

A Virtual Reality Game to Assess Obsessive-Compulsive Disorder

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Abstract

The retrospective and subjective nature of clinical interviews is an important shortcoming of current psychiatric diagnosis. Consequently, there is a clear need for objective and standardized tools. Virtual reality (VR) can be used to achieve controlled symptom provocation, which allows direct assessment for the clinician. We developed a video VR game to provoke and assess obsessive-compulsive disorder (OCD) symptoms in a standardized and controlled environment. The first objective was to evaluate if the VR game is capable of provoking symptoms in OCD patients as opposed to healthy controls. The second objective was to evaluate the tolerability of the VR game in OCD patients. The VR game was created using a first-person perspective and confronted patients with 15 OCD-specific items, while simultaneously measuring OCD symptoms, including the number of compulsions, anxiety, tension, uncertainty, and urge to control. In this pilot study, eight patients and eight healthy controls performed the VR game. OCD patients performed significantly more compulsions ($U=5$, $p=0.003$) during the VR game. The anxiety, tension, uncertainty, and urge to control in response to the specific items were also higher for OCD patients, although significance was not yet reached because of the small sample. There were no substantial adverse effects. The results of this pilot study indicate that the VR game is capable of provoking a variety of OCD symptoms in OCD patients, as opposed to healthy controls, and is a potential valuable tool to objectify and standardize an OCD diagnosis.

Keywords: obsessive-compulsive disorder, symptom assessment, diagnosis, virtual reality, virtual environment

Introduction

THE CORE ACTIVITY of psychiatry is diagnosis: the identification of the nature and cause of certain mental symptoms. Diagnosis in psychiatry is generally based on a clinical interview and questionnaires. Consequently, a psychiatric diagnosis is prone to recall bias, defined as the inaccuracy or incompleteness of recollection by the patient and interviewer bias, defined as the subjectivity of the interpretation of patient responses by the clinician.¹⁻³ Therefore, there is a clear need to add objective and standardized tools to the diagnostic process of psychiatric disorders.

To overcome recall and interviewer biases, psychiatric symptoms should ideally be assessed when patients are actually experiencing their symptoms. This may be achieved by controlled symptom provocation. Virtual reality (VR) can be used to create a controlled and standardized environment in which symptoms may be provoked and simultaneously assessed. VR is defined as a computer simulated environment

with which a subject may interact.⁴ Over the past decades, the use of VR in the assessment of psychiatric disorders has been expanding. VR environments have been developed to expose patients to a life-like simulation of potentially stressful situations while maintaining the possibility for experimental control.⁵ One of the earliest applications was the creation of virtual height situations to be able to assess and treat acrophobia.⁶ Advantages of VR include the possibility to observe and gain insight into reactions of patients to various situations and the ability to log certain behaviors. Nowadays, VR has been successfully investigated in the assessment of cognitive processing, affective responses, and social interaction in multiple psychiatric disorders.⁷ Examples include multiple specific phobias, psychosis, and attention deficit hyperactivity disorder (ADHD).⁸⁻¹⁰ Currently, only one research group used virtual environments for the assessment of obsessive-compulsive disorder (OCD),^{11,12} even though this disorder is particularly suitable for this method since it is characterized by obsessions that induce anxiety and neutralizing compulsions.¹³ To date, in

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clinical practice the symptoms of OCD are assessed by means of a clinical interview, complemented by the Yale-Brown Obsessive Compulsive Scale (Y-BOCS) as a severity measure.^{14,15}

In this pilot study, we evaluated a newly developed video VR game specially designed to provoke and assess OCD symptoms. We chose a video-based design instead of a computer-animated design to create a realistic environment and optimize the experience. The objective of our study was to evaluate if the VR game is capable of provoking OCD symptoms in OCD patients, as opposed to healthy controls. If this is the case, patients could experience their OCD symptoms in a controlled consulting room setting, which allows the clinician to directly observe and assess these symptoms, which would overcome recall and interviewer biases. We hypothesized that in OCD patients, relative to healthy controls, the items in the VR game would provoke more emotional responses and more compulsions. Since the VR game is a newly introduced method, we were also interested in possible adverse effects.

Methods

Study participants

We included eight OCD patients and eight age- and gender-matched healthy controls. Demographic and clinical data of the participants are shown in Table 1. Patients were recruited from the outpatient clinic for anxiety disorders at the Academic Medical Center in Amsterdam. Healthy control subjects were recruited through advertisements and were included if they were free of mental disorders as determined by a psychiatrist and validated with the MINI-International Neuropsychiatric Interview (MINI).¹⁶ Exclusion criteria included (a) severe neurological or cardiovascular disorders, (b) mental retardation, (c) severe comorbid axis I disorders, (d) alcohol or substance abuse during the last 6 months, (e) abnormal hearing or uncorrected vision, and (f) alcohol or recreational drug use 24 hours before investigation. Participants provided written informed consent before participation.

All included patients had a primary diagnosis of OCD according to *Diagnostic and Statistical Manual of Mental Disorders-IV* (DSM-IV) criteria using the Structured Clinical Interview for DSM-IV Axis I disorders.¹⁷ One patient had a comorbid depressive disorder, two patients a comorbid panic disorder, and one patient a comorbid body dysmorphic disorder. Five patients had symptoms in the dimension of contamination/cleaning and three patients mainly in the dimension doubt/checking. All patients performed the VR game during a

cognitive behavioral treatment; seven patients used medication at the time of participation, six patients used a selective serotonin reuptake inhibitor, and one patient used clomipramine.

VR game

The VR game was created and designed by Dr. Denys. It is a first-person perspective game based on video images where the participant walks through a house with OCD-related items. The VR game can be run on a computer screen, specifications include a Pentium 4 processor and an Intel graphics driver. At the start of the game, the written story line mentions that the house was suddenly abandoned by a family who nearly missed their flight. The doors were left open, the gas was still on, candles were burning, the table was disorganized, the sink was filthy, etc. The participant is asked to carefully check every room of the first floor of this house. In the interest of standardization and uniformity, every participant is confronted with the same OCD items in a preset order. The walk-through takes 25 minutes on average from the moment the participant enters the house. During the walk-through the participant is confronted with 15 OCD-related items (Fig. 1a, b) in different rooms. The items represent three of the most important OCD symptom dimensions, including contamination/cleaning, doubt/checking, and symmetry/ordering.¹⁸ When confronted with an OCD-related item, the participant is asked to rate emotional responses, including anxiety, tension, uncertainty, and the urge to perform a compulsion (urge to control). Subsequently, the participant has the option to dismiss and proceed or to solve the item. The items are solved by performing compulsive behavior such as washing hands or closing objects from a first-person perspective with human hands performing the action. Finally, the participant is again asked to rate emotional responses. This sequence may be repeated at each item endlessly throughout the game. Even when a participant reaches the next item, there still is a possibility to return to the previous item and perform a compulsion. We classified the actions as compulsions when they were repeated more than once.

Before performance of the VR game, trained psychiatrists obtained questionnaires, including the Y-BOCS and the MINI. A baseline rating of emotional responses was integrated in the introduction phase of the VR game. Participants performed the VR game on a Lenovo G505s laptop using a mouse and wearing a stereo headphone in a quiet isolated room.

Measures

We assessed OCD symptoms in the VR game using two parameters: (a) emotional responses when confronted with an item, by means of scores on a digital 0–10 Visual Analog Scale (VAS) expressing anxiety, tension, uncertainty, and urge to control and (b) the amount of compulsions performed at each item. The adverse effects of the VR game were assessed in OCD patients using a telephone questionnaire the day after participation, which included questions on anxiety or distress after the VR game, physical symptoms, and willingness to perform the VR game again.

Data processing and statistical analysis

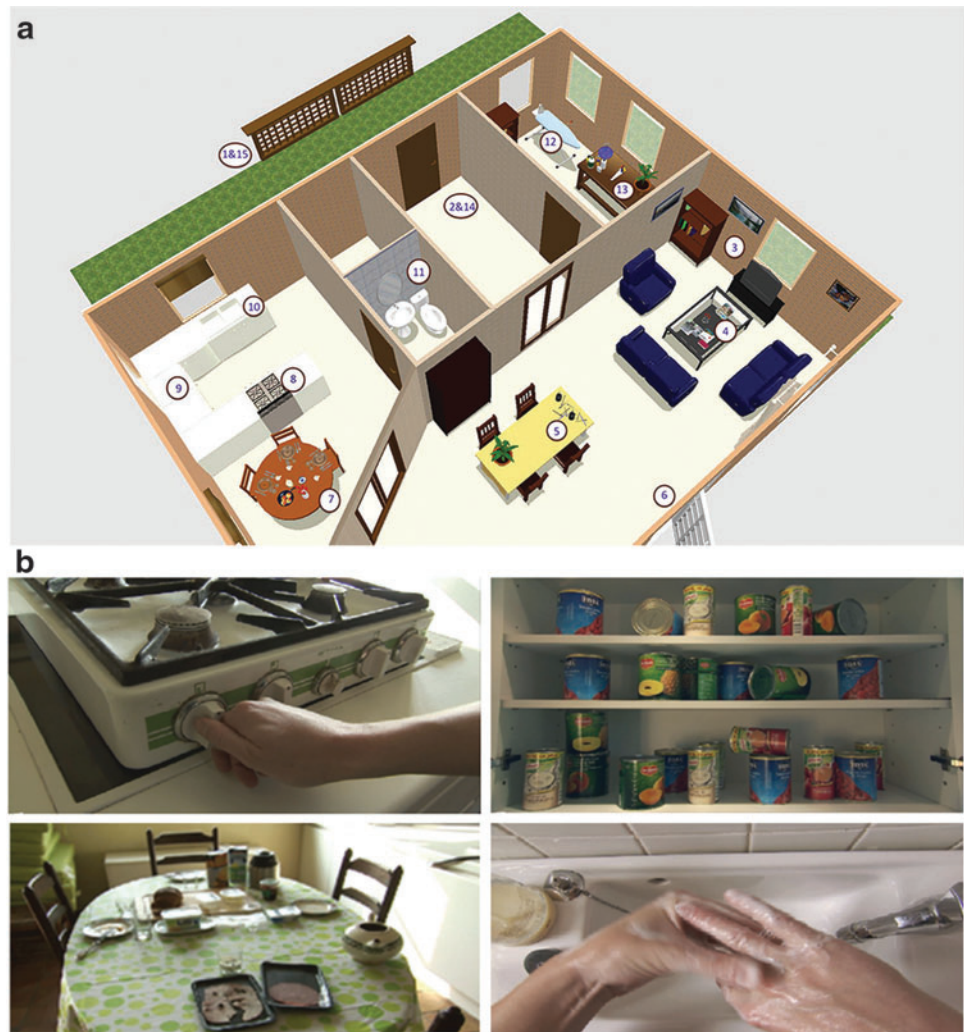
We used the Mann-Whitney *U* test to compare the age and the Fisher Exact test to compare the sex and ethnicity

TABLE 1. DEMOGRAPHIC AND CLINICAL DATA OF OBSESSIVE-COMPULSIVE DISORDER PATIENTS AND HEALTHY CONTROLS

	Patients (n=8)	Controls (n=8)	p
Age (SD), years	30.9 (7.4)	32.3 (12.6)	0.92
Male sex (%)	3.0 (38)	4.0 (50)	1.00
Caucasian (%)	7 (88)	6 (75)	1.00
Y-BOCS score (SD)	20.3 (7.9)	0 (0)	
HAM-D score (SD)	11.8 (5.8)	1.5 (2.2)	
HAM-A score (SD)	12.9 (6.0)	0.6 (1.8)	

HAM-A, Hamilton Anxiety Rating Scale; HAM-D, Hamilton Depression Rating Scale; SD, standard deviation; Y-BOCS, Yale-Brown Obsessive Compulsive Scale.

FIG. 1 (a) 3D-map of house indicating obsessive-compulsive disorder related items. 1, locking gate start; 2, locking front door start; 3, switching off television; 4, extinguishing candle; 5, organizing pencils; 6, closing window; 7, cleaning breakfast table; 8, putting off gas; 9, organizing cans; 10, cleaning sink; 11, hand washing after toilet; 12, switching off flat iron; 13, organizing hazardous substances; 14, locking front door end; and 15, locking gate end. (b) Screenshots from the VR game; running gas, nonsymmetrically ordered cans, filthy breakfast table, compulsive hand washing. (a) Created using Sweet Home 3D, Copyright © 2005–2014 Emmanuel PUYBARET/eTeks.



between the patient and healthy control group. The VR game output scores were transported to Statistical Package for the Social Sciences (SPSS) and linked to the clinical data using a standard syntax. We inspected the data manually and visualized individual output scores in graphs to describe the data. Because the data were not normally distributed, we used the Mann-Whitney U test to compare output scores of patients and healthy controls. Alpha was set at 0.05. All statistical tests were computed with SPSS for Windows 18.0 (SPSS, Inc., Chicago, IL).

Results

Anxiety, tension, uncertainty, and urge to control

Figure 2 summarizes the provoked emotional responses over all items in the VR game, compared to baseline level. As can be visualized, patients scored generally higher on all provoked emotional responses. However, no significant differences were detected yet between the patient and control group.

Figure 3 shows the average level of provoked anxiety per item in both groups (item 0 = baseline measurement). Graphs of the other emotional responses showed a similar pattern. Anxiety in the patient group fluctuated per item and was higher in all items compared to the control group.

Compulsions

In the patient group, the average number of compulsions over all items was 6.6 and varied between 1 and 14, with a maximum for any item of three compulsions. In the control group, the average number of compulsions was 1.3 and varied between 0 and 3 with a maximum for any item of one compulsion.

Comparison showed a significant difference between both groups ($U=5$, $p=0.003$). A subgroup analysis of OCD symptom dimensions showed the largest difference between patients and controls for doubt/checking items in the VR game.

Adverse events

The majority of the OCD patients (7/8) did not experience any anxiety, distress, or insomnia after performing the VR game. One patient reported anxiety after participation, caused by obsessions about contamination after touching the laptop rather than the content of the VR game. None of the patients experienced nausea and dizziness during or after participation. All patients indicated that they were willing to perform the VR game again.

Discussion

This is the first video-based VR game designed to provoke and assess OCD symptoms. As hypothesized, the number of

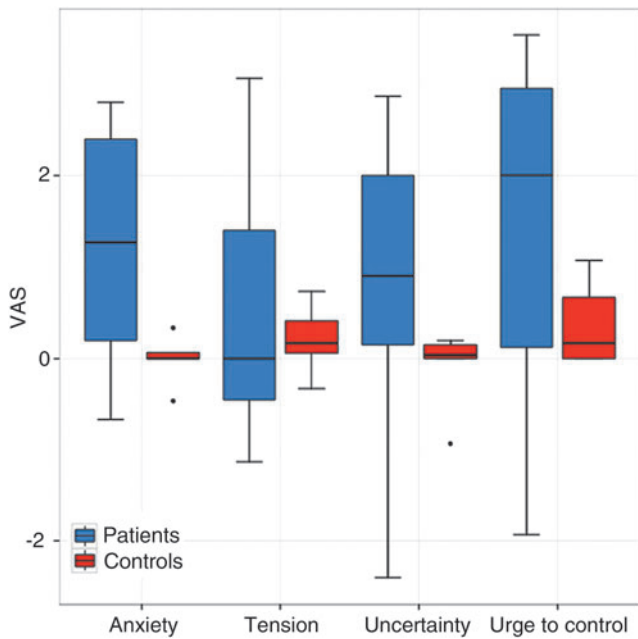


FIG. 2. Box plot of emotional responses compared to baseline during the VR game. VAS, Visual Analog Scale.

performed compulsions during the VR game is significantly higher for patients compared to healthy controls. OCD patients also show higher scores on the intensity of emotional responses compared to baseline, although significance could not yet be reached. This could be due to several factors. First, because this is a pilot study sample sizes were small. Second, OCD patients often experienced high intensity of emotional responses at baseline level due to anxiety or tension in anticipation of the game. Therefore, the increase in emotional responses compared to baseline could have turned out lower than expected. Finally, the values represent the mean over all OCD related items encountered in the VR game. OCD is a heterogeneous disorder concerning both the content of the obsessions and the emotional responses involved. Therefore,

within patients there will be variation in the intensity of emotional responses during the VR game. As expected, adverse effects of the VR game were minimal.

Our results correspond with two other studies performed by Kim et al. in 2008 and 2010. This research group developed two computer-animated virtual environments to provoke anxiety and checking compulsions in OCD patients.^{11,12} They tested anxiety in a virtual house where participants had to check everything before they left. They found that both pretest and posttest anxiety were significantly higher in the OCD group than in the control group.¹¹ Checking compulsions were tested in a virtual house and office environment. OCD patients showed a higher number of checking compulsions and duration of time spent on checking behavior compared to healthy controls.¹² Limitations of these virtual environments included being confined to one OCD symptom dimension, the use of computer animation, and the possibility of free navigation through the virtual environment leading to a lack of standardization. Nevertheless, the overlap in results between the studies confirms that VR has the potential to provoke and assess OCD symptoms.

Interestingly, a combination of high intensity of emotional responses and a lack of compulsions is frequently seen in our VR game. This possibly indicates virtual avoidance behavior. For example, a patient with severe OCD showed high intensity of emotional responses, but performed only three compulsions overall. The patient explained that she felt a strong urge to perform compulsions throughout the VR game but refrained because of contamination fear. This suggests that the VR game was able to provoke emotional responses to such an extent that OCD patients felt the need to avoid virtual situations.

The small sample size is a limitation of this pilot study. In addition, not all OCD dimensions were represented in the VR game. Although we did not discriminate based on the OCD dimension, we still found an evident difference between the OCD patient and healthy control group. This would fit the hypothesis that patients suffering from OCD, regardless of their main symptom dimension, do not tolerate uncertainty in general.¹³

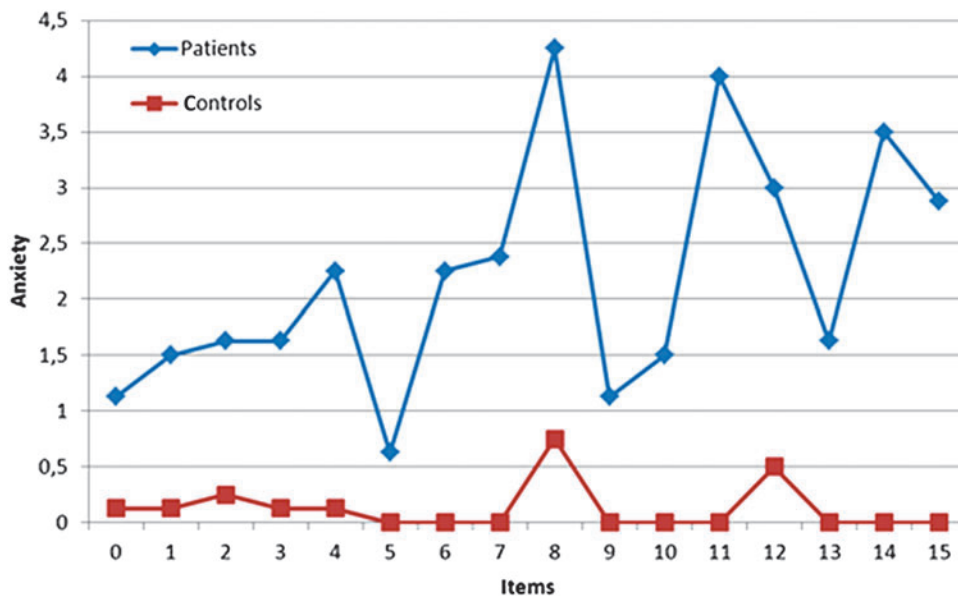


FIG. 3. Anxiety per item.

The results of this pilot study indicate that the VR game, which was tolerated well, is capable of provoking OCD symptoms in OCD patients, as opposed to healthy controls. When verified in a larger sample, the VR game will allow clinicians to directly observe and assess OCD symptoms, making it a valuable objective and standardized tool in the diagnostic process of OCD. The VR game also has potential to be implemented in the treatment of OCD, where it could facilitate “virtual exposure.” OCD patients could practice to refrain from virtual compulsions after exposure to a relevant OCD item as an interim step before exposure *in vivo*. The possibility to add or remove preset or tailor-made OCD items in the VR game in line with the OCD dimension of the individual patient would benefit this application.

Finally, this VR game represents a unique research method; underlying neurobiological and electrophysiological mechanisms can be studied when the VR game is used in combination with fMRI, EEG, or physiological measures. Thus, the VR game is a promising method for diagnostic, research, and possibly even treatment purposes in OCD.

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Author Disclosure Statement

No competing financial interests exist.

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