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Assessment of Virtual Reality as an Anxiety and Disgust Provoking Tool: The Use of VR Exposure in Individuals With High Contamination Fear

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Abstract

Preliminary studies have provided promising results on the feasibility of virtual reality (VR) interventions for Obsessive-Compulsive Disorder. The present study investigated whether VR scenarios that were developed for contamination concerns evoke anxiety, disgust, and the urge to wash in individuals with high (n = 33) and low (n = 33) contamination fear. In addition, the feasibility of VR exposure in inducing disgust was examined through testing the mediator role of disgust in the relationship between contamination anxiety and the urge to wash. Participants were immersed in virtual scenarios with varying degrees of dirtiness and rated their level of anxiety, disgust, and the urge to wash after performing the virtual tasks. Data were collected between September and December 2019. The participants with high contamination fear reported higher contamination-related ratings than those with low contamination fear. The significant main effect of dirtiness indicated that anxiety and disgust levels increased with increasing overall dirtiness of the virtual scenarios in both high and low contamination fear groups. Moreover, disgust elicited by VR mediated the relationship between contamination fear and the urge to wash. The findings demonstrated the feasibility of VR in eliciting emotional responses that are necessary for conducting exposure in individuals with high contamination fear. In conclusion, VR can be used as an alternative exposure tool in the treatment of contamination-based OCD.

Keywords: Obsessive-compulsive disorder; virtual reality; contamination fear; disgust

Introduction

Obsessive-compulsive disorder (OCD) is defined by recurrent, distressing, and time-consuming obsessions and/or compulsions (American Psychiatric Association, 2013). Fear of contamination is the most common symptom type in OCD (Ball et al., 1996; McKay et al., 2004). Individuals with contamination obsessions associate objects such as toilet seats, money, unwashed fruits or vegetables, raw meat, sink faucets, and doorhandles with germs or dirt. They tend to overestimate the probability and severity of contamination. Contamination obsessions often lead to washing and cleaning compulsions. Individuals with contamination fear perform compulsive rituals to avoid contact with potential contaminants and to reduce anxiety. Moreover, they often avoid situations and objects that trigger contamination-related obsessive thoughts (Rachman & Shafran, 1998).

Persistent anxiety is an important component of contamination obsessions (Rachman, 2004). Recent evidence suggests that disgust also plays a critical role in the etiology and persistence of contamination-based OCD (Cisler et al., 2009). This is unsurprising since disgust is conceptualized as a defensive emotional response to common contamination-based OCD stimuli such as food, poor hygiene, smells, animals, death, injury, sexual acts, and moral violations. Studies have indicated that feelings of disgust are significantly associated with fear of contamination in

both clinical (e.g., Olatunji et al., 2011) and non-clinical (e.g., Tolin et al., 2006) samples. Furthermore, studies have indicated that components of disgust proneness significantly predicted contamination-related OCD symptoms, especially washing compulsions (Moretz & McKay, 2008; Olatunji et al., 2010). In addition to direct association studies, a series of research findings have pointed out that disgust mediated the relationship between fear of contamination and contamination-related behaviors (Deacon & Olatunji, 2007). For instance, the link between contamination cognitions and responses to behavioral avoidance tasks was mediated by contamination fear (Deacon & Olatunji, 2007). In another study, Inozu et al. (2014) found that feelings of disgust mediated the relationship between religiosity and contamination symptoms. These findings have revealed the mediating role of disgust in the relationship between contamination fear and contamination-related OCD symptoms.

A large body of evidence has shown that exposure with response prevention (ERP) should be the first-line treatment choice for patients with OCD (Öst et al., 2015). In ERP, individuals are exposed to objects or situations (e.g., touching a toilet seat) that produce fear or anxiety while being prevented from performing the compulsions. The patient is confronted with actual phobic stimuli/situations during *in vivo* exposure, whereas the patient visualizes a feared situation in his/her mind in imaginal exposure. The emotional processing theory (Foa & Kozak, 1986) proposes that the effectiveness of exposure therapy depends both on its ability to induce considerable anxiety and its generalizability to real-world settings (Krijn et al., 2004). Research has suggested that exposure efforts should be oriented towards the facilitation of inhibitory learning, which, in turn, facilitates non-threat associations (Craske et al., 2008). Craske et al. (2014) stated that targeting inhibitory learning processes via exposure to multiple feared cues and aversive outcomes with varying stimuli and context, removing safety behaviors, and labeling the affect have crucial importance in the implementation of the exposure settings. *In vivo* exposure is an effective treatment method that elicits high levels of anxiety. It is also of particular importance in reducing disgust (Olatunji et al., 2011). For instance, a recent study by Mathes et al. (2020) showed that fear, disgust, and the urge to wash were significantly decreased within and between *in vivo* exposure sessions. In addition, within-session changes in fear and disgust were associated with the ERP outcome, indicating that fear and disgust are important indicators of the therapy outcome. However, creating real-life situations in *in vivo* exposure can be unpredictable, unsafe, unpractical, costly, or even impossible (Gega, 2017). Thus, a considerable number of clients tend to refuse ERP and drop-out rates are significant (for a review see Öst et al., 2015). Imaginal exposure in the treatment of contamination-related OCD helps patients confront the feared stimuli/scenarios without any safety problems such as an actual risk of contamination. Although imaginal exposure may be a safer alternative, it might not be realistic, thus failing to provoke anxiety (Bush, 2008). We therefore need a new strategy for exposure therapy that addresses these existing limitations.

Virtual reality (VR) is a computer-generated simulation in which users interact with an environment in a realistic way (Pratt et al., 1995). VR applications in clinical psychology have expanded in recent years (Powers & Emmelkamp, 2008). Meta-analysis studies have shown that VR environments successfully induced a significant amount of anxiety in patients with anxiety disorders and repeated exposure in VR is highly functional in reducing anxiety (Carl et al. 2019; Morina et al., 2015; Oprüş et al., 2012). In addition, VR exposure overcomes the limitations of traditional exposure techniques. VR exposure in the private and protective environment of the therapy room provides clients with a safe and confidential setting and increases perceived control and self-efficacy (Botella et al., 2004; Bush, 2008). Thus, VR exposure constitutes a more acceptable form of exposure therapy compared to traditional exposure techniques (Botella et al., 2015; Garcia-Palacios et al., 2007). In a study on the treatment of specific phobias, most participants reported that they were more eager and motivated to participate in VR exposure and 76% of the participants preferred VR over *in vivo* exposure (Garcia-Palacios et al., 2007). The treatment refusal rate was 3% for VR exposure, while it was 27% for *in vivo* exposure (Garcia-Palacios et al., 2007). Moreover, VR can be more realistic than mental imagery (Riva, 2009).

The development and use of VR interventions in the assessment and treatment of OCD have a relatively short history compared to their use in anxiety disorders such as simple phobia, claustrophobic fear, and social anxiety. Nonetheless, preliminary studies provided promising results on the feasibility of VR exposure in the treatment of contamination-based OCD. For instance, Laforest, Bouchard, Bosse et al. (2016) showed that a contaminated virtual environment significantly increased the anxiety levels of twelve OCD patients. The single-case study conducted by Laforest, Bouchard, Cretu et al. (2016) also provided preliminary support for the use of VR exposure in the cognitive-behavioral treatment of contamination-related OCD. Belloch et al. (2014) examined the feasibility of VR exposure on four patients with contamination-based OCD and found that the anxiety and disgust levels increased as the level of dirtiness of the virtual environment increased. Furthermore, repeated exposure to the

VR environment resulted in decreased symptom severity. In a pilot study conducted with eight OCD patients and eight healthy controls, a VR game was able to trigger and assess OCD symptoms that are related to contamination, doubt, and symmetry (van Bennekom et al., 2017). The results of a recent study conducted with a small analog sample ($n = 9$ in the experimental group) indicated that repeated VR-based exposure sessions could be effective in the reduction of contamination fear (Inozu et al., 2020).

Individuals with OCD reported greater levels of anxiety, tension, and uncertainty and performed significantly more compulsions than healthy controls when interacting with OCD-related items such as a disorganized table, a filthy sink, or a gas stove left on. Overall, the findings suggest that VR exposure can be a convenient alternative for the treatment of OCD. However, the number of studies that specifically apply VR exposure to the fear of contamination is limited. Additionally, the first trials were pilot studies that were conducted with a very small number of participants (Belloch et al., 2014; Inozu et al., 2020; Laforest, Bouchard, Cretu et al., 2016; van Bennekom et al., 2017). Another major limitation was the lack of control groups in previous studies. Moreover, although disgust is a critical factor in the maintenance of contamination-related OCD symptoms (Olatunji et al., 2010; Tolin et al., 2006) most studies have solely focused on the anxiety-provoking role of VR. As far as we know, no experimental research on VR exposure for contamination fear that involves instant measurement of anxiety, disgust, and the urge to wash during VR applications has been conducted. To evaluate VR as an alternative exposure tool for the fear of contamination, examining the role of VR in triggering anxiety, disgust, and compulsive behaviors such as hand-washing in an experimental design that includes a larger sample and a control group will be worthwhile.

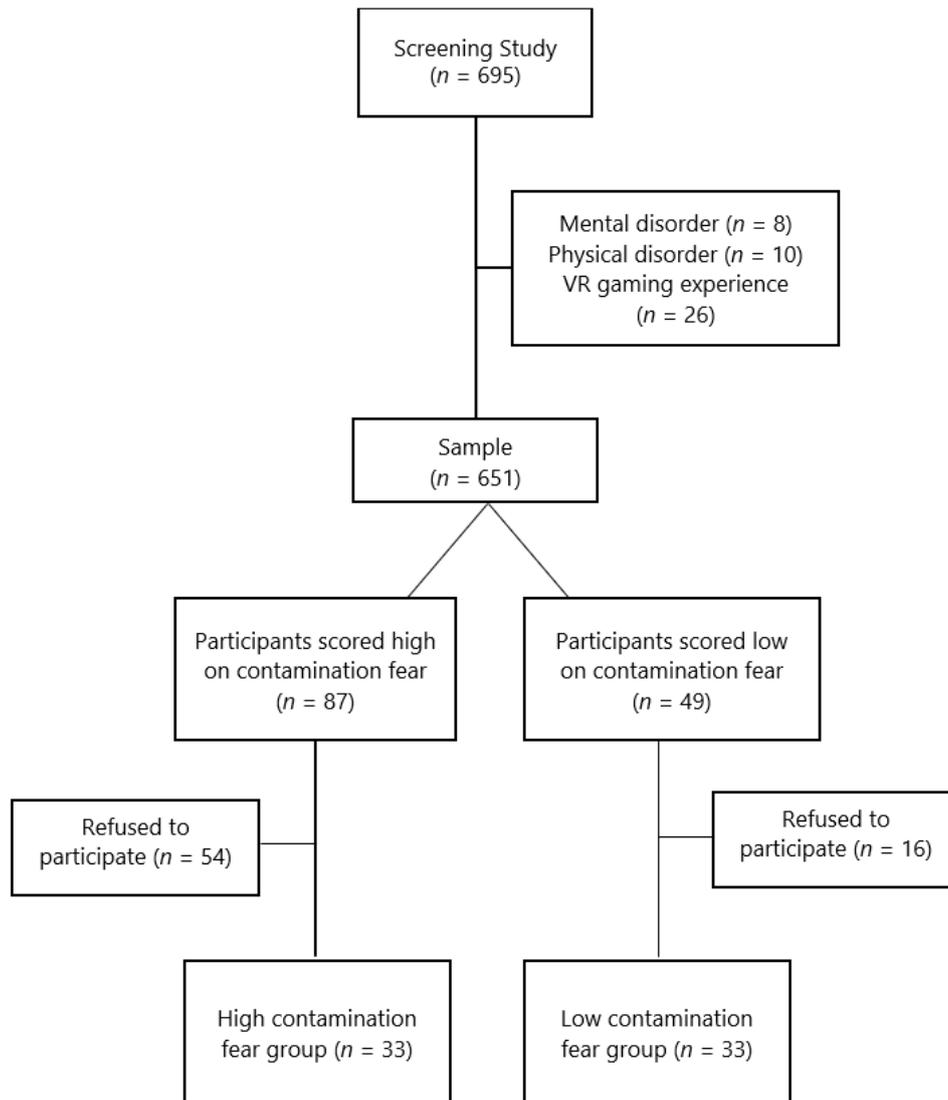
The main goal of the present study is to explore whether VR scenarios that were developed for contamination concerns evoke anxiety, disgust, and the urge to wash in people with high and low contamination fear. An experimental design with a contamination provocation task was employed. Individuals with high contamination fear (HCF) and low contamination fear (LCF) were exposed to virtual scenarios with varying degrees of dirtiness. We hypothesized that virtual scenarios with different levels of dirtiness would provoke higher anxiety, disgust, and urge to wash in the HCF group than in the LCF group. In addition, we hypothesized that the levels of anxiety, disgust, and the urge to wash would increase with increasing degrees of dirtiness of the VR scenarios. Finally, we hypothesized that the virtual environment-elicited disgust level would mediate the relationship between contamination fear and the urge to wash.

Method

Participants

An initial screening study was conducted with undergraduate students from different departments of the university to assign them to the high and low contamination fear groups (see Figure 1). The screening sample ($n = 695$) completed a demographic sheet that determined age, sex, pre-psychiatric history, and the Padua Inventory-Washington State University Revision (PI-WSUR) Contamination Obsessions, and Washing Compulsions Subscale (Burns et al., 1996). Individuals who reported to have been diagnosed with a chronic physical ($n = 10$) or mental disorder ($n = 8$) were excluded from the study. Since prior VR gaming experience could reduce the emotional impact of immersion and VR gamers reported lower levels of fear and engagement during immersion (Geslin et al., 2011), individuals who play VR games more than once a month ($n = 26$) were also excluded from further analysis. The final sample was composed of 651 individuals (533 females) with a mean age of 22.00 ($SD = 2.43$). The mean PI-WSUR Contamination Subscale score of the 651 individuals was 15.10 ($SD = 8.85$). Individuals who scored at least 1.5 SD above (87 individuals) and below (49 individuals) the mean were invited to the experiment by telephone and/or e-mail. The HCF group consisted of 33 participants (29 females, $M_{age} = 20.85$, $SD_{age} = 3.55$, range between 18-31 years old). The LCF group consisted of 33 participants (26 females, $M_{age} = 22.33$, $SD_{age} = 3.59$, range between 18-32 years old). The mean PIWSUR Contamination Subscale score was 2.79 for the HCF group ($SD = 0.41$, with a mean range of 1.60 to 3.90) while it was 0.29 ($SD = 0.14$, with a mean range of 0-0.50) for the LCF group. The results section presents the statistical analyses of the differences between the two groups.

Figure 1. Study Flow Chart.



Measures

Demographic information

The demographic information sheet included items assessing gender, age, and frequency of previous experience with VR environments that includes VR games. In addition, the participants were asked to indicate whether they had been diagnosed with a mental health disorder and receive treatment in mental health care.

Contamination Fear

The Padua Inventory-Washington State University Revision (PI-WSUR) is a self-report measure of the OCD symptoms (Burns et al., 1996). The Contamination Obsessions and Washing Compulsions Subscale consists of 10 items that are rated on a five-point scale ranging from 0 (*not at all*) to 4 (*very much*). The validity and reliability of the PI-WSUR are well documented (Taylor, 1998). The PI-WSUR was adapted to Turkish by Yorulmaz et al. (2007). Consistent with the original form, the Turkish version of the PI-WSUR had a five-factor structure, high internal consistency, and test-retest reliability. The Cronbach's alpha coefficient for the Contamination Subscale was .90 ($N = 651$) in the present study.

State Anxiety

The Spielberger State-Trait Anxiety Inventory (STAI, Spielberger, 1972) is a self-report measure assessing situational and trait anxiety. The State Anxiety Subscale that was used in the present study has 20 items and was

rated on a scale ranging from 0 (*not at all*) to 3 (*very much so*). The STAI has good reliability and validity (Spielberger, 1972). The Turkish form of the scale has comparable psychometric properties to those of the original version (Öner & Le Compte, 1983). The State Anxiety Subscale had a Cronbach's alpha of .90 ($N = 66$) in the present study.

Immersive Tendencies

The Immersive Tendencies Questionnaire (ITQ, Witmer & Singer, 1998) consists of 18 self-report items measuring the capability to feel immersed in virtual environments. Items are rated on a scale ranging from 1 (*never*) to 8 (*often*). The questionnaire was translated to Turkish for this study¹ and had a Cronbach's alpha of .78 ($N = 66$).

Presence

The Presence Questionnaire (PQ, Witmer & Singer, 1998) is a self-report instrument assessing a participant's sense of presence during the immersion in the virtual environment. The presence as measured by the PQ can be defined as a subjective experience and sensation of being in a virtual environment. The PQ has 25 items rated on a scale of 1 (*not at all*) to 7 (*completely*). The scale was translated to Turkish for the present study and had a Cronbach's alpha value of .66 ($N = 66$).

VR Material

The virtual environments that were employed in the study were developed photo-realistically with a Unity graphics engine. The environments were shown to the participants as they were rendered in real-time by a computer with an Intel Core i7 7700HQ (3.8 GHz) processor, a 32GB RAM, and an NVIDIA GeForce GTX 1080 graphics card. The participants experienced the environments using an HTC Vive VR system. The system consists of a head-mounted display, two controllers, and two light emitters for tracking the location and orientation of the head-mounted display and the hand controllers.

A participant wearing the head-mounted display observed the virtual environments in the study from the first-person perspective and engaged with the environments using the controller in each hand. The design of the virtual environments highlights spatial realism so that a participant would be able to move in them with ease simply by walking around in the physical space where the study was conducted.

To provide a comfortable VR experience without detrimental factors such as visual distress or cybersickness, the average latency between a controller input and the time the pixels consequently update was kept imperceptibly low and the rendering rate was persistently kept over 90 computer-generated-frames per second via the use of various optimizations during the graphics generation procedures.

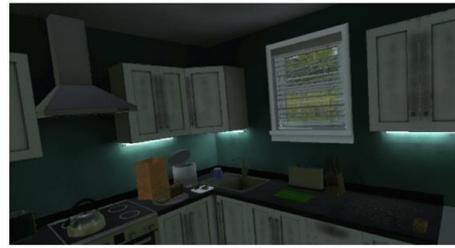
Procedure

Upon arrival, all participants were provided with a written informed consent form and filled out the demographic information sheet, STAI State Anxiety Subscale, and the Immersive Tendencies Questionnaire (See Table 1 for the scheme of the study procedure). The Presence Questionnaire was filled out upon the completion of the experiment. Later, they were asked to put on a head-mounted display and handheld tracking controllers. The experiment was conducted by three clinical psychology graduate students. Based on scenarios developed by Belloch et al. (2014), four different virtual scenarios consisting of a total of 12 tasks were developed (Table 1, Figure 2). In a similar manner to that of Belloch et al. (2014), all scenarios took place in a kitchen setting where the degree of dirtiness and disgust gradually increased from Scenario 1 to Scenario 4. Each scenario included three different tasks with increasing difficulty. The kitchen included an L-shaped kitchen counter with a sink and a faucet, an oven, and a refrigerator (Figure 2). Scenarios played out in the same order for all participants without an intermission, except for the brief self-report ratings. After the completion of each task, participants rated the level of anxiety, disgust, and the urge to wash hands on a scale ranging from 0 to 100. We calculated the mean of the self-report ratings after the completion of the three tasks for each scenario. We used the scores to compare the scenarios with each other. All the tasks were executed with the same hand. Each trial lasted about 30 minutes. Following the experiment, participants filled out the Presence Questionnaire and were debriefed. The study was approved by the University Ethics Committee. Data were collected between September and December 2019.

Figure 2. Images From the Training Scenario and the Kitchen Where the VR Tasks Took Place.



Training scenario



Kitchen



Scenario 1 - Task 2



Scenario 4 - Task 1

Table 1. Scheme of the Study Procedure.

Phase	Explanation
Before Intervention: Self-report measures	Demographics, contamination fear, and immersive tendencies
Intervention: Immersion in VR	Training scenario The training environment consisted of a regular living room. Participants were asked to move around and interact with objects until they became familiar with the interface and the equipment.
After the completion of each task, participants rated the level of anxiety, disgust, and the urge to wash hands on a scale ranging from 0 to 100.	Scenario 1 In the first scenario, there were chicken and a paper bag on the kitchen counter. The paper bag contained a bundle of lettuce and a loaf of bread. Task 1: Taking lettuce out of the bag. Task 2: Opening the fridge and putting the lettuce on the rack above the shelf where there is a plate with two cupcakes. Task 3: Taking and eating a cupcake.
	Scenario 2 In the second scenario, there were a plastic bag, a slice of bread, a chopping board, a plate with left-overs, and a sponge on the kitchen counter. Task1: Throwing the left-overs in the trash. Task 2: Cleaning the dirty section of the counter with the sponge. Task 3: Putting the slice of bread on the counter, then taking and eating the bread.
	Scenario 3 In the third scenario, there were raw chicken, a chopping board, and an apple on the countertop. Task 1: Putting one hand on the dirty chopping board. Task 2: Holding the apple that touched the raw chicken and putting the apple on the chopping board. Task 3: Eating the apple.
	Scenario 4 In the fourth scenario, there was a trash bin on the kitchen counter. Task 1: Putting one hand into the trash bin for 3 seconds. Task 2: Taking an open bottle of fruit juice out of the bin and touching the top of the bottle with the hand they recently took out of the bin. Task 3: Drinking the juice.
Following intervention: Self-report measure	The Presence Questionnaire

Statistical Analysis

Data analyses were conducted using the SPSS 23.0 package program (IBM Corp., Armonk, NY). Indirect effects were examined using Model 4 of the PROCESS macro version 3 for SPSS (Hayes, 2017). PROCESS macro infers the significance of the indirect effects from the 95% confidence intervals of bootstrap estimates. Confidence intervals that do not contain zero are considered as statistical evidence for indirect effects at $p < .05$ (Preacher & Hayes 2004). We determined the sample size in advance. We reported all manipulations and measures that we included in the study. We did not exclude any variables or conditions from the study during the data analyses.

Results

Preliminary Analysis

Table 2 presents intercorrelations among the PIWSUR Contamination Subscale, STAI State Anxiety Subscale, ITQ, and PQ for the HCF and LCF groups. The results showed that the scales were not significantly correlated with each other.

Table 2. Correlations Among the PI-WSUR, STAI, ITQ, and PQ.

Group	Variables	PIWSUR-C	STAI-S	ITQ	PQ	M	SD
HCF (<i>n</i> = 33)	PIWSUR-C	-				2.79	0.41
	STAI-S	-.24	-			1.78	0.42
	ITQ	.05	-.10	-		4.09	0.77
	PQ	.27	-.15	.22	-	4.47	0.40
LCF (<i>n</i> = 33)	PIWSUR-C	-				0.29	0.14
	STAI-S	.14	-			1.61	0.36
	ITQ	-.02	-.08	-		3.97	0.71
	PQ	.05	-.12	.28	-	4.24	0.46

Note. PIWSUR-C: Padua Inventory Washington State University Revision - Contamination Subscale; STAI-S: State-trait Anxiety Inventory - State Anxiety Subscale; ITQ: Immersive Tendencies Questionnaire; PQ: Presence Questionnaire; M: Mean; SD: Standard deviation.

* $p < .05$, ** $p < .01$, *** $p < .001$

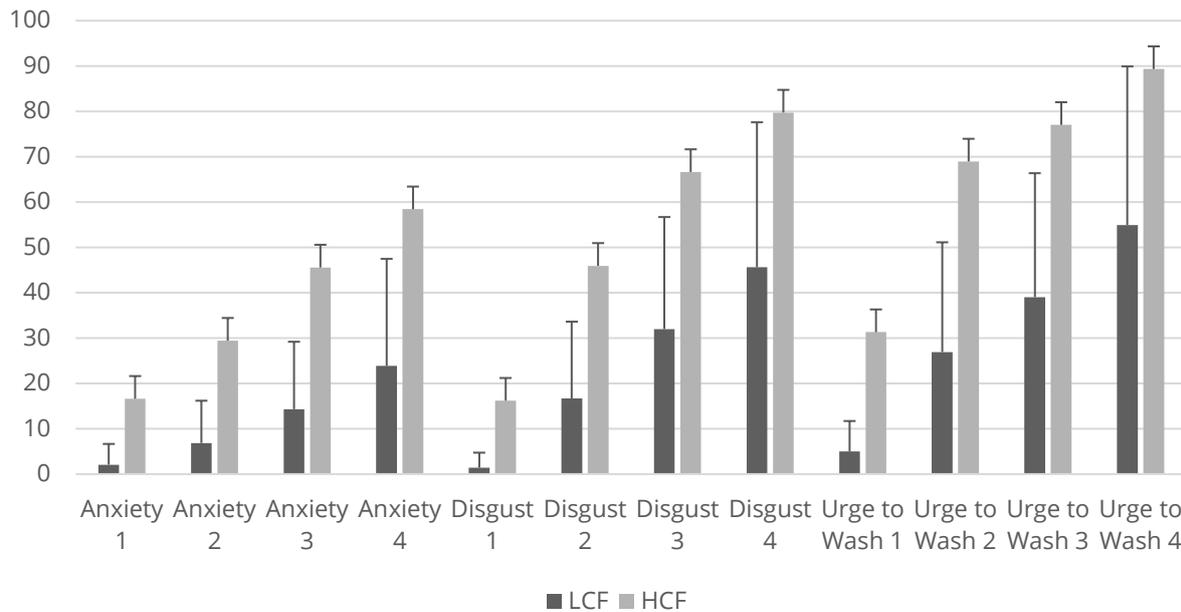
The HCF and LCF groups were compared with each other in terms of their PIWSUR scores. The HCF group reported significantly higher levels of contamination fear compared to the LCF group, $t(65) = 9.65$, $p < .001$. Two groups were also compared with each other in terms of their age, immersive tendency, and state anxiety levels using independent t-tests. There was not a significant difference between the groups. The PQ scores of the groups were also compared. The results revealed that the HCF group reported significantly higher levels of presence following immersion in the VR compared to the LCF group, $t(64) = -2.25$, $p < .05$.

Effects of Contamination Fear and VR-Based Exposure on the Anxiety, Disgust, and the Urge to Wash

The effects of CF and the degree of dirtiness in the VR scenarios on anxiety, disgust, and the urge to wash were analyzed using a 2 (Group: High and Low CF) x 4 (Degree of Dirtiness: 4 VR Scenarios) mixed design repeated measures MANOVA, where the degree of dirtiness was considered a within-subject factor and the group was considered a between-subject factor. According to the results of the Mauchly's test, the assumption of sphericity was violated for anxiety ($\chi^2(5) = 44.77$, $p < .001$), disgust, ($\chi^2(5) = 35.72$, $p < .001$) and the urge to wash ratings ($\chi^2(5) = 75.27$, $p < .001$). Therefore, the Huynh-Feldt correction was applied ($\epsilon = .70$ for anxiety; $\epsilon = .75$ for disgust; $\epsilon = .65$ for the urge to wash). The results indicated that the main effect of dirtiness (Wilks' $\lambda = .28$, $F[9, 462.56] = 35.14$, $p < .001$, $\eta^2_{\text{partial}} = .35$) was significant. The main effect of group was also significant for anxiety ($F(1, 64) = 34.61$, $p < .001$, $\eta^2_{\text{partial}} = .35$), disgust ($F(1, 64) = 40.53$, $p < .001$, $\eta^2_{\text{partial}} = .39$), and the urge to wash ratings ($F(1, 64) = 36.69$, $p < .001$, $\eta^2_{\text{partial}} = .36$). Also, as predicted, the Dirtiness x Group interaction (Wilks' $\lambda = .85$, $F[9, 462.56] = 3.35$, $p < .001$, $\eta^2_{\text{partial}} = .05$) was significant.

The follow-up ANOVA indicated that the effect of dirtiness was significant for anxiety ($F[2.09, 134] = 72.71, p < .001, \eta^2_{\text{partial}} = .53$), disgust ($F[2.25, 144.21] = 139.49, p < .001, \eta^2_{\text{partial}} = .70$), and the urge to wash ($F[1.95, 124.88] = 52.79, p < .001, \eta^2_{\text{partial}} = .45$). The post-hoc Bonferroni comparisons showed significant differences among the four VR scenarios for all variables (see Figure 3). The anxiety, disgust, and the urge to wash scores increased with increasing degrees of dirtiness. Furthermore, the interaction of the group by dirtiness was significant for both anxiety and disgust ($F_{\text{anxiety}}[2.09, 134.00] = 7.68, p < .01, \eta^2_{\text{partial}} = .11$; $F_{\text{disgust}}[2.25, 144.21] = 5.50, p < .01, \eta^2_{\text{partial}} = .08$, respectively), but not for the urge to wash ratings. The significant group by scenario interaction, as established using the post-hoc Bonferroni comparisons, indicated that the HCF group grew significantly more anxious and disgusted than the LCF group after each consecutive immersion in the virtual scenario when compared to previous one (see Figure 3).

Figure 3. Means and Standard Deviations for the Anxiety, Disgust, and the Urge to Wash Ratings of the Contamination Fear Groups After a Gradual Exposure to Increasing Dirtiness.



Mediation Analysis

Four simple mediation analyses were conducted to test whether the association between contamination anxiety and the urge to wash hands (outcome variable) is mediated by VR-elicited disgust (Figure 4). The group variable (i.e., High and Low Contamination Fear) was entered as covariate. As seen in Table 3, significantly predicted the strength of the disgust response that was elicited by a virtual environment (path *a*) in all scenarios. Disgust significantly predicted the urge to wash hands (path *b*) in all scenarios, except the second scenario. The total effect of contamination anxiety on the urge to wash (path *c*) was significant in third and fourth scenarios, while in the simple mediation model, the direct effect of contamination anxiety on the urge to wash (path *c'*) was not significant. The bias-corrected bootstrap confidence interval for the indirect effect of contamination anxiety on the urge to wash (path *ab*) did not contain zero in all scenarios, except the second one. In other words, disgust mediated the relationship between contamination anxiety and the urge to wash.

Figure 4. Simple Mediation Model.

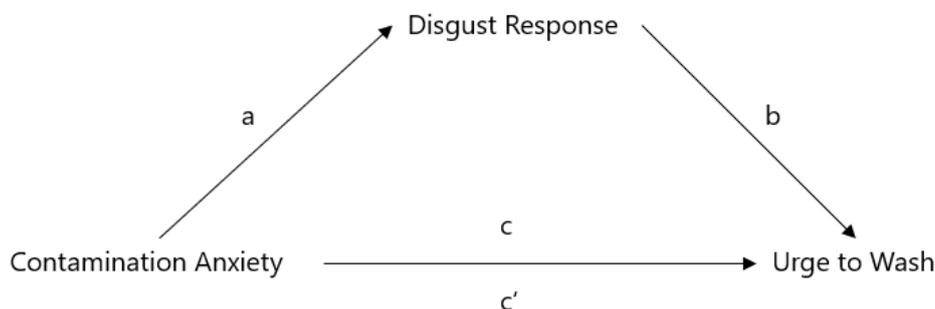


Table 3. Simple Mediation Analysis With Contamination Fear and Disgust (Mediator) on the Urge to Wash.

Degree of Dirtiness 1 (First Scenario)	Path/effect	B	SE	T
$R^2 = .77, F_{(2, 63)} = 105.07, p < .001$	a (CA on D)	0.76	0.07	11.19***
	(group on D)	3.70	1.89	1.96
$R^2 = .44, F_{(3, 62)} = 16.50, p < .001$	b (D on UW)	1.30	0.36	3.62***
	c' (direct effect of CA on UW)	-0.63	0.34	-1.86
$R^2 = .33, F_{(2, 63)} = 15.28, p < .001$	(group on UW)	16.15	5.55	2.91**
	c (total effect of CA on UW)	0.37	0.21	1.73
	(group on UW)	20.97	5.88	3.56***
		Effect	Boot SE	95% CI
	ab (indirect effect of CA on UW through D)	0.99	0.35	[0.3705, 1.6992]
Degree of Dirtiness 2 (Second Scenario)	Path/effect	B	SE	T
$R^2 = .71, F_{(2, 63)} = 76.05, p < .001$	a (CA on D)	0.88	0.10	9.26***
	(group on D)	9.36	4.19	2.24*
$R^2 = .22, F_{(3, 62)} = 5.94, p < .01$	b (D on UW)	0.79	0.41	1.95
	c' (direct effect of CA on UW)	-0.43	0.47	-0.92
$R^2 = .18, F_{(2, 63)} = 6.70, p < .01$	(group on UW)	28.64	13.98	2.05*
	c (total effect of CA on UW)	0.27	0.31	0.85
	(group on UW)	36.04	13.75	2.62*
		Effect	Boot SE	95% CI
	ab (indirect effect of CA on UW through D)	0.70	0.35	[-0.3197, 1.1837]
Degree of Dirtiness 3 (Third Scenario)	Path/effect	B	SE	T
$R^2 = .54, F_{(2, 63)} = 37.26, p < .001$	a (CA on D)	0.61	0.11	5.38***
	(group on D)	15.47	6.25	2.48*
$R^2 = .76, F_{(3, 62)} = 64.97, p < .001$	b (D on UW)	0.83	0.10	8.61***
	c' (direct effect of CA on UW)	-0.06	0.10	-0.59
$R^2 = .47, F_{(2, 63)} = 27.97, p < .001$	(group on UW)	11.31	4.98	2.27*
	c (total effect of CA on UW)	0.44	0.13	3.49***
	(group on UW)	24.08	6.99	3.44**
		Effect	Boot SE	95% CI
	ab (indirect effect of CA on UW through D)	0.51	0.13	[0.2985, 0.8134]
Degree of Dirtiness 4 (Fourth Scenario)	Path/effect	B	SE	T
$R^2 = .53, F_{(2, 63)} = 35.90, p < .001$	a (CA on D)	0.63	0.11	5.99***
	(group on D)	12.34	6.75	1.83
$R^2 = .81, F_{(3, 62)} = 87.99, p < .001$	b (D on UW)	0.88	0.08	10.77***
	c' (direct effect of CA on UW)	-0.02	0.09	-0.26
$R^2 = .45, F_{(2, 63)} = 26.21, p < .001$	(group on UW)	5.21	4.48	1.16
	c (total effect of CA on UW)	0.53	0.11	4.64***
	(group on UW)	16.04	7.34	2.18*
		Effect	Boot SE	95% CI
	ab (indirect effect of CA on UW through D)	0.55	0.14	[0.3230, 0.8815]

Note. CA: Contamination anxiety elicited by VR Tasks; D: Disgust response elicited by VR Tasks; UW: Urge to wash elicited by VR Tasks; CI: Confidence interval.

* $p < .05$, ** $p < .01$, *** $p < .001$.

Discussion

The present study examined whether four virtual scenarios that were related to contamination concerns evoked distressing emotions and the urge to wash in individuals with high and low contamination fear. Our results showed that VR tasks successfully induced anxiety, disgust, and the urge to wash in both the HCF and LCF groups.

Consistent with the hypothesis, findings indicated that the HCF group had higher levels of anxiety and disgust than did the LCF group. Also, anxiety and disgust levels of the HCF group systematically increased as the dirtiness levels of the scenarios increased.

Previous studies revealed that VR tasks are effective in triggering anxiety in individuals with contamination obsessions (Belloch et al., 2014; Laforest, Bouchard, Cretu et al., 2016). This study extends previous research by showing that VR can be used as a disgust-provoking tool in addition to anxiety. In fact, the results indicated that both groups perceived more disgust than fear in each scenario, underlining the importance of disgust. Prior research has revealed disgust as a critical component of exposure for contamination-based OCD and has suggested that effective ERP for contamination fear should target disgust (Brady et al., 2010; McKay, 2006). Other studies have found that ERP can reduce disgust and increased disgust tolerance was related to better psychotherapy outcomes (e.g., Olatunji et al., 2011; Smits et al., 2002). A recent study showed that both fear and disgust decreased within and between exposure sessions and the changes in fear and disgust were predictors of therapy outcome (Mathes et al., 2020). Arousing disgust using VR can result in greater activation of fear structures, which may accelerate the habituation process during exposure therapy. Therefore, invoking disgust with VR has important implications for virtual exposure to fear of contamination. Furthermore, previous studies indicated that disgust showed slower habituation and stronger resistance during the extinction phase when compared to fear (Adams et al., 2011; Olatunji et al., 2011; Smits et al., 2002). OCD patients suffering from contamination anxiety were less likely to get used to disgusting stimuli than OCD patients with other symptoms (e.g., McKay, 2006). It is quite possible that there may be significant differences between anxiety and disgust emotions in terms of the rate and duration of the decrease during the repeated exposure sessions in the treatment of contamination-based OCD (Olatunji et al., 2009). Hence, the use of ERP in combination with the VR technology can enable therapists to set longer and repeated exposure sessions to deal with slower habituation and the stronger resistance rate of disgust. Individuals who have contamination obsessions often engage in repeated and prolonged washing and cleaning behaviors until it feels “right” (Rachman, 2004). Mathes et al. (2020) showed that people with contamination-related OCD had stronger urges to wash at the beginning of the treatment and the decline in the urge to wash was significantly slower than that in fear and disgust in ERP. Since compulsive washing is considered a core component of contamination-based OCD, the present study also evaluated participants’ need to wash their hands after completing VR tasks in a contaminated environment. In accordance with previous findings, the HCF group reported a greater urge to wash hands after the VR tasks compared to the LCF group. Moreover, participants’ need to wash hands systematically increased with increasing levels of dirtiness. However, the effect of the interaction between virtual scenarios and contamination fear on the urge to wash was not significant. The VR tasks provoked a strong urge to wash for the participants in both groups. Consistent with studies demonstrating the effects of anxiety on handwashing behavior (Cogle et al., 2007), the increase in anxiety and disgust levels in the HCF group could have led to a greater urge to wash hands. These findings provided further support for prior research that suggests the use of VR to induce various OCD symptoms and urge to neutralize (Belloch et al., 2014; Kim et al., 2008; Laforest, Bouchard, Cretu et al., 2016; van Bennekom et al., 2017).

In parallel with previous findings pointing out disgust-mediated behavioral avoidance in contamination-based OCD (Deacon & Olatunji, 2007; Jones & Menzies, 1997; Olatunji et al., 2007; Tsao & McKay, 2004), the findings of the present study indicated that the effect of contamination anxiety on the urge to wash was mediated by disgust. In other words, contamination anxiety was associated with an increased disgust response to the VR tasks and higher disgust, which, in turn, was associated with a stronger urge to wash hands. These findings support Rachman’s (2004) contention that individuals with HCF are prone to overestimate the probability and seriousness of contaminants, which could lead them to react with disgust and fear to various substances or situations. Individuals’ estimates regarding contamination can lead to them being more easily disgusted when confronted with potentially contaminated stimuli. The results of the study also suggested VR as a powerful tool to investigate the role of disgust in the relationship between contamination anxiety and OCD symptoms.

Another important finding was that the HCF group reported a higher level of sense of presence in the virtual environment than the LCF group did. Presence is considered a subjective experience and a product of the mind rather than a direct outcome of technology (Ijsselstein et al., 2000). Personal characteristics such as mental health conditions or the level of anxiety can affect how people experience the world and, consequently, their sense of presence (Huang & Alessi, 1999). Several studies have pointed out that individuals with high levels of anxiety experienced a higher level of sense of presence in virtual environments (Price & Anderson, 2007; Robillard et al., 2003). Consistently, individuals with a higher contamination fear could have felt a stronger sense of presence in a

contaminated virtual environment. Previous studies have revealed that individuals are more willing to participate in VR exposure (Garcia-Palacios et al., 2007), which may be due to the assumption that real exposure is more difficult than VR exposure. Participants can simply try to avoid the feelings of anxiety and disgust when they are due to an *in vivo* exposure and they may think that VR exposure is “not real”. On the other hand, the present study showed that individuals perceived the virtual environment as very real and VR exposure provoked strong emotions, just like real exposure would. Thus, VR exposure can be conceptualized as a more appealing and convenient alternative that is also capable of provoking anxiety and disgust feelings. In addition, a recent study showed that willingness for exposure is an important predictor of the success of disgust exposure (Fink-Lamotte et al., 2020). In the light of the findings, VR may also increase willingness for exposure to disgust, which, in turn, can increase the effectiveness of exposure treatments for people with contamination-related OCD.

Another important finding was that the HCF and LCF groups did not significantly differ in terms of their immersive tendencies prior to immersion in the VR. However, the HCF and LCF groups significantly differed from each other in terms of presence, after immersion in VR. The participants in the HCF group rated their VR experience as more realistic compared to the participants in the LCF group. These findings provide further support for the feasibility of VR as an exposure tool for individuals with high fear of contamination.

The present study extended existing literature by examining whether a contaminated virtual environment evokes anxiety, disgust, and the urge to wash in the HCF and LCF groups. However, the findings should be interpreted in the context of several limitations. For example, the present study used an analog sample of undergraduates with high and low contamination fear. Even though previous research has shown that OCD symptoms are dimensional in frequency and severity and supported the employment of analog samples in OCD research (for a review, see Abramowitz et al., 2014), future research using clinical samples is necessary to establish the generalizability of the findings. In addition, the high percentage of women participants (88%) constituted another limitation of the study since gender is strongly associated with disgust and women tend to display stronger disgust (Schienle et al., 2005). Also, the psychometric properties of the ITQ and PQ were first examined in this study with a relatively small sample size. Attributable to the small sample size, the results revealed a relatively low Cronbach’s alpha for the scales. Therefore, future studies should reexamine the psychometric properties of the ITQ and PQ. The use of a generic scenario content for all participants is another potential limitation of the investigation. Although kitchens are among the most common locations evoking contamination concerns in OCD patients (Rachman, 2004), future studies should consider employing individually tailored virtual stimuli that are related to contamination obsessions. Also, VR exposure in the present study has several limitations since cognitive neutralization strategies were not covered during exposure and there were no odors that induce even stronger disgust and provoke more avoidance or neutralizing behavior. Future studies with VR exposure may include odor and other components to induce stronger emotions. Furthermore, the study did not examine the role of contamination cognitions, obsessive beliefs, and mental contamination. As shown by previous studies, contamination cognitions, obsessive beliefs, and mental contamination have strong associations with disgust responses and contamination symptoms. Hence, future studies can examine the association of these variables with disgust and contamination-related symptoms. Finally, future studies should consider using physiological measures of anxiety in addition to subjective measures of anxiety to increase reliability.

Notwithstanding these limitations, our findings have clinical implications for individuals with contamination obsessions. Fear of contamination is a complex, intense, and difficult to control symptom presentation of OCD (Rachman, 2004). The treatment of contamination symptoms can be compelling and traditional exposure can be difficult to apply and not even feasible in some cases (Coelho & Whittal, 2001; Rachman, 2004). VR exposure can be a convenient tool that can improve the cognitive-behavioral treatment of contamination-based OCD. Disgust has a crucial role in contamination-related OCD and should be addressed within the context of psychotherapy. The study showed that VR can elicit emotional responses that include disgust and are necessary for exposure therapy for contamination-based OCD.

Conclusion

Aiming to address the role of VR in triggering different components of fear of contamination, this study with a controlled experimental design and a relatively large sample size overcomes the limitations of previous studies. Our results suggested that VR can be a promising exposure therapy tool with its high level of control, realism, and

practicality and can be used to induce anxiety, disgust, and the urge to wash in individuals with OCD symptoms, especially in individuals with high contamination fear. Future research with clinical samples should investigate the effectiveness of VR as an exposure tool in the treatment of contamination-related OCD.

Footnote

1. ITQ and PQ were initially translated into Turkish by two independent translators, who were fluently bilingual in English and Turkish, and had strong psychology backgrounds. Three independent judges evaluated these two alternative translations that were similar with some minor differences, chose one of the translations, or provided an alternative translation. Then, three judges met together and decided on the final forms of the Turkish versions of the questionnaires. Finally, the final forms of the scales were back translated into English by an independent translator. The items of the back-translated forms were quite close to the items of the original scales. The internal reliability of the scales was examined in the participants who participated in the VR-exposure session.

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