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Review article

Design and validation of virtual environments for the treatment of cleaning obsessive-compulsive disorder☆

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ABSTRACT

During the coronavirus outbreak, it was noted that pre-existing psychological illnesses worsened, and numerous research indicate that those with contamination-related obsessions and cleaning compulsions (C-OCD) may be more affected. Virtual Reality (VR) and other immersive technologies have shown to be effective for the treatment of disorders related to anxiety, thus showing their potential to transform OCD treatment by means of integrating virtual elements. VR exposure has shown benefits compared to live or imagined exposure, however, to be effective it must be able to elicit high emotional arousal in users. Based on this, the present work aimed to develop different virtual environments scenarios and evaluate their efficacy in generating an emotional response in people with C-OCD symptoms. Based on the literature review, two virtual scenarios were created (dirty public bathroom and unhygienic kitchen). Subsequently, two groups were then constituted: C-OCD group (n = 20, aged between 18 and 48 years) characterized by an obtained score of more than 13 points (cut-point) in the Yale-Brown Scale for Obsessive-Compulsive Disorder (Y-BOCS) and by showing C-OCD symptoms when doing the structured interview (SCID-I), and a control group (n = 20, aged between 18 and 56 years), all participants were residents of the Dominican Republic. Exposure to the virtual environments generated high levels of state and subjective anxiety in both groups, although significantly higher in the C-OCD group. The results obtained indicate that the VR scenarios developed are suitable for eliciting emotional responses and, consequently, that they can be used to complement the treatment of C-OCD.

1. Introduction

In December 2019, SARS-COV-2 or COVID-19, a new and extremely contagious coronavirus, first detected in Wuhan, China, and rapidly spread throughout the world before being formally recognized as a global pandemic in March 2020 (World Health Organization, 2020). Most nations have used a variety of strategies to slow the spread of the virus, including social isolation and lockdowns that require people to stay inside (Trógolo et al., 2022). During the pandemic, the media increased the dissemination of information related to the risk of contagion and the importance of preventive actions. Thus, the population was encouraged to protect themselves from incidences of mild contamination, such as handshake or touching things, and the importance of washing or disinfecting hands was emphasized (Jelinek et al., 2021).

The coronavirus disease (COVID-19) outbreak was associated with an aggravation of pre-existing psychiatric problems (Yao et al., 2020), and various research indicate that those with contamination-related OCD and washing compulsions ('washers') may be more vulnerable than any other group of individuals (Fineberg et al., 2020; Fontenelle and Miguel, 2020). According to Davide et al. (2020), the COVID-19 epidemic caused patients who already had symptoms of contamination and patients who had not established remission prior to quarantine to experience worsening of their symptoms. Comparable results were obtained by Benatti et al. (2020) who report an increase in obsessive-compulsive disorder the

☆ C-OCD: contamination/cleaning obsessive-compulsive disorder.

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severity of (OCD) symptoms during the initial lockdown in 2020. More recently, in a large online sample, Jelinek et al. (2021) examined the variations in OCD symptom intensity generated by the COVID-19 pandemic. As shown by the results, 72% of participants said their OCD symptoms had become worse. The International College of Obsessive-Compulsive Spectrum Disorders and the Obsessive-Compulsive Research Network of the European College of Neuropsychopharmacology have emphasized the need to modify or even interrupt therapy with exposure and response prevention during the epidemic (Fineberg et al., 2020; Jelinek et al., 2021). Since COVID-19 is exceptionally contagious and exposure response prevention treatment for contamination/cleaning OCD (C-OCD) may require, for example, contacting heavily used "public" surfaces without washing one's hands first, the advantages and disadvantages of treatment must undoubtedly be considered.

Mental health practitioners must offer the assistance required to treat individuals who still report OCD symptoms as well as to enhance relapse prevention in the face of deteriorating symptoms. It is suggested that alternate approaches like virtual psychological and psychiatric consultations be improved in this area (Ćosić et al., 2020). Virtual reality (VR) has shown to be useful in the treatment of anxiety disorders (Carl et al., 2019), demonstrating the promise of immersive technology to transform OCD therapy by including virtual aspects (García-Batista et al., 2020; Laforest et al., 2016b). VR is a technology that creates three-dimensional environments that allow users to interact with them in real time and from a first-person perspective while also stimulating various sensory receptors (Aymerich-Franch, 2013; Botella et al., 2009). As a result, people exposed to VR will experience emotions, responses and thinking patterns similar to those that would be provoked by a real situation (Alsina- Jurnet et al., 2011). VR offers the possibility of immersion, of creating as many environments, situations and events as the participant demands, letting the participant interact synchronously with the virtual world in a manner that creates associations with a real event or fact (Quero et al., 2012). VR also provides users with a gradual, regulated, and secure way to confront their worst fears. The therapeutical objectives of virtual reality exposure therapy (VRET) are founded on behavioral therapy treatment procedures, however VRET uses virtual environments that mimic real-life frightening circumstances. Results from many studies indicate that VRET is a practical and efficient method (Morina et al., 2015; Opriş et al., 2012; Parsons and Rizzo, 2008). According to a recent meta-analysis (Carl et al., 2019), the effect sizes of VRET compared to waiting lists and psychological placebo conditions were both large ($g = 0.90$) and medium to large ($g = 0.78$), respectively. Although study results provide evidence supporting the efficacy of the VRET for the treatment of various mental health problems, there is still a lack of research regarding the efficacy of VR technology for the assessment and treatment of OCD. The disorder's heterogeneous structure is one of the reasons why VR use in OCD has received less research. Various studies have demonstrated that VR enables in patients with verification and checking (Kim et al., 2008a; Bennekom et al., 2017), symmetry and order OCD (Kim et al., 2012; Bennekom et al., 2017) a high emotional arousal. Nevertheless, the use of virtual technology for C-OCD is still emerging (Belloch et al., 2014; García-Batista et al., 2021; Laforest et al., 2016a). To date, there are few technological developments involving the application of VR to treat C-OCD and limited randomized controlled trials (Dehghan et al., 2022) with a modest amount of subjects treated (Belloch et al., 2014; Inozu et al., 2020; Laforest et al., 2016a; Laforest et al., 2016b). Moreover, it should be noted that these studies were limited to a single virtual scenario, so to date there have been no studies comparing different scenarios in the same sample.

VRET can be an effective treatment method for C-OCD, however, its effectiveness will depend largely on how well the virtual stimuli can activate an anxiety response. The exposure and response prevention technique involves patients confronting their anxiety-provoking stimuli as opposed to continuing to evade them or temporarily coping with them through compulsive behaviors. Not surrendering to their compulsive behaviors and learning to tolerate certain levels of anxiety is necessary for exposure therapy to be successful. If the stimuli do not generate an emotional response, VRET will not be effective. For this reason, it is crucial to evaluate how effective VR stimuli is in provoking anxiety. Taking this into consideration, the aim of this research is to develop and determine the how effective the created virtual environments are at inducing anxiety in individuals with C-OCD. Our hypothesis is that those with C-OCD would experience more anxiety when exposed to a "contaminated" virtual environment than people without the disorder. If this hypothesis is verified, we will have virtual scenarios susceptible to be used in exposure therapies and response prevention for patients with C-OCD.

2. Material and methods

2.1. Participants

This study received approval of the National Council of Bioethics (CONABIOS) of the Dominican Republic (No. 028-2014). Through various social networks, a request for volunteers to take part in a study about the use of technological tools for the treatment of C-OCD was made. Volunteers who were interested in taking part had to attend to the Dominican Republic's Pontificia Universidad Católica Madre y Maestra, where they were provided written information on the study's procedures and requested to sign an informed consent form.

The structured interview [Structured Clinical Interview for Axis I Mental Disorder (SCID-I)] and questionnaires were applied by trained team members. Two groups were formed in accordance with the evaluation's results: control group ($n = 20$) and C-OCD group ($n = 20$). The sample consisted of 15 men (37.5%) and 25 women (62.5%), with ages ranging from 18 to 56 years (Mean = 26.13; SD = 9.91). The control group was made up of 9 men (45.5%) and 11 women (54.5%), with ages ranging from 18 to 56 years (Mean = 28.36; SD = 11.60). On the other hand, the C-OCD group was made up of 6 men (27.8%) and 14 women (72.2%), with ages ranging between 18 and 48 years (Mean = 23.39; SD = 6.69). Participants in the C-OCD group are categorized by scoring above 13 points (cutoff point) on the Yale-Brown Scale for Obsessive-Compulsive Disorder (Y-BOCS) and by exhibiting C-OCD symptoms when performing the structured interview (SCID-I).

2.2. Instruments

Structured Clinical Interview for Axis I Mental Disorder (SCID-I). The primary groups of DMS-IV-TR Axis I disorders, including OCD, were evaluated using the Spanish version of this semi-structured interview (First et al., 1999). The SCID-I has good psychometric qualities and is frequently utilized in the field of mental health (Lobbestael et al., 2011).

Y-BOCS (Goodman et al., 1989). This inventory contains a list of symptoms and a scale of severity. This list includes 40 obsessions and 29 compulsions, categorized by content. The severity scale contains 10 items: 5 for obsessions and 5 for compulsions. Regarding the symptom checklist, 17 items were considered: those related to obsessions of contamination and need for symmetry/accuracy, and the compulsions to clean/wash and sort/fix (Leal Carcedo and Cano-Vindel, 2008). The study sample's Cronbach's alpha coefficient was .80.

State-Trait Anxiety Inventory (STAI). This instrument was developed by Spielberger, Gorsuch and Lushene (Spanish adaptation by Buela-Casal et al., 2011). This 40 items scale evaluates anxiety as a state and personality trait which assess the welfare or absence of anxiety, as well as the presence of anxiety. These items are evaluated by means of a Likert type scale. Items from 1 to 20 assess state-anxiety (S-A), that which is experienced at the time of application. The S-A items are measured as follows: 0 (nothing), 1 (some), 2 (quite) or 3 (a lot). Items from 21 to 40 evaluate trait-anxiety (T-A), that is, the anxiety that the individual frequently experiences. The score of their items is: 0 (almost never), 1 (sometimes), 2 (often) or 3 (almost always). Given that certain items are written in a

negative way, the overall score is determined after the direct sum of the positive items plus the sum of the reversal of those that are written in a negative way. The spanish version of STAI was used (García-Batista et al., 2017). In the study sample, the Cronbach's alpha coefficient was .82.

Subjective Units of Anxiety Scale (SUDS). This scale was developed by Joseph Wolpe in 1969. It is an instrument that evaluates the subjective level of anxiety experienced by the person in a certain moment. Its original version corresponds to a valuation of 0 (state of absolute tranquility) to 100 (maximum level of anxiety) according to the self-evaluation granted (Kim et al., 2008b).

Hardware. The virtual environments were created and implemented with the use of a computer Intel(R) Core (TM), i5-6500 CPU @, 3.20GHz, 3.19GHz, with a RAM memory of 32.0 GB DDR4, and a graphic card of NVIDIA GeForce GTX 1080 (8 GB GDDR5). It should be noted that this hardware is the same as a prior investigation (García-Batista et al., 2020). The Oculus Rift headsets, a modern VR HMD that has been extensively used in VR research, were employed for the immersion (Caserman et al., 2021). Although these VR environments were also available for cheaper devices, such as Google Cardboard.

2.3. Procedure and data analysis

First, a literature review was conducted to decide which virtual scenarios to construct. Two contamination scenarios were found in previous studies, a contaminated kitchen (Belloch et al., 2014; Inozu et al., 2020), and a contaminated bathroom (Laforest et al., 2016a,b).

As noted by Inozu et al. (2020), the exposure hierarchy must be appropriately adapted to the anxiety levels of individuals. Indeed, for highly sensitive individuals, a longer and more precise hierarchy might be necessary. Therefore, it is ideal to have the option of several scenarios and different levels of contamination. Accordingly, we chose to construct a neutral scenario (a clean room of a house), and two aversive scenarios with four levels of contamination: a kitchen and a bathroom.

All the models were made in Autodesk 3Ds Max. Then, the scenarios were exported to the Substance Painter software to create all the textures (from the neutral level to the dirtiest level). Finally, the models and textures were exported to Unity3D to merge the above with the Oculus Integration package. In addition, lines of code were created to be able to control dirt levels and enable the user to interactively operate with various elements of the scenarios. The following is a brief description of the neutral stimulus, as well as both aversive scenarios and their contamination levels.

- Clean room of a house (Figure 1): this is the room of a small apartment. It contains typical elements and decorations: a television in the middle of the room, a small table on a colorful carpet, a tropical green sofa, bookcases, paintings and lamps. This scenario, on the one hand, served to familiarize the subject with the controls and the different VR elements; here, the individual could interact with his surroundings, sit on the couch, use the TV, open and close the windows, walk around the room, etc. On the other hand, this neutral stimulus also served to evaluate the anticipatory anxiety that arose in the patient when faced with an environment that made him uneasy because he perceived it as potentially dirty/contaminated.
- Kitchen (Figures 2, 3, 4, and 5): This setting contains four levels of exposure to dirt. At level 0 (Figure 2), a clean and tidy kitchen is shown, consisting of cabinets, dishes, teapot, cups, pans on the stove, knives, and other kitchen items. All of them are clean and tidy. On level 1 (Figure 3), characteristics are added, with the floor appearing dirtier, used pans, a garbage bag on the floor, as well as some food and other items that are dirty and/or out of place. On level 2 (Figure 4), dirtiness and clutter are increased; more food scraps, dirty kitchen utensils, trash bags, among others, are added. Level 3 (Figure 5) is where most of the elements that are representative of poor hygiene are present, including extreme dirt on the floor, dishes, walls and cabinets, decomposed food, excess food remains, containers and garbage everywhere, and a greater number of garbage bags on the floor, among other elements of contamination.
- Bathroom (Figures 6, 7, 8, and 9): This setting has four levels of exposure to dirt. On level 0 (Figure 6), a clean, white bathroom is shown, consisting of a large mirror, three sinks, two toilets, two urinals, a space where cleaning products are stored, as well as other typical elements present in public bathrooms (paper dispensers, toilet paper, etc.) On level 1 (Figure 7), some dirt begins to be incorporated,

Note. Neutral stimulus (clean room)

Figure 1. Neutral scenario.

Figure 2. Level 0: no dirt in the kitchen.

Figure 3. Level 1 of dirtiness in the kitchen.

with stains and contamination appearing everywhere, as well as urine residue (yellow liquid) in the toilets. On level 2 (Figure 8), contamination increases even more; the toilets and urinals remain the same shade of dirty water as on level 1. Finally, level 3 (Figure 9) incorporates the greatest amount of contamination; many stains are shown on all sides of the stage, with opaque and dirty walls and floor, mold, as well as black water in the toilets.

After creating the virtual environments, the interaction with research participants started. First, participants voluntarily read and signed the informed consent document. Secondly, the STAI-S and SUDS instruments were applied in a face-to-face manner by a team trained for this purpose. Thirdly, the neutral virtual environment (the clean room of a house) was administered for 3 min so that the user could become familiar with the operation of the controls and the virtual world. After this first interaction, STAI-S and SUDS were applied. Finally, participants entered the kitchen and the bathroom. In each space, they remained for 3 min while the psychologist accompanying him was in charge of progressively making the changes of textures in each environment, going from level 0 (clean space) to level 3 (highest degree of dirtiness). After having completed the immersion in each one of the environments, STAI-S and SUDS were administered again.

In this study, modern robust tests were applied to respond adequately to the objectives. This group of tests is suggested in cases of deviation of the data from the basic assumptions of the parametric tests, such as the normal distribution, as well as in case of not fulfilling other requirements such as those based on the size of the sample or the equity in the number of cases of the contrasted groups (Wilcox and Keselman, 2003). Overall, there are no assertions made about the probability distribution's functional form in this collection of tests (Wilcox, 2012). In this case, to confirm if there were differences between the groups tested (i.e., control vs. clinical), as well as to check the effect of the different measures applied (i.e., environments), the bwtrim function proposed by Wilcox (2012) for mixed ANOVA models was applied. The function allows the analysis between and within subjects based on the means cut to 20%. In this way, it is possible to analyze in the same analysis if there are effects due to the groups, to the different measures in the same subjects, or some type of interaction between these variables.

Figure 4. Level 2 of dirtiness in the kitchen.

Figure 5. Level 3 of dirtiness in the kitchen.

Additionally, with the objective of graphing, as well as verifying the magnitude of the differences, the ezANOVA and ezPlot function proposed by Lawrence (2015) was used. The effect size function allows obtaining the Generalized Square Stage recommended by Bakeman (2005) for repeated measurement designs. As a complement to verify the differences between C-OCD and control groups in induction settings, robust position measurements were calculated: the mean trimmed to 20% as well as its corresponding standard error (Wilcox, 2012), and the Yuen test was applied (also relied on a mean trimmed to 20%). Additionally, the effect size was computed using Cohen's d to confirm the magnitude of the changes (Lakens, 2013). Calculations were also made of its robust version based on the clipped mean suggested by for Algina et al. (2005). For all the above-mentioned analyses, the statistical software R was used, making use of the WRS-2 (Wilcox and Schonbrodt, 2016) and ez (Lawrence, 2015) packages.

3. Results

Prior to the analysis of the data, it was found that there were no differences between the groups when it came to sex and age. Neither in the case of the sex variable ($X2 = 1.32$, $p = .251$), nor for the age variable ($t = 1.69$, $p = .10$), were there any statistically significant differences.

In the second instance, mixed ANOVA statistical models were applied. Results corresponding to the SUDS measure of anxiety are shown in Table 1. Statistically significant inter and intra-subject effects are observed, and no interaction effect is evident. The effects observed are of moderate and great magnitude. Figure 10 shows inter and intra group effects.

It is possible to appreciate the increasing tendency in the levels of anxiety in both groups, as one passes from the neutral environment to the bathroom environment. For all these cases, the C-OCD group shows higher levels of anxiety. No statistically significant interaction effect was observed.

In Table 2 the results corresponding to the measure of state anxiety (STAI-S) are shown. Statistically significant inter and intra-subject effects are observed, with no interaction effect evident. The observed effects are of moderate and large magnitude. Figure 11 shows inter and intra-group effects.

It is possible to appreciate the increasing tendency in the levels of anxiety in both groups, as one passes from the neutral environment to the

Figure 6. Level 1: no dirtiness in the bathroom.

Figure 7. Level 1 of dirtiness in bathroom.

bathroom environment. For all these cases, the C-OCD group shows higher levels of anxiety.

As a complement to verify the differences between C-OCD and control groups in induction settings, robust position measurements were calculated: the mean trimmed to 20% as well as its corresponding standard error (Wilcox, 2012), and the Yuen test was applied using a mean trimmed to 20% (see Tables 3 and 4).

For all cases, statistically significant differences in favor of the C-OCD group are observed, with large effect sizes. The growing tendency in anxiety levels can also be seen, starting in the neutral setting that presented the lowest anxiety levels, and ending in the bathroom area which presented the highest scores.

4. Discussion

The COVID-19 epidemic was associated with an aggravation of preexisting psychiatric problems, and multiple studies indicate that those with contamination-related obsessive-compulsive disorder and washing compulsions (sometimes known as "washers") could have a higher level of symptoms than other groups. Mental health practitioners must offer the assistance required to treat individuals who still report OCD symptoms as well as to enhance relapse prevention in the face of deteriorating symptoms. Different studies report that almost 50% of patients with OCD do not obtain the expected reduction of symptoms through the exposure and response prevention therapy, even when pharmacotherapy is added (Belloch et al., 2014). Notably, approximately 20% of these patients refuse or drop out of ERP, due to their reluctance to be exposed in vivo to contamination stimuli. VRET is receiving increasing attention and is viewed as an innovative alternative to the treatment standard. VRET is an alternative method that is safer and more cost-effective than conventional treatment method, as it allows patients to gradually, safely, and in a controlled manner be exposed to their main fears. The findings of many studies point to VRET as a technique that is both effective and efficient. However, there are few randomized controlled studies using VR for C-OCD. Since the effectiveness of VRET will largely depend on the virtual stimuli's capacity to cause an Anxiety Response, the aim of this study was to develop and evaluate the efficacy of virtual environments to induce anxiety in individuals with C-OCD. Our hypothesis was that people with

Figure 8. Level 2 of dirtiness in bathroom.

Figure 9. Level 3 of dirtiness in bathroom.

Table 1. Inter and intra groups effects regarding levels of perceived anxiety (SUDS).

	F	*GL 1*	*GL 2*	*p*	$\eta 2_G$
Group (C-OCD Group Vs. Control Group)	18.25	1	25.48	<.001	.234
Scenarios	17.84	2	21.36	<.001	.132
Interaction effect	2.25	2	21.36	.129	.004

cleaning OCD would experience more anxiety when exposed to a "contaminated" virtual environment than people without the disorder.

In general terms, the results obtained allow us to corroborate this hypothesis. Indeed, it was observed that the levels of anxiety experienced by the C-OCD group were higher, and that these increased as the virtual contamination increased. The findings obtained are similar to previous studies, where it was corroborated, that patients exposed to contaminated virtual environments experience greater anxiety symptoms (Belloch et al., 2014; Inozu et al., 2020; Laforest et al., 2016a; Laforest et al., 2016b) and it is in line with the outcomes mentioned in the meta-analysis by Dehghan et al. (2022), regarding how effective VR environments are in provoking anxiety symptoms in patients with OCD.

In contrast to previous studies, statistically significant differences were observed in the present study (Belloch et al., 2014; Inozu et al., 2020), partly due to a larger sample size. On the other hand, it should be noted that in the present work modern robust tests were applied. This group of tests is suggested in cases of deviation of the data from the basic assumptions of the parametric tests, such as the normal distribution, as well as in case of not fulfilling other requirements such as those based on the size of the sample or the equity in the number of cases of the contrasted groups (Wilcox and Keselman, 2003). The use of alternative statistical procedures may be another contributing factor in the detection of statistically significant differences. Evidence is mounting that C-OCD is more treatment-resistant than other types of OCD (Mathes et al., 2019). As pointed out by Inozu et al. (2020), for VRET treatment to be effective and to have lower dropout rates, it is important that the exposure hierarchy is appropriately tailored to individuals' anxiety levels. Indeed, for highly sensitive individuals, a longer and more precise hierarchy might be necessary. Therefore, it is ideal to have the option of various scenarios

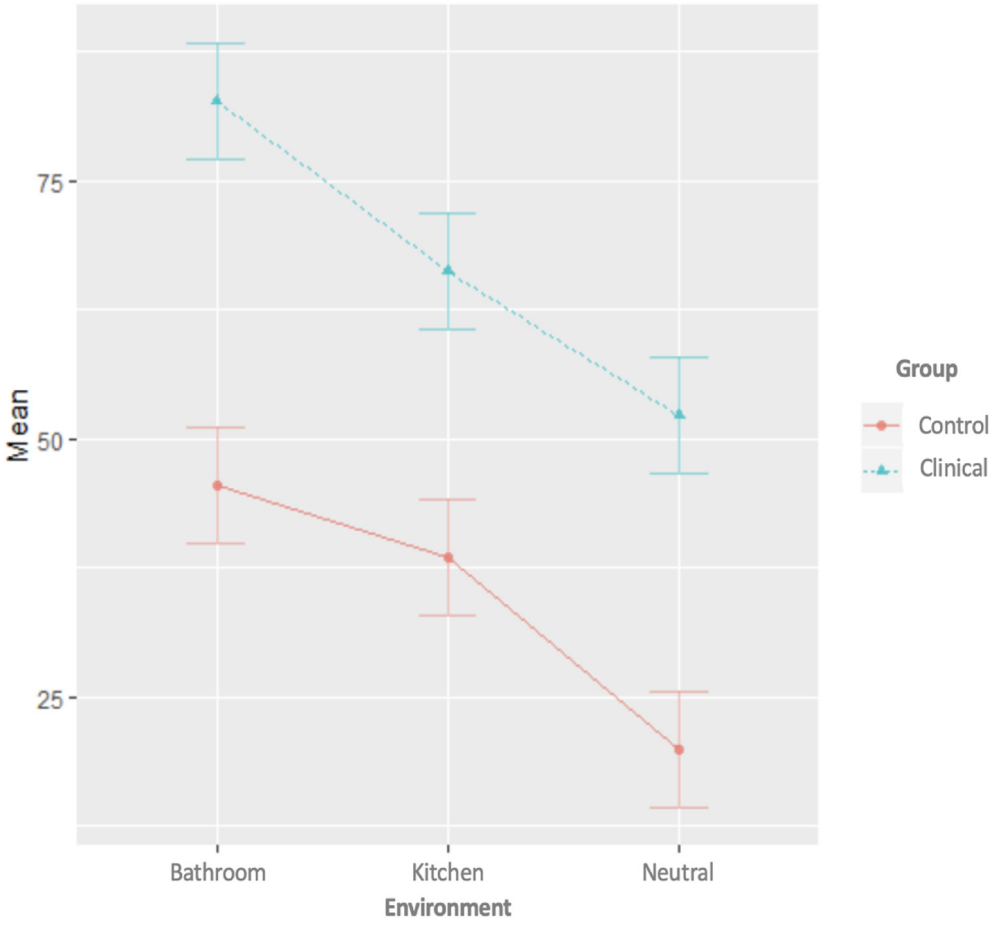

Figure 10. Inter and intra groups effects on levels of perceived anxiety (SUDS)

Table 2. Inter and intra groups effects on levels of state anxiety (STAI-S).

	F	*GL 1*	*GL 2*	*p*	$\eta 2_G$
Group (C-OCD Group Vs. Control Group)	30.83	1	23.23	<.001	.285
Scenarios	29.08	2	20.62	<.001	.196
Interaction effect	2.92	2	20.62	.076	.006

and different levels of contamination. Unfortunately, the few studies conducted to date have focused on a single virtual scenario (a kitchen in Belloch et al., 2014 and Inozu et al. (2020); and a public bathroom in Laforest et al., 2016a,b), without the possibility to compare in the same sample the anxiety response generated by different virtual scenarios. Therefore, the present work aimed to develop different virtual environments for the treatment of C-OCD and to assess how effective it is at provoking anxiety responses. Accordingly, we chose to construct different virtual scenarios: a neutral scenario (a clean room of a house), and two aversive scenarios with four levels of contamination: a kitchen and a bathroom.

The findings show that the individuals' levels of anxiety were higher in the kitchen scenario than in the bedroom, and that the bathroom was the scenario that generated the highest levels of state anxiety and subjective anxiety. The differences between the scenarios were statistically significant, with high effect sizes. These results are consistent in theoretical terms, since it is expected that in a public bathroom the risk of contamination is higher (Cárdenas-López et al., 2012; García-Batista et al., 2021). It's also noteworthy to notice that the emotionally neutral setting (a clean room) caused the C-OCD group to experience higher levels of state anxiety and subjective anxiety than the control group. The reason for this may be that it was a virtual environment in which a house unknown to the patients was represented and in which certain elements could relate to a certain level of dirt and disorder (for example: books on the shelves, objects on the table, etc.). In future studies, more neutral environments will be developed, without all the elements and virtual objects that could be related to dirt. Apart from this, it is suggested to use the living room as the first environment in an exhibition hierarchy aimed at the treatment of C-OCD.

According to the information found until this point, this seems to be the first study to compare various virtual settings in the same sample of C-OCD patients. Having this information will make available a more accurate determination of the most appropriate hierarchy for a VRET. Having few scenarios leads to a rigid and inflexible application of VRET, preventing an individualized approach that fits the needs of each patient. From the present research therapists could count on different contamination scenarios with and with different levels of contamination to create exposure hierarchies more finely tailored to the needs and evolution of each patient.

Another important practical implication to note is that having effective stimuli to generate anxiety responses in a controlled and safe manner may be a tool for better assessment of OCD. As Dehghan et al. (2022) point out, VR has the possibility to change how assessments are made for OCD. These virtual scenarios could be used for the measurement of OCD symptoms in the clinical consultation, which may lead to a more thorough assessment than by self-report tests. It is easier to treat OCD patients on time when there are suitable tools for the early detection of these diseases. Future research should focus on overcoming the significant lag between the onset of OCD symptoms and the start of therapy, as well as establishing that VR-based technology promotes quicker recognition and diagnosis of OCD in primary care settings.

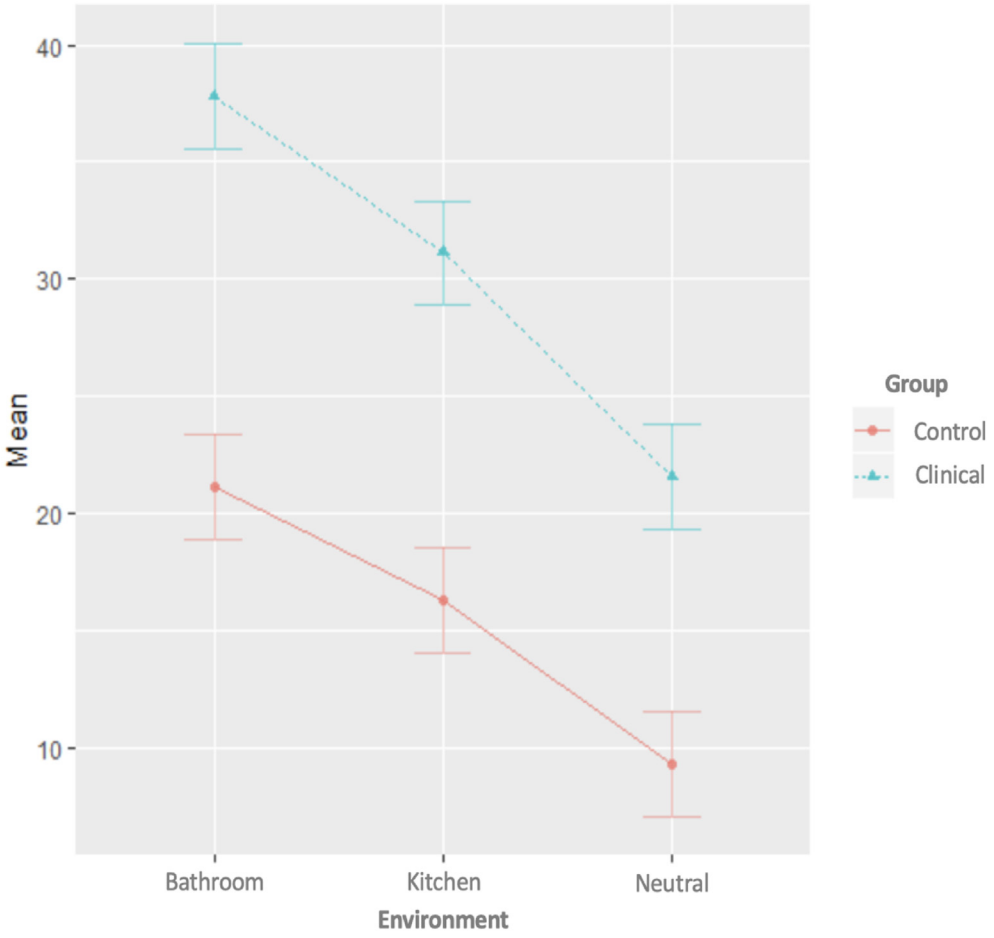

Figure 11. Inter and intra groups effects of state anxiety (STAI-S) measures.

Table 3. General levels of perceived anxiety between control and C-OCD group.

	Group				
	Control T-M (SE)	Clinical T-M (SE)	T_y	p	$\hat{\xi}$
Scenarios					
Neutral	15.00 (4.48)	56.00 (13.33)	3.17	.006	.57
Kitchen	35.71 (9.12)	73.08 (8.17)	3.25	.003	.58
Bathroom	43.92 (8.58)	92.08 (6.36)	4.79	<.001	.71

Note. T-M = trimmed mean (20%); SE = standard error for the T-M; Ty = Yuen's test. $\hat{\xi}$ = effect size.

Table 4. General levels of State Anxiety (STAI-S) between control and C-OCD group.

	Group				
	Control T-M (DE)	Clinical T-M (DE)	T_y	p	$\hat{\xi}$
Scenarios					
Neutral	8.14 (1.30)	19.66 (2.85)	3.98	.001	.82
Kitchen	13.78 (1.53)	32.16 (3.04)	5.83	<.001	.77
Bathroom	19.21 (3.32)	39.66 (3.37)	4.61	<.001	.71

Note. T-M = trimmed mean (20%); SE = standard error for the T-M; Ty = Yuen's test. $\hat{\xi}$ = effect size.

The sample size would be considered the study's primary limitation. Because contamination-subtype OCD is not very common, recruitment proved to be difficult. However, the sample size provides an adequate power to detect a moderate and large magnitude effect size. Replicating this study with a bigger sample size would be beneficial to get more representative and generalizable results. Another limitation is that only anxiety symptoms were examined, however, the etiology and phenomenology of contamination and washing symptoms may also be influenced by disgust. For this reason, the importance of also assessing the extent to which VR scenarios evoke disgust in patients with C-OCD was recently highlighted (Inozu et al., 2020). Therefore, it would be significant for future studies to contemplate the effectiveness of the scenarios we have developed to evoke disgust emotions.

Although encouraging, our results need to be interpreted cautiously. It is important to establish that in this work we only evaluated the efficacy of different virtual scenarios in generating an anxiety response, but it is still unknown whether their use in a psychotherapy setting is effective in reducing OCD symptoms. Recent meta-analytic studies (Dehghan et al., 2022) demonstrate that VR-based technologies may dramatically lessen OCD-related psychological symptoms, but more studies are required to determine if the developed scenarios have at least comparable efficacy to EPR.

Creating a more reliable foundation for future research was one of the objectives of this study. According to the meta-analytic review by Dehghan et al. (2022), the development of technologies to evoke emotional responses via VR stimuli should be intensified, which in due course might improve the effectiveness of VR therapy methods. Therefore, the present research intended to examine whether different VR scenarios create anxiety in people with C_OCD. We believe this is a necessary first step before directly conducting efficacy studies with a clinical sample. The current results reflect the need for further research regarding the efficiency of VR-ERP in lowering anxiety reactions in patients with

contamination-based OCD. The study's findings imply that VR-ERP might play a crucial role in the treatment process for OCD.

Declarations

Author contribution statement

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The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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