 2014). Obsessions and compulsions are clearly excessive, intrusive, unwanted and time-consuming. Thus, individuals with OCD experience a great amount of anxiety and stress,

which often lead to significant impairment in different areas of functioning (American Psychiatric Association, 2013).

The lifetime prevalence of OCD has been estimated to be at 1.0-3.0% (e. g. Ruscio et al., 2010; Fawcett et al., 2020) and symptoms are oftentimes accompanied by comorbid disorders, with mood disorders and anxiety disorders being the most common (Sharma et al., 2021). According to a recent worldwide meta-analysis by Fawcett et al. (2020), women are generally 1.6 times more likely to experience OCD symptoms than men. Main OCD symptoms also differ across gender: females more frequently develop symptoms related to washing, hoarding and aggressive thoughts, while males more often develop forbidden thoughts, obsessions related to symmetry and sexual/religious obsessions (Mathes et al., 2019).

1.2.3 Contamination vs. Checking Subtypes.

OCD is a highly heterogeneous disorder and oftentimes completely distinct symptoms can be found in diagnosed individuals (Bloch et al., 2008). Due to the heterogeneity of OCD, researchers in recent years have been attempting to form OCD subgroups, based on e. g. symptom themes, dysfunctional beliefs or comorbidity (Rowsell & Francis, 2015). Although no overall consensus on subtypes has been reached, research by Hollander et al. (1997) has shown that contamination obsessions/ washing compulsions and doubting obsessions/checking compulsions seem to be the most common subtypes. In most OCD subtypes emotional regulation processes influence the tendency to avoid, suppress or escape cues that may evoke anxiety (Barlow, 2002). Within the contamination subtype disgust plays an important role in OCD symptom provocation. While fear/anxiety and disgust exhibit similarities in arousal, their biological indications differ. Biologically, fear is a reaction to a potentially deadly threat (Quinn & Fanselow, 2006), while disgust is a reaction to contamination, which represents a potential danger (Olatunji & McKay, 2009). In line with this, contrary to individuals experiencing checking obsessions/compulsions, individuals experiencing contamination

obsessions/compulsions might not fear the harmfulness of certain cues, but instead fear the feeling of disgust provoked by certain cues (Melli et al, 2015). A study by Mason and Richardson (2012) suggests that disgust is more resistant to extinction than fear, while research by McKay (2005) showed that disgust reduction through ERP showed less and slower reduction in a contamination subgroup than in other subgroups. Research by Sookman et al. (2005) indicates that distinct subtypes might require distinct and specialized treatment to successfully dismantle dysfunctional beliefs based on different emotions.

1.2.4 Exposure and Response Prevention Therapy.

Cognitive behavioral therapy (CBT) with exposure and response prevention (ERP) is recommended by international guidelines as first-line treatment for individuals suffering from OCD, alongside pharmacotherapy with serotonin-reuptake inhibitors (National Institute for Health and Care Excellence [NICE], 2005). In ERP for OCD, the traditional approach involves exposure to OCD-related stimuli that elicit a significant level of anxiety, followed by resisting engagement in anxiety reducing behaviors. From a theoretical viewpoint, obsessions are formed through classical conditioning and compulsions are maintained by operant conditioning. This implies that a neutral stimulus can trigger relevant burdening emotions (s. a. anxiety and disgust) when it is associated with a situation causing distress. These conditioned obsessions then are upheld through the temporary relief felt from performing compulsions serving as reward (Law & Boisseau, 2019). Accordingly, ERP aims to weaken the conditioned response through habituation (Foa et al, 1983) and/or forming new, non-threatening associations (Craske et al, 2005), as this should eliminate obsessions and compulsions.

Even though ERP in the treatment of OCD is highly effective (Ferrando & Selai, 2021), ERP is often not applied *in vivo* (Külz et al., 2010) and a majority of individuals with OCD remain untreated (Kohn et al., 2004). Simulating anxiety triggering situations within in-office therapy sessions can feel unrealistic and not in line with individuals's

daily experiences and ERP compliance rates between sessions are often low (Lind et al., 2013). Beside this, the treatment gap largely stems from uncertainties on both the therapist's and the client's side: Individuals with OCD e. g. often shy away from ERP due to fear of being exposed to feared stimuli. Therapists' fear of acute psychological reactions of their clients alongside general organizational difficulties (time, cost) further present as obstacles (Moritz et al., 2019). In sum, a better accepted implementation of ERP is needed to treat individuals with OCD and narrow the existing treatment gap.

1.3 Virtual Reality Exposure Therapy

An emerging and exciting new form of treatment is Exposure and Response Prevention in Virtual Reality, where individuals experience exposure to immersive scenarios that approximate naturalistic environments through virtual reality software. The successful immersion of an individual into a virtual reality is established through two factors: sense of immersion and sense of presence (Servotte et al., 2020). While immersion describes the ability of a software to let the user engage with the virtual environment (Kim & Biocca, 2018), sense of presence describes the feeling of being present in the virtual environment (Schubert, 2003).

In the ERP in VR setting, ERP is administered in a computer-generated, three-dimensional and carefully controlled environment that individuals can access through VR glasses. Through software such as Oculus Quest or the HTC Vive Pro 2, several different environments can be simulated and used for ERP treatment of multiple psychiatric disorders. In order to utilize ERP in VR for individuals with OCD, relevant emotions (anxiety, disgust) first need to be induced in the virtual environment, which in their studies, Kim et al. (2008) and Belloch et al. (2014) succeeded in. A recent literature review and meta-analysis by Dehghan et al. (2022) also found a significant increase of relevant factors such as anxiety, disgust and checking time in OCD patients during ERP in VR. To achieve the induction of relevant emotions, environments are specifically designed to trigger obsessions and/or compulsions (e.g. for washing compulsions a filthy

bathroom can be chosen as a virtual environment) and individuals are further able to interact with and physically move through the environment.

Due to its immersive nature, ERP in VR has the potential to tackle pitfalls of traditional ERP. As ERP in VR can take place in a therapist's office, organizational hassles (time, cost) can be eliminated (Emmelkamp, 2005). Further, in ERP in VR the therapist has greater control over anxiety inducing stimuli, as he/she is able to manipulate the intensity and sequence of exposure through factors such as movement, distance and amount of stimuli (Wrzesien et al., 2011). From a client's perspective studies show that ERP in VR is more accepted than exposure *in vivo* (Garcia-Palacios et al., 2007). Due to its use of realistic environments, ERP in VR for OCD could offer experiences that are more in accordance with individuals' daily experiences. Moreover, exposure that may appear as dangerous and/or impractical *in vivo* could feel safer in VR environments (Cullen et al., 2021). All these advantages of ERP in VR could potentially improve the implementation of tailored ERP for different OCD subgroups.

The effectiveness of ERP in VR has already been confirmed by various studies for psychiatric disorders such as claustrophobia (Botella et al., 2000), acrophobia (Emmelkamp et al., 2002), social anxiety (Anderson et al. 2003) and post-traumatic stress disorder (López-Soler et al., 2011). While there is very limited research available aiming at ERP in VR efficiency in the treatment of the OCD checking subtype, a number of newer studies (Laforest et al., 2016; Inozu et al., 2020; Cullen et al., 2021) have emerged, confirming successful reduction in OCD symptoms in patients with contamination compulsions following ERP in VR.

1.4 Factors influencing the Efficacy of Exposure Response Prevention Therapy in Virtual Reality in Patients with Obsessive-Compulsive Disorder

1.4.1 Sense of Presence.

To successfully perform ERP in VR, the individual must feel as if they are 'in' the virtual environment. This feeling of being present in the virtual space has been found to

be the key mechanism facilitating relevant emotions (anxiety, disgust) needed for behavior changes in ERP in VR (Wiederhold & Wiederhold, 2005). Thus, sense of presence is associated with efficacy of treatment in ERP in VR (Guitierrez-Maldonado et al., 2010).

While several slightly different definitions of sense of presence can be found in the literature, most researchers agree on the construct consisting of three main components, which are needed to form realistic cognitive, emotional and behavioral responses in a virtual environment: Sense of physical space, engagement/involvement and ecological validity/realism. While the sense of physical space refers to spatial awareness, engagement/involvement refers to the attention given to the virtual environment and ecological validity/realism refers to the perceived realism of the virtual environment. (Schubert, 2003). The components are necessary in order to enable users to experience anxiety that resembles anxiety in the real world. A meta-analysis conducted by Ling et al. (2014) investigated sense of presence in ERP in VR and found a significant correlation between sense of presence and anxiety in most anxiety related disorders. Based on these findings, Ling et al. (2014) emphasized the relevance of sense of presence in studies aiming at ERP in VR efficacy.

Several influencing factors of sense of presence are currently still being investigated. Felnhofer et al. (2012) reported that gender might be of high influence, as their study revealed that men showed higher sense of presence in two of the three main components. According to the researchers, these findings could be based on differences in computer use, as well as men's better performance in spatial abilities. Bangay and Preston (1998) further suggested that age could be of importance, as their study found individuals at the age of 35 and older experienced a lower sense of presence than younger individuals. Furthermore, in their review, Weech et al. (2019) found a negative relationship between sense of presence and cybersickness, suggesting the absence of cybersickness to be another important aspect in order to achieve a high sense of presence.

1.4.2 Cybersickness.

Unlike sense of presence, cybersickness is considered to have a negative impact on the efficiency of psychological treatments in VR (e. g. Wiederhold et al., 2014) and has concerned VR developers and researchers in recent years. Cybersickness is described to be the discomfort experienced due to being in a virtual environment. Its symptoms are comparable to those of motion sickness with symptoms including headache, disorientation and nausea but can occur in the absence of physical motion (LaViola, 2000). Cybersickness and terms such as simulator sickness and VR induced symptoms are often used simultaneously (Brown et al, 2022). A literature review by Lawson et al. (2002) found that 5% of VR users reported intense cybersickness that forced them to quit the program they were in, while 5% of VR users did not experience any cybersickness and 70-90% experienced mild symptoms. Studies on the influence of gender on cybersickness have been inconsistent (Saredakis et al., 2020). Concerning age as an influencing factor, most studies suggest that the older population suffers from more severe cybersickness when experiencing a virtual environment (Hildebrandt et al., 2018), while a few studies found opposing results (Saredakis et al., 2020).

1.5 The Present Study

The present study aims to evaluate factors potentially influencing sense of presence in two different customized environments, as this has not yet been investigated in the context of ERP in VR in individuals with OCD and could offer insight into which groups could profit most from such an intervention. As contamination and checking compulsions are based on different emotions (disgust and fear), the treatment of both subtypes could potentially be improved by specialized treatment approaches. Because this might be easier to implement in VR than in in-office ERP, both subtypes were compared in terms of sense of presence. Further, genders were compared in terms of sense of presence. Finally, cybersickness was examined as a factor predicting sense of presence in different age groups. We expected to see higher sense of presence in

participants experiencing contamination compulsions than in participants experiencing checking compulsions, due to the fact that disgust has successfully been implemented in a contamination context in past research and fear in a checking context has not. As past studies have confirmed higher sense of presence in male participants, it is expected to also see higher sense of presence in males in this study. Finally, past research has found a negative relationship between cybersickness and sense of presence, as well as more pronounced cybersickness symptoms in the older population, which are the expected results in this study. The hypotheses are as follows:

H1: Sense of presence is significantly higher in participants experiencing contamination compulsions, than in participants experiencing checking compulsions.

H2: Male participants experience a significantly higher sense of presence than female participants.

H3: Cybersickness is negatively associated with sense of presence and this association is pronounced in older individuals.

2. Methods

2.1 Design

The present study is using data from a randomized controlled trial (RCT) comparing ERP in VR for individuals with checking/contamination compulsion to a care-as-usual control group. The RCT was conducted in accordance with the Declaration of Helsinki and has received ethical approval (LPEK-0020) by the Ethics Committee of the German Psychological Association. Furthermore it has been pre-registered at the German Clinical Trials Register (DRKS00016929). It has been sponsored through public fundings. As the present study is investigating participant's sense of presence in a virtual environment, only the group receiving ERP in VR (intervention group) was examined. There is no conflict of interest to disclose.

2.2 Participants

Recruitment of participants took place between February 2019 and July 2022 and various channels were used. Former patients and study participants from the Universitätsklinikum Hamburg-Eppendorf's (UKE) trial participants data bank were recruited via phone and online and traditional advertisements commissioned by the UKE's Clinical Neuropsychology research unit were published. Furthermore, psychotherapists in the Hamburg area were contacted with information about the study and flyers were distributed at surrounding health suppliers' offices. Interested individuals that reported the presence of contamination and/or checking obsessions and compulsions were screened for the inclusion/exclusion criteria via phone. The inclusion criteria were as follows: presence of contamination/checking obsessions and compulsions, ability to give consent, willingness to participate in six VR interventions and three assessments, sufficient understanding of the German language and age between 18 and 75 years. Patients were excluded if they had been diagnosed with a past or present psychotic or bipolar disorder, a present severe substance use disorder, acute suicidality or a severe neurological disorder.

A priori analysis with G*power 3.1.9.6 revealed that a sample of at least 70 participants was needed in order to reach sufficient power ($1\text{-}\beta = 0.80$ and $\alpha = 0.05$). A 15% dropout rate (similar to a meta analysis on attrition in ERP in VR by Draheim & Anderson, 2018) was estimated and taken into consideration, leaving the final desired sample size to be at $N = 80$.

2.3 Procedure

Prior to the beginning of the study, all participants were informed about the study procedure. A week ahead of the baseline-assessment, participants filled out an online questionnaire which was sent to them via email. In this survey, participants were first asked for their consent to the study. If the participants did not fill out the survey before the baseline-assessment, they were asked to do so on site at the Universitätsklinikum Hamburg-Eppendorf, immediately after the baseline-assessment. The baseline-

assessment consisted of a diagnostic interview, conducted by a trained interviewer. Prior to the interview, consent was given again. The interviewer then asked a number of demographic questions and conducted the Mini-International Neuropsychiatric Interview (MINI, Sheehan et al., 1998), followed by the Yale-Brown Obsessive-Compulsive Disorder Scale (Y-BOCS, Goodman, 1989). Participants further were handed an envelope that contained their allocation to either the intervention or the control group. The interviewer was blind to randomization and participants were asked not to reveal their group allocation to the interviewer at any time of the study. Participants in the intervention group underwent ERP in VR once a week for a total of six weeks. After each VR session, a questionnaire about the VR experience (including the s*imulator sickness questionnaire*) was filled out by each participant. After six weeks, a second online questionnaire (including the *I-group presence scale*) was sent to all participants via email and participants were again asked to fill out the questionnaire prior to the post-assessment. The post-assessment consisted of demographic questions as well as the Y-BOCS. After each assessment (baseline, in-session and post) all collected data was manually fed into IBM® SPSS® Statistics by a designated member of the Clinical Neuropsychology team.

2.4 Intervention

The ERP in VR sessions were all conducted by master psychologists going through postgraduate therapy training. Each of the six sessions took place at the UKE and lasted 60 minutes. The sessions were based on a highly structured manual to ensure high standardization. The first session consisted of an anamnesis of the patient and his/her OCD related complaints. The second session was mainly focused on psychoeducation regarding OCD and ERP in VR. The third session took the participants through a VR environment that did not yet contain any triggering stimuli, to get familiarized with the concept of ERP in VR. Sessions four to six consisted of ERP in VR, in which the psychologist encouraged the participant to confront increasing anxiety inducing settings

and prevented the participant from surrendering to compulsions and/or safety behaviors. The psychologist mainly suggested graded exposure, which began at medium intensity and increased to the most anxiety provoking stimuli. In the virtual environments, anxiety was provoked by anxiety and/or disgust inducing objects of different intensity and participants were asked to walk through the environments and get physically close to the anxiety/disgust inducing objects, without resorting to compulsive or avoidant behaviors. After each ERP in VR, the participant's experiences with the intervention were discussed and participants filled out a small questionnaire battery (including the *simulator sickness questionnaire*).

The software used was a downloadable game-engine called *Unity* (Version 2018.2.9f1) with a Head-Mounted Display (HTC Vive Pro). There were two virtual environments to choose from, that the participant could walk through. The environments were designed by two members of the clinical neuropsychology UKE research team and are currently not available publicly. One environment aimed at contamination obsessions/ washing compulsions and displayed a dirty public bathroom (e. g. urine, feces, blood etc.). A hallway, which included mirrors and sinks, nine stalls, which all included a toilet and no germ-eliminating items were part of this environment (see appendix A, image 1). A second environment aimed at checking obsessions and compulsions and displayed a six room (four living/bedrooms, one bathroom and one kitchen) apartment triggering these obsessions/compulsions (e. g. electronic devices, stove etc.) (see appendix A, image 2). The participants walked around the environments freely and were able to hear realistic sounds (e. g. opening doors).

2.5 Measures

2.5.1 Yale-Brown Obsessive-Compulsive Scale.

In order to assess OC symptoms and their severity, the Yale-Brown Obsessive-Compulsive Scale (Y-BOCS; Godman et al., 1989; German version [Hand & Büttner-Westphal, 1991]), a semi-structured interview, was used. The Y-BOCS consists of a

symptom checklist to identify current and former OC symptoms as well as 19 structured questions aimed at investigating symptom severity during an average day of the previous week. While items 1-5 deal with obsessions, items 6-10 assess compulsions and items 11-19 relate to insight into related constructs (e. g. avoidance, degree of indecisiveness etc.). The Y-BOCS is rated on a 4-point Likert scale ranging from (0) no symptoms to (4) severe symptoms. The Y-BOCS total score is obtained by adding up items 1-10 and ranges from 0 to 40. Total scores of 0-13 imply mild symptoms, 14-25 moderate symptoms, 26-34 moderate to severe symptoms and 35-40 severe symptoms. The internal consistency of the Y-BOCS in our study was good, with Cronbach's alpha = .83.

2.5.2 Mini-International Neuropsychiatric Interview.

The Mini-International Neuropsychiatric Interview (MINI) is a structured interview (Sheehan et al., 1998; [German version] Ackenheil et al., 1999) that was used to evaluate comorbid disorders and to confirm an OCD diagnosis. The MINI investigates the most common psychiatric disorders in the DSM-V(American Psychiatric Association, 2013) through 17 modules. Lecrubier et al. (1997) found the retest-reliability to be acceptable to excellent (*kappa* = .76 to .93), even though it has to be mentioned that dysthymia, mania, OCD and eating disorder were not included in the retest-reliability due to small sample sizes. Inter-rater reliability was found to be good to excellent (*kappa* = .88 to 1.0; Lecrubier et al., 1997). For this study taking into account reliability scores of past research was deemed appropriate.

2.5.3 The I-group Presence Questionnaire.

The I-group presence questionnaire (IPQ) is a self-rating questionnaire (Schubert, 2003) used to measure sense of presence in virtual environments. The IPQ includes 14 items, of which 12 items are rated on a 7-point Likert scale from (0) fully disagree to (6) fully agree. Item 7 is rated on a 3-point Likert scale from (1) extremely aware, (2) moderately aware, to (3) not aware at all and item 12 is rated on a 3-point Likert scale from (1) not consistent, (2) moderately consistent, to (3) very consistent. The items are

distributed between three subscales: spatial presence (item 2-6), involvement (item 7-10), experienced realism (item 11-14) and one separate general item (general "sense of being there").The total score ranges from 14 to 94 and is obtained by adding up all item scores, . While Schuemie et al. (2001) found the internal consistency of the IPQ to be good (Cronbach's alpha = .88), internal consistency of the IPQ in our study was low, with Cronbach's alpha = .57.

2.5.4 Simulator Sickness Questionnaire.

The simulator sickness questionnaire (SSQ) is a self-rating questionnaire (Kennedy et al, 1993) which includes 16 items that aim to describe and assess cybersickness experienced during VR. The items each assess one of the following components of cybersickness: General discomfort, fatigue, headache, eyestrain, difficulty focusing, increased salivation, sweating, nausea, difficulty concentrating, fullness of head, blurred vision, dizzy (eyes open), dizzy (eyes closed), vertigo, stomach awareness and burping. All items are rated on a 4-point Likert scale from (0) none, (1) slight, (2) moderate and (3) severe. The items are grouped into three subscales: Nausea (N), oculomotor disturbance (O) and disorientation (D). The subscale scores add up to a total score ranging between 0 and 20, which can be interpreted as follows: negligible (< 5), minimal (5– 10), significant (10– 15), and concerning (15– 20) symptoms. The internal consistency of the questionnaire in our study was acceptable (Cronbach's alpha = .76).

2.6 Statistical Analysis.

Data was analyzed using IBM® SPSS® Statistics 28 and G*power 3.1.9.3. Sense of presence was measured once at the post-assessment through the IPQ. For the first two hypotheses, total sense of presence scores for each participant were calculated. Then, independent t-tests with group allocation (contamination/checking; male/female) acting as the independent and sense of presence acting as the dependent variable were performed. In an exploratory analysis, the three sense of presence subscales were further

examined in order to find out if any subscale was particularly associated with group differences.

The third hypothesis included cybersickness as a variable, as measured by the SSQ. Cybersickness was measured four times, once after each VR session. Total scores of cybersickness for each of the four VR sessions were calculated for each participant. The mean sum score of the four session sum scores was determined. Finally, a one-way ANCOVA with cybersickness as the independent variable, sense of presence as the dependent variable and age as a covariate was conducted.

3. Results

3.1 Participant Characteristics

The characteristics of the studied participants can be found in *table 1*.

For the RCT 80 persons were enrolled and randomized (N = 80). For the present study, only the 40 participants of the intervention group were taken into consideration, 20 of which reported mainly suffering from checking related compulsions and 20 of which reported mainly suffering from contamination related compulsions. The 40 participants were between 21 and 64 years old (M = 38,17, SD = 11,60). 70 % of the sample was female and 30 % was male. As sense of presence was measured at the post-assessment only, solely data from participants that fully completed the post assessment was used. One participant was lost to post. Five participants failed to fill out the post-assessment online questionnaire, which led to exclusion. One participant did not fully complete the online post-questionnaire, which led to exclusion as well. Thus, data of only 33 participants was used for analysis.

The Y-BOCS showed that 55% of participants experienced checking obsessions (n = 18) and 45% washing obsessions (n = 15). Prior to the intervention, OC symptom severity was moderate, M = 23,75 (SD = 5,80), according to the Y-BOCS total mean score. According to the total mean IPQ score, sense of presence experienced by

participants was low to moderate, M = 46,66 (*SD* = 9,57). Cybersickness as measured by the SSQ total mean score was minimal, M = 6,52 (*SD* = 5,66). At baseline, comorbid disorders were present in at least 61% of the participants, according to the MINI, with current or recurrent depression being the most common comorbid disorder (n = 20).

Table 1

Participant Characteristics.

Variables	Categories	Sample (N = 33)
Gender, n (%)	Male Female	8 (24%) 25 (76%)
Age, M (*SD*) n (%) n (%)	Years Low (<35) High (>35)	37,94 (*SD* = 11,07) 14 (42%) 19 (58%)
Y-BOCS score, M (*SD*)	Total score	23,76 (*SD* = 5,81)
IPQ score, M (*SD*)	Total score	46,66 (*SD* = 9,57)
SSQ score, M (*SD*)	Total score	6,52 (*SD* = 5,66)
Primary compulsion, n (%)	Contamination/washing Checking	15 (45%) 18 (55%)
Illness duration, M (*SD*)	Years	16,70 (*SD* = 12,75)

Comorbid disorders (according to the MINI), n (%)	Major depressive disorder	20 (60,7%)
	Generalized anxiety disorder	4 (12,1%)
	Panic disorder	4 (12,1%)
	Agoraphobia	2 (6,1%)
	Anorexia nervosa	2 (6,1%)
	Post traumatic stress disorder	1 (3%)
	Alcohol-related disorder	1 (3%)
	Binge eating disorder	1 (3%)

Note. *M* = Mean, *SD* = Standard Deviation, *N* = Total sample size, *n* = Number of participants; Y-BOCS = Yale-Brown Obsessive-Compulsive Scale, IPQ = I-group Presence Questionnaire, SSQ = Simulator Sickness Questionnaire

3.2 Compulsion Group Allocation and Sense of Presence

The independent t-test did not reveal any significant differences between the contamination and the checking condition in terms of sense of presence, $t(31) = -.25$, $p = .40$. Using an exploratory approach, three more independent t-tests were used to determine whether there were significant differences between the two groups in terms of the three IPQ subscales spacial presence, involvement and experienced realism. The analysis revealed no significant difference between the contamination and the checking group regarding spacial presence ($t(31) = -1.093$, $p = .141$) and experienced realism ($t(31) = -.466$, $p = .322$), but disclosed that involvement was significantly higher in participants experiencing checking compulsions than in participants experiencing contamination compulsions ($t(31) = 1.944$, $p = .031$).

3.3 Gender and Sense of Presence

No significant differences in terms of sense of presence were found between male and female study participants, $t(31) = -1.35$, $p = .094$. Further, an exploratory analysis into the three IPQ subscales again using independent t-tests revealed no significant gender difference in spacial presence ($t(31) = -.963$, $p = .172$), involvement ($t(31) = -1.030$, $p = .156$) and experienced realism ($t(31) = -.325$, $p = .374$).

3.3 Cybersickness, Age and Sense of Presence

No significant effect of simulator sickness on sense of presence after controlling for age was found, F (1, 27) = .061, p = .814. A pearson correlation revealed a weak and non-significant negative correlation between cybersickness and sense of presence, r (33) = -.036, p = .843.

4. Discussion

The aim of this study was to investigate group differences (compulsion type, gender, age, cybersickness) in terms of sense of presence in order to better understand which factors could potentially influence sense of presence in an ERP in VR intervention for OCD. The study investigated three main hypotheses. The first two hypotheses investigated whether there were significant group differences in terms of sense of presence in the two different OCD subtypes contamination and checking compulsions, as well as between genders. Lastly, it was tested if cybersickness is negatively associated with sense of presence and if this is more pronounced in the older participant population. All hypotheses were not supported.

As none of the results confirmed our expectations, assumptions about group differences in terms of sense of presence have to be reevaluated.

4.1 Compulsion Group Allocation and Sense of Presence

The hypothesis that participants experiencing contamination compulsions would feel more present in the virtual environment than participants experiencing checking compulsions was not confirmed. In fact, the contamination group showed only minimal non-significantly higher scores in sense of presence than the checking group. As there were no significant differences between both groups, general sense of presence seemed to have been similar throughout the sample, despite both groups having been exposed to two completely different virtual environments. According to Sookman et al. (2005), different OCD subtypes require specialized treatments, which the study's intervention implemented by creating two different virtual environments for the contamination (dirty bathroom) and the checking (apartment) group. While contamination compulsions are

based on disgust (Bhikram et al, 2017) and checking compulsions are based mainly on fear (Strauss et al, 2020), the difference in emotions did not seem to have varying effects on total sense of presence in this study.

In general, it could be argued that the lack of group difference can be interpreted as a strength of the intervention. As the descriptive analysis only showed little to moderate sense of presence in the total sample, another explanation for the lack of group differences could be that sense of presence was not high enough to properly compare the two groups to each other. This might be due to imperfections in the technique used for the ERP in VR intervention used in this study: Slater (2009) argued that the used technique is a main factor in the successful induction of sense of presence in a VR environment. Another explanation for the lack of sense of presence could be the inability of the virtual environments to elicit a sufficient level of anxiety/disgust in the participants, but anxiety is needed to stimulate sense of presence (Alsina-Jurnet et al., 2010).

The analysis of the IPQ subscales again revealed no significant differences in the participants' spatial awareness, nor their perceived realism of the virtual environment. In terms of involvement, the checking group experienced a higher involvement in the virtual environment than the contamination group, which countered our expectations. A possible explanation for this could be that participants struggling with contamination compulsions might have not feared the consequences of contamination (e. g. sickness or death) because they were aware of being in a virtual environment and hence did not feel as involved in the VR as participants experiencing checking compulsions. In line with this explanation is the nature of fear vs. disgust: As fear is a reaction to a potentially life threatening cue and triggers active reactions such as fighting, freezing and fleeing (Ekman, 1992), disgust is a reaction to a potential danger and is thereby characterized by stronger avoidance and withdrawal behaviors (Olatunji & Sawchuk, 2005). Taking this into account, participants experiencing contamination compulsion could have shown stronger avoidance patterns than participants experiencing checking compulsions and not

accept their involvement in the VR as means of avoiding disgust. This implies that in the future there need to be even more tailored interventions aiming at reducing disgust rather than focusing on just fear, as this seems harder to implement. This is in line with past research pointing at disgust compared to fear being relatively resistant to change (Olatunji et al, 2009) and should be looked into further.

4.2 Gender and Sense of Presence

The hypothesis that male participants would experience higher sense of presence than female participants was also not confirmed. Same holds true for all sense of presence subscales. This indicates that males and females did not perceive being ”in” the virtual space significantly differently, despite past research suggesting that males generally experience higher levels of sense of presence in virtual environments (Felnhofer et al., 2012). Again, this could be interpreted as a strength of the intervention, but could also be due to a lack of sense of presence induced by the intervention. Past research suggested males to be more accustomed to VR, as they more frequently participate in online gaming than women (Hartmann & Klimmt, 2006). Newer statistics show an almost even contribution between males and females in the gaming community, which could be a possible alternative explanation for the lack of differences in sense of presence in this study (ESA, 2021). Furthermore, sense of presence is based on cognitive abilities, most importantly the ability to shift attention from the real world to the virtual environment (Velichkovsky et al., 2016). According to this study, both males and females showed similar cognitive abilities of shifting their attention from the real world to VR.

While there were no significant results, females showed slightly higher scores in sense of presence than males, contradicting the hypothesis. An explanation for this tendency could be the difference in sample distribution, as the sample was only 24% male and 76% female. Lombard et al. (2000) offered an alternative explanation, as they assessed males’ and females’ experiences of presence while watching television and found that women had stronger emotional responses than men which they suggested

meant higher levels of presence. In this context, research by Gamito et al. (2008) used an "emotion" sub-component, where female participants scored significantly higher than men. These findings underline that males and females might have experienced slightly differing sensitivity to the VR environments. These findings and the non-significant results of this study need to be taken into consideration when designing new VR treatment environments, in order to offer the best customized treatment for both genders.

4.3 Cybersickness, Age and Sense of Presence

The hypothesis that cybersickness is negatively associated with sense of presence and this association is more pronounced in older individuals was not supported either. A weak but also non-significant negative impact of cybersickness on sense of presence was detected, which is in line with past research pointing at the negative relationship between the two variables.

While the lack of significant effects in this study could be interpreted as age not being a strong predictor for cybersickness and thereby sense of presence, it must again be assumed that due to the low induced sense of presence in the intervention, the investigation itself was not optimal. On the other hand, there has been conflicting studies on the role of age in terms of virtual reality environments, with few past studies claiming that younger populations are more likely to experience cybersickness (Dilanchian et al., 2021) and others reporting that the older population is more prone to cybersickness (Arns & Cerney, 2005) and hence lower sense of presence. The results therefore could also suggest that there is simply no clear link between age and cybersickness. This could also be due to the fact that VR is a relatively new field for all age groups and all age groups need to learn to adapt to virtual environments in a similar fashion. This would mean that assumptions that younger participants have an advantage over older participants due to being more prone to technology and gaming technologies (Boot et al, 2020) would have to be reconsidered.

From a methodological viewpoint, the results could have been skewed because not all participants participated in the same amount of ERP in VR sessions. This could mean that habituation to the VR environment could have been induced in some participants more than in others, which could have led to non-comparable levels of cybersickness.

4.4 Limitations and Future Research

The study needs to be interpreted according to its limitations. First and foremost, as no hypothesis was confirmed, generalization of the results is limited. Second, the sample size was relatively small and the number of participants actually included in the data analysis was compromised due to irregular completion of all measurement questionnaires. Furthermore, the sample was unevenly distributed across genders, which could have been limiting comparability. In order to properly compare groups regarding sense of presence, higher sense of presence must be induced. As sense of presence was relatively low across all participants, it is clear that the virtual environments require technical and practical improvements. This could include further enhancing graphics, which could potentially be achieved by learning from gaming VR research or collaborating with such. Moreover, additional sensory feedback such as odor, vibrations and more enhanced audio cues have proven to increase presence in past research (Jung et al., 2020) and therefore could potentially do so in future ERP in VR studies. Contextual priming has also been found to induce sense of presence in past studies (Cerda et al., 2021), suggesting that future studies could make use of this as well. To better understand the relationship between sense of presence and different genders and age groups, other variables such as experience with gaming and prior exposure to virtual reality that could have potentially influenced sense of presence should be taken into account in future studies. Generally, in future research pilot studies should confirm the ability of a virtual environment to immerse participants at a more acceptable level.

Moreover, there has not been plenty of research on general differences between the checking and contamination subtypes of OCD in virtual reality interventions, a research gap that can be filled in order to offer future specialized treatment to different OCD patient groups tailored to the divergent emotional groundwork of the subtypes.

As two completely different virtual environments were used to treat the two different OCD types, it can be considered questionable whether a comparison of the two groups in terms of sense of presence is appropriate. Because both examined subtypes require differing ERP cues and anxiety evoking triggers, it would have been close to impossible as well as unethical to establish a single environment to compare both subtypes. Furthermore, the environments were designed by the same design team and mainly differed in the used cues, not the quality, sound or immersive layout. Sense of presence scores were very similar throughout both groups and throughout all four sessions, including the first session, which was lacking anxiety inducing cues, suggesting that the variable was indeed comparable in two different environments. Nevertheless, future research could establish separate studies for the different OCD subtypes or establish one neutral virtual environment in which anxiety/disgust inducing cues could be added individually, as it is e. g. possible in a mixed reality setting.

In terms of measurements and analysis, only self-report measures were used, even though psychophysiological assessments are considered to be highly relevant in treatment evaluation in disorders such as OCD (Alberto et al., 2014). Future research could use objective means such as heart-rate and skin conductance to further capture participants' sense of presence. Furthermore, the study did not control for any other covariates except for age, leaving a possibility of otherwise influenced results. As internal consistency of the IPQ was low in this study, it can be argued that the IPQ might have not been the ideal tool to measure sense of presence in the context of two ERP in VR environments. As IPQ items measure different sense of presence components (spatial presence, involvement and experienced realism) the scale might be too heterogeneous. Further, study participants

might have been interpreting the items as well as the constructs themselves very differently. Concluding, a more in depth analysis of the different IPQ and SSQ items would have been necessary to gain a better understanding of the constructs.

4.5 Conclusion

The present study did not confirm group differences in terms of perceived sense of presence in participants of an ERP in VR intervention for OCD. These findings could be interpreted in two ways: it is possible that the lack of difference in sense of presence between the compulsion groups (contamination/checking), genders and age groups underlines that the differences indeed are not as big as expected and sense of presence is experienced similarly by all participants. Taking into account the immense importance of sense of presence in VR treatment efficiency (Wiederhold & Wiederhold, 2005), this would imply that while VR treatments should be specialized to fit a patient's needs, it is possible to offer interventions for different groups. The lack of sense of presence can therefore be seen as a success. An alternative interpretation of the results could be that by failing to induce high enough levels of sense of presence in participants, comparisons between groups were not implementable. As sense of presence was perceived as only low to moderate, technical improvements in the VR are strongly advised. Despite the inability of the intervention to induce high levels of sense of presence this was, to our knowledge, the first study to investigate factors influencing sense of presence in a virtual OCD treatment and future research could potentially profit from its insights.

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Appendix

Image 1

Contamination environment

Image 2

*Checking environmen*t