

# Virtual Reality Assessment for Obsessive Compulsive Disorder: A Review

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## ABSTRAK

Penggunaan teknologi berasaskan komputer termaju menjadi keperluan untuk menangani kerumitan masalah manusia yang semakin meningkat dan meningkatkan komunikasi yang berkesan. Pandemik COVID-19 baru-baru ini bukan sahaja menyebabkan banyak morbiditi dan kematian, tetapi juga meningkatkan masalah kesihatan mental di seluruh dunia. Disebabkan oleh peningkatan faedah realiti maya (VR) dalam menangani keadaan perubatan, VR dipercayai boleh digunakan sebagai alat diagnostik untuk menilai pelbagai masalah perubatan dan gangguan psikiatri. Sehingga kini, terdapat kekurangan bukti tentang keupayaan VR sebagai alat diagnostik untuk menilai gangguan obsesif kompulsif (OCD). Dalam kajian ini, kami telah menjalankan semakan sistematik untuk menyiasat penggunaan VR sebagai alat diagnostik untuk OCD dan menilai faedah dan kelemahannya berbanding dengan alat bantuan komputer. Carian komprehensif pangkalan data elektronik termasuk PubMed dan Google Scholar telah dilakukan untuk menemui bukti semakan rakan sebaya dalam menilai tugas simulasi berasaskan komputer dalam mengesan gejala OCD. Dua belas daripada 9325 kertas yang disaring telah disemak. Lima artikel melaporkan berkenaan alat berkomputer dan tujuh artikel menerangkan alat VR. Berbanding dengan tugas berasaskan komputer, kehadiran VR sebagai alat penilaian menunjukkan keputusan yang menjanjikan kerana persekitaran maya yang tertentu dan resolusi tinggi yang mampu mencetuskan gejala kebimbangan. Walaupun terdapat banyak kelemahan, penilaian masih boleh digunakan dalam bentuk berkomputer untuk mengesan dan menjana pelbagai diagnosis psikiatri di kalangan populasi umum. Walaupun tugas penilaian berkomputer dan VR menunjukkan hasil yang menjanjikan, penemuan itu tidak sekata disebabkan oleh perbezaan reka bentuk kajian, penggunaan tugas kandungan kebolehubahan yang luas, saiz sampel yang kecil, beberapa isu

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*metodologi dengan tugas berkomputer serta kekurangan kumpulan kawalan yang sesuai. Kesimpulannya, pilihan untuk menggunakan pengkomputeran atau VR untuk penilaian OCD adalah bergantung kepada matlamat, kandungan, peralatan teknikal dan bajet. Kajian yang lebih mendalam tentang isu-isu ini adalah diperlukan.*

*Kata kunci: komputer, naratif, OCD, penilaian, reality maya*

## ABSTRACT

The use of advance computer-based technology is becoming necessary to address the growing complexity of human problems and enhance effective communication. The recent pandemic COVID-19 not only induces many morbidities and mortalities but also intensifies mental health problem worldwide. Due to the increasing benefits of virtual reality (VR) in addressing medical condition, it is believed that VR can be used as a diagnostic tool to assess numerous medical conditions and psychiatric disorders. To date, there is still scarce evidence of VR as a diagnostic tool to assess obsessive compulsive disorder (OCD). In this study, we had conducted a systematic review to investigate the use of VR as a diagnostic tool for OCD and assess its benefits and weaknesses in comparison to computer-assisted tools. Comprehensive searches of electronic databases including PubMed and Google Scholar were undertaken to discover peer review evidence of computer-based simulation tasks in detecting OCD symptoms. Twelve out of 9325 papers were screened and reviewed. Five articles reported on computerised tools and seven articles described VR tools. In comparison to computer-based tasks, VR is a promising assessment tool due to specific virtual environments and high resolutions which are able to induce anxiety symptoms. Despite numerous shortcomings, assessment can be utilised in computerised form to detect and generate a variety of psychiatry diagnoses among the general population. Although computerised assessment task and VR show promising results, the finding are uneven due to study design differences, wide variability content task use, small sample size, several methodological issue with the computerised tasks and lack of appropriate control groups. In conclusion, the choice to use computerisation or VR for OCD assessment will depend on aim, content, technical equipment and budget. More in-depth studies of these issues are required.

Keywords: computer, OCD, virtual reality, narrative, review

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## INTRODUCTION

Obsessive compulsive disorder (OCD) is a chronic neuropsychiatric disorder

that affects millions of people worldwide (Banerjee 2020). This disorder affects not only the individual's social life and occupational functioning, but

also increases burden of care (Steketee 1997; Subramaniam et al. 2013). The OCD has also been associated with psychiatric comorbidities (Sharma et al. 2021). Tactful identification can help in designing an effective intervention to manage this disorder, especially during the COVID-19 pandemic. In a Canadian online survey during early COVID-19, 60.3% of respondents reported developing OCD symptoms were often in stress situations, and 53.8% exhibited compulsions to wash their hands (Abba-Aji et al. 2020). COVID-19's effects on OCD not only caused an increase in contamination worries and stress, but also worsened OCD symptom dimensions, such as an increase in compulsive washing (Khosravani et al. 2021; Liu et al. 2021). Additionally, the pandemic affected treatments in hospitals and other medical facilities. Appointments were often postponed for months, lowering the efficiency of communication between patients and clinicians and increasing patients' vulnerability to stress, posing a hindrance to their treatment and support to families (Liu et al. 2021). There is increasing demands and queries for the use of suitable technology that is able to improve in detecting other OCD symptoms during COVID-19 period and enhance the continuity of the existing management care during the pandemic.

One powerful invention of technology is computer-based tools that are now distributed in the form of desktop and mobile or smartphones. Both types require a motherboard and power supply as well as random access memory (RAM), hard disk

drive, video card, optical drives and input (touch pad, webcam) (Riedel et al. 2001). Compared to smartphones or tablets, computers have more RAM and larger data storage, which increases the speed and allows more advanced software to be installed (Kuehr & Williams 2007; Riedel et al. 2001). Computer functionality has been expanded with a wide range of devices (head-mounted displays, audio and haptic device), enabling a computer-generated environment or virtual reality (VR) that is powerful for users to immerse in and interact with virtual windows that look, feel and sound realistically as actual scenario (Bamodu & Ye 2013). The complexity of computer invention, especially VR (Guze 2015), nowadays has widely used by medical experts due to strength of computer environment that mimic the real surroundings as large part of psychological intervention for psychiatric disorders which the clinician can personalise to individual needs (Park et al. 2019). Nonetheless, there is little information on the role of VR as a diagnostic tool.

Obsessive compulsive disorder is a long-term condition marked by persistent obsessions and compulsions. Type of obsessions included contamination, hoarding, symmetry, organising, sexual and religious obsessions. In order to reduce the obsession, an individual tends to perform compulsion such as counting, checking and other similar activities (Hasler et al. 2005). For traditional assessment or screening method, OCD can be diagnosed using clinician diagnostic questionnaire or self-report

questionnaire, which has strong psychometric properties (Goodman et al. 1989; Sheehan et al. 1998; Storch et al. 2010). Some questionnaires had been built in computerised form since 1990s and it was supported the suitability of computer in assessing OCD (Baer et al. 1993; Herman & Koran 1998; Marks et al. 1998; Roca-Bennasar et al. 1991; Rosenfeld et al. 1992). Roca-Bennasar et al. (1991) published first Kraepelin application, a measure for OCD symptoms using a computer. The application included 50 natural language based questions and 155 reasoning principles. However, it was not widely accepted by the users, as admitted by the authors, due to its difficulty to understand besides lacking publications to replicate the findings (Roca-Bennasar et al. 1991). The Yale-Brown Obsessive-Compulsive Scale (YBOCs) is a gold standard paper pencil questionnaire, when computerised, it produced good results compared to that of using the clinician version (Rosenfeld et al. 1992). User rated the computerised version of YBOCs as friendly and easy to use, and subsequently was used in palmtop computers (Herman & Koran 1998). Another computer program known as BT STEPS (computerised program), which combined the OCD computerised assessment and treatment, showed an 84% completion rate of assessment (Marks et al. 1998). All these findings not only provided evidence that computerised assessment had good psychometric properties similar to paper and pencil questionnaires; but also caused subjects to be less anxious as a result

of answering the assessment, besides usable among all populations and educational backgrounds (Sederer 2002). Computerised assessment can standardise administration and scoring systems, and provide feedback in the form of reports that may ease the clinician's job (Cantillon et al. 2004). Common criticisms include that the test is concluded into a score and has little generalisability to real problem, and lacks of clinical judgement as well as high costs, slowing the development and growth of computerised forms in assessing OCD symptoms (Dawes et al. 1989; Yates & Taub 2003). Self-reports or online surveys were found to be insufficient in detecting mental illness symptoms and objective professional testings. Diagnostic tools are crucial to make a conclusive diagnosis (Agyapong et al. 2016). Therefore, an effective testing medium is needed especially during pandemic restraints that able to increase efficiency and instrument validity and test content resulting in better mental health assessment in the OCD community (Sunderland et al. 2017; Yates & Taub 2003; Bloch et al. 2021). Moreover a valid assessment should be conducted in ethical protocol without jeopardising anyone's health as the OCD symptoms may have been worsen due to COVID-19 pandemic (Stifel et al. 2020).

Virtual reality has been suggested as an useful tool to overcome this problem, since a virtual environment has more ecological validity and may be utilised to establish a standardised and controlled environment in which symptoms can be elicited and monitored concurrently, as compared

to computerised assessment (Van Bennekom et al. 2021). Behavioral assessments are particularly valuable in measuring human behavior because they include both direct observation and a measure of performance which can be incorporated and tested with VR (Roh et al. 2013). Computerised tasks, with or without environmental situations, can help with the diagnostic process by collecting all relevant data in a systematic manner and prioritise a clinician's time by forming an educated initial diagnosis to the first contact with the patient (Handal et al. 2018). In comparison to other method assessment, precise and consistent presentation of test stimuli can be built in VR as well as sensitivity of the test can be adjusted according to OCD symptoms and pandemic surroundings (Parsons & Phillips 2016). Furthermore, virtual evaluations can be incorporated into adaptable assessment batteries tailored to each participant within the context of the presenting question. Through virtual environments, the clinician has more control over dynamic perceptual stimuli and the test's sensitivity while simultaneously collecting data based on the client's performance in everyday activities (Parsons & Phillips 2016).

Other research has documented the use of VR to assess and assist the treatment of medical condition (Dascal et al. 2017) as well as psychiatric disorders such as schizophrenia (Keefe et al. 2016), social anxiety and others (Dechant et al. 2017; Sorkin et al. 2006). As limited information was found on the use of VR in screening or assessing OCD patients. The present study

attempted to provide a review of the role of VR in assessing OCD symptoms in comparison to computer assisted screening tools. Our research questions included; (i) whether VR was more useful for psychological screening in patients with OCD and less side effects than computerised assessment; (ii) it was critical to consider the potential negative effects (e.g., dizziness, sickness, and displacement) in order to ensure that wearable technologies (e.g., HMDs) were acceptable for all age groups and diverse disabilities (Meyerbröcker & Morina 2021; Parsons & Phillips 2016) and; (iii) practicality aspect before adopting this method of assessment. Few studies stated no psychological side effect following VR or computerised assessment (Keefe et al. 2016; Maples-Keller et al. 2017; Welch et al. 2019). Other researcher believe there is still a risk of unanticipated negative consequences following exposure with virtual environment (Bisso et al. 2020). It is stated that if the stimulus intensity is increased too much, it can exacerbate and may exhibit more negative behaviors rather than alleviate a deficit among the people with psychiatric problems (Bisso et al. 2020). This review helped clinicians to develop an innovative technology assessment for OCD tailored to personal individual and unique cultural aspects and help in designing an effective intervention. There is a larger number of undetected or untreated individuals with mental illness worldwide which could have been increased during the pandemic (Stahnke 2021; Pfefferbaum & North 2020). This should be addressed with

appropriate screening technology tools.

## MATERIALS AND METHODS

Article searches were performed using electronic databases, including PubMed and Google Scholar. PRISMA principles were used to guide the search technique (Page et al. 2021). The search was conducted using PubMed to include articles that were published between January 31, 2012, and up to January 2022. Keywords were entered as follows; (computer) OR (computerised) AND (assessment) OR (evaluation) AND (virtual reality) AND (OCD) OR (obsessive compulsive disorder). Full-text original research articles that were published, accepted for publication, or available online in English meet the qualifying criteria (i.e. not case reports, case studies, letters to the editor, or review articles, including narrative, systematic reviews, and meta-analysis). These review articles were not included in the data extraction process, but were utilised as references in the search. Patients with other neurodevelopmental, psychiatric, or neurological diseases (such as autism, bipolar disorder, and traumatic brain damage) without mentioning OCD were also excluded from studies. Randomised control trials and VR intervention studies were also excluded from studies. This search was carried out by two independent researchers where they removed papers that did not meet the predetermined eligibility criteria during the research selection procedure. This procedure was followed in order, starting with the

title, then the abstract and lastly the whole content. Moreover, the included publications' references were retrieved from Google Scholar and evaluated for new eligible research to ensure that no relevant studies were left out. Any discrepancies in the review outcomes were settled through consensus by the third researcher. Both computerised and VR as assessment tools from narrative research might have some differences in terms of different methodology during assessment, and slight differences in terms of the contents of the assessment and measures used.

## RESULTS

Out of a total of 9325 studies, 9150 studies were removed based on title. A total of 175 studies were screened based on the abstract. Subsequently, 160 studies were excluded due to review, due to having no indication of computerised assessment tool, VR or using only paper and pencil self-reports. A total of 15 studies were evaluated and screened for full text eligibility and three studies were eliminated due to describing VR as intervention. Finally, 12 selected articles with 5 reported articles on computerised tool and 7 articles from VR tool were included (Figure 1).

### Computerised Assessment

Based on Table 1, five studies had provided evidence on the potential of assessing OCD symptoms via computer (Handal et al. 2018; Roh et al. 2013; Simon et al. 2012; Sunderland

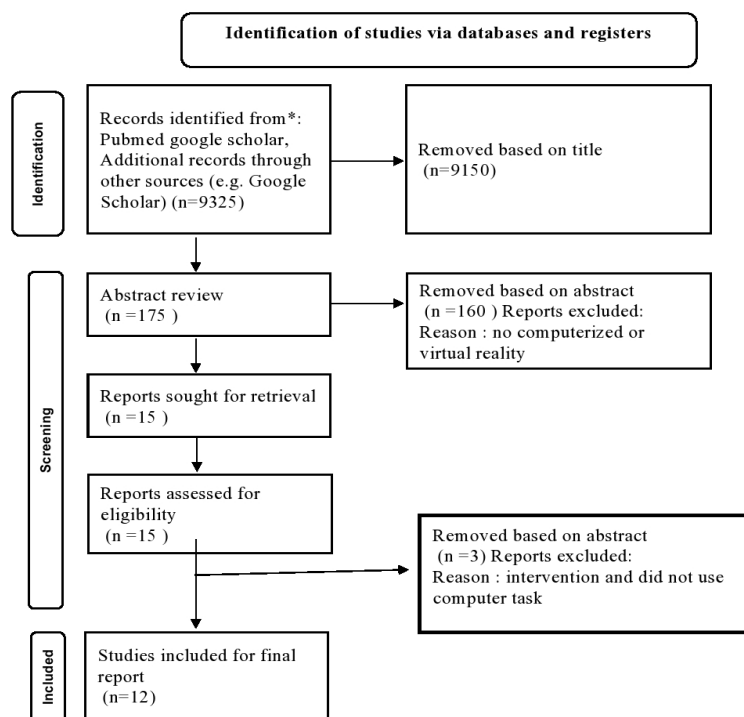


Figure 1: The PRISMA - compliant search process for studies included in the current systematic review

et al. 2017). Three studies focused on OCD symptoms using either validated behavioral assessment task or with pictures as well as films or videos. The other two used a new online survey via a computerised task that was able to generate score for multiple domain of psychiatric disorder on healthy population. All assessments were validated and found to be correlated with various self-report questionnaires. None of the studies considered adverse effects following exposure to the computerised assessment task

In term domain, two studies focused on the commonest OCD themes, specifically checking (Roh et al. 2013) and symmetry, while the seven general OCD themes were stated in

one study (Simon et al. 2012). Roh and team (2013) employed the only computer-simulated environment with concept of draw, redraw object animation where they provoked OCD with subtype of symmetry among healthy subjects. They found that a computer-simulated environment was validated and correlated with ordering symptoms assessed by obsessive compulsive inventory-revised (OCI-R). Simon and team (2012) utilised pictures and films consisting of OCD triggers and presented in computerised form to provoke OCD symptoms. They found that by higher anxiety that associated with symptom greater in OCD patient than in healthy people. Furthermore, patient performance on OCD picture

Table 1: Computerised assessment studies

Description	Studies				
	(Roh et al. 2013)	(Simon et al. 2012)	(Bernstein et al. 2017)	(Sunderland et al. 2017)	(Handal et al. 2018) USA
Aim of study	Assess psychometric qualities for objective and quantitative measurement of symmetry and arranging-related obsessive symptoms	Validate a set of pictures and films comprising a variety of prominent OCD triggers that can be used for individually tailored symptom provocation in experimental studies	To discover and quantify behavioral markers in OCD youth versus healthy adolescents controls	Planned to utilize computer simulations to estimate the efficiency versus precision of an adaptive test based on multidimensional IRT.	CliniCom™ Psychiatric Assessment Software was tested for its specificity and repeatability in diagnosing five common mental health problems.
Subject (patient/control)	35 college students	13 OCD patients and 13 healthy respondents	18 youths with OCD and 21 matched healthy controls, ages 5–17	3,175 respondents to an online survey	222 First-time, self-referred patients
Session	In a counter-balanced order, four separate computer-simulated environment activities were provided. After practice, the participant were test with behavioral assessment task	Set of pictures and films comprising a variety of prominent OCD triggered anxiety, aversiveness and arousal during exposure to OCD-relevant, aversive and neutral control stimuli.	Record their behavior during three tasks. Each video was cropped in time to include only the activity of interest and to spatially center the child engaging in activity	Online survey	Online assessment
Domain	Symmetry and arranging behavior	OCD triggers- aggressive obsessions, religious washing, checking, symmetry/ordering, hoarding and counting	Ordering/ repeating	Generalized anxiety, depression, obsessive-compulsive disorder, panic disorder, social anxiety disorder	Generalized anxiety, depression, obsessive-compulsive disorder, panic disorder, social anxiety disorder
Software Availability/systems	Computer-simulated environment	Computer based task	Computer vision tool	Multidimensional computerized adaptive test (CAT), derived from IRT models	Web based psychiatric assessment (CliniCom™ Psychiatric Assessment Software)
Hardware Requirements	A computer and mouse for virtual object rotation and movement	- photographs (image size: 1024 x 768 pixels; Sony cyber shot digital camera)	1) Five GoPro cameras to record patients behavior 2) Video recorder	-	Not mentioned
Resolution	-	-	-	-	-
Field of View	-	-	-	-	-



Description	Studies			
	(Roh et al. 2013)	(Simon et al. 2012)	(Bernstein et al. 2017)	(Sunderland et al. 2017) (Handal et al. 2018) USA
User Interaction with VR	-	-	-	-
Outcomes	No significant main effect of distraction on task Good correlation detected between task performance and both the SOAQ and the OCI-R "ordering" subscale. CliniCom assessment able to determine a patient's type and severity of psychiatric illness.	OCD patients differed in their ratings for OCD stimuli from healthy controls. Correlational analyses demonstrated greater relationships between OCD questionnaire subscales and anxiety to corresponding OCD stimulus categories than to non-matching categories, demonstrating the specificity of certain OCD-relevant triggers to induce symptoms in specific patient subgroups. Validated; No ecological assessment	Using video recorded, result of time spend of object ordering and longer duration time of washing positively correlated with CY-BOCS ordering/repeating dimension scores	Bifactor model with one general and five specific factors produces comparison with the IRT models Any effect of multidimensionality on OCD was minimal and the OCD items could be sufficiently modeled using a single OCD factor
Psychometric properties	Convergent and discriminant validity; No ecological assessment; high level of reliability as evidenced by an overall concordance level of 78% when administered twice in the same patient	Validated; No ecological assessment	No ecological assessment; Perform discriminant validity	High level of reliability as evidenced by an overall concordance level of 78% when administered twice in the same patient; No ecological assessment
Side effect	-	-	-	-
<p>Note : - Not mentioned; CY-BOCS=Child Obsessive-Compulsive Impact Scale-Revised; MAS-C-2=Multidimensional Anxiety Scale for Children-2; GAD=Generalized Anxiety Disorder Factor; PHQ9=Patient Health Questionnaire; SOCS=The Short OCD Screener; PADIS=The Panic Disorder Screener; SOPHS=Social Phobia Screener; VOCL=Vancouver Obsessional Compulsive Inventory; HAM-A=The Hamilton Anxiety Rating Scale; Spin=Social Phobia Inventory (SPIN); NEBA=Neuropsychiatric Electroencephalogram-Based Assessment; Obtest=device used for assessing the core symptoms of ADHD; SOAQ=Symmetry, Ordering and Arranging Questionnaire; OCI-R=Obsessive Compulsive Inventory-Revised; BDI=Beck Depression Inventory; BAI=Beck Anxiety Inventory; BIS-11=Barratt Impulsiveness Scale-11; WHOQOL=World Health Organization Quality of Life Scale; IRT=item response theory</p>				

and film correlated with performance in the self-report questionnaire (Simon et al. 2012). Similar with Simon study, Bernstein et al. (2017) applied computer vision tool to monitor OCD behavior and validate the outcomes with standard clinical measures among OCD youth (Bernstein et al. 2017). Using video recordings, the results of time spent on object ordering and longer duration time of washing positively correlated with CY-BOCS ordering/ repeating dimension scores (Bernstein et al. 2017). In contrast to other studies focused on detecting obsession, where OCD stimuli was used to induced anxiety, Bernstein and team implemented video recording to capture compulsion behavior as target assessment rather than provoking anxiety. Three studies did not specific any software and hardware requirement needed for the study, making questionable replication (Bernstein et al. 2017).

Sunderland and teams (2017) designed and validated a new computerised adaptive test (CAT) using to assess generalised anxiety, depression, OCD, panic disorder and social anxiety disorder. Based on computer stimulation of 3,175 healthy respondents, an adaptive algorithm was created with an average 44 items in comparison with the full 133-item bank to generate general internalising and specific disorder scores. This CAT scores also showed convergent and divergent validity when compared to previously validate short severity ratings, and they can be used to distinguish cases of DSM-5 illness (Sunderland et al. 2017). In contrast to

Sunderland study, Handal et al. (2018) utilised software namely as CliniCom™ Psychiatric Assessment Software, an Online Mental Health Assessment Tool that screened various type mental disorder at one time for an individual. This demonstrated that online assessment tools such as CliniCom™ Psychiatric Assessment Software produced plausible opportunity to assess specific psychiatric conditions (Handal et al. 2018). Based on their objective, both of these studies used a computer to screen and created profile psychiatry disorders in the community, which suggested that there was a need in developing a software that able to screen OCD symptoms.

In term assessment using VR (Table 2), three studies from Korea, two studies from the Netherlands and one study in Canada supported that VR assessment had good ecological validity findings (Inozu et al. 2021; Kim et al. 2008; Kim et al. 2010; Kim et al. 2012; McCabe-Bennett et al. 2020; van Bennekom et al. 2021; van Bennekom et al. 2017). Target assessment involved contamination obsession, checking behavior and hoarding behavior. Only two studies utilised big resolution and IBM compatibility as well as computer accessories such as speakers and head mounted displays to assess OCD checking and hoarding behavior (Kim et al. 2010; McCabe-Bennett et al. 2020). Kim and team utilised IBM compatible hardware as well as computer accessories such as speakers and head mounted displays, but they did not specifically state the resolutions used in the study for comparison purposes (Inozu et al. 2021; Kim et al.

Table 2: Virtual reality assessment

Description	Studies						
	Kim et al. 2008	Kim et al. 2010	Kim et al. 2012	van Bennekom et al. 2017	McCabe-Bennett et al. 2020	Inozu et al. 2021	Van Bennekom et al. 2021
Aim of study	A preliminary test of a virtual reality (VR) anxiety-provoking tool using a sample of participants with obsessive-compulsive disorder (OCD)	Determine VR as a tool for evaluating compulsive checking behavior in OCD patients and relating task performance to self-reported and clinician-rated OCD symptoms	To see if a new computer-based behavioral evaluation could tell the difference between checking behavior and non-checking behavior in adults with OCD.	To determine whether video VR game to provoke and assess obsessive-compulsive disorder (OCD) symptoms in a standardized	To investigate group differences in perceptual and physiological responses to virtual reality cluttered surroundings, clutter preferences, and claustrophobic concerns	To test if our virtual reality video game is capable of eliciting and measuring OCD symptoms in patients when compared to healthy controls	To test if our virtual reality video game is capable of eliciting and measuring OCD symptoms in patients when compared to healthy controls.
Subject (patient/control)	33 OCD patient and 30 healthy control group	30 adult OCD and 27 healthy subjects	22 OCD patients with compulsive checking behaviors (OCD checkers), 17 OCD controls without checking behavior (OCD controls), and 31 healthy controls (HCs)	8 subject OCD and 8 subject healthy adults	36 hoarder and 40 without hoarder symptoms	26 OCD patients and 26 healthy controls	26 OCD patients and 26 healthy controls
Domain	Checking	VR-based behavioral task, specifically for compulsive checking behavior	cChecking	OCD symptom dimensions, including contamination/ cleaning doubt/checking, and symmetry/ordering	Hoarding behavior	Contamination	Contamination

		Studies					
Description	Kim et al. 2008	Kim et al. 2010	Kim et al. 2012	van Bennekom et al. 2017	McCabe-Bennett et al. 2020	Inozu et al. 2021	Van Bennekom et al. 2021
Session	There were three phases to the virtual environment: training, diversion, and the final phase. Participants were free to check (a frequent OCD habit) after the training and distraction periods, just as they would in the real world.	Three consecutive phases of the task: (1) training, and (2) distraction and (3) main test	Three consecutive phases of the task: training, distraction, and main phase	Every room on the first level of this residence must be thoroughly examined by the participant. The same OCD items were shown to each participant in a predetermined order. From the time the participant entered the residence, the walk-through took on average 25 minutes. The participant was confronted with 15 OCD-related items during the walk-through. The individual was then asked to score their emotional responses, such as anxiety, tension, uncertainty, and the desire to perform a compulsion (urge to control)	After spending more or less 5 minutes acclimating to the VR and observing a virtual room that was identical to those utilized in the future testing phase, a baseline SUDS rating was acquired. Then, in 20-second intervals, they experienced each of the nine VR rooms mentioned above and supplied current SUDS ratings. They were then given the choice of reviewing the sequence of VR crowded rooms and selecting their favorite. The following tasks were then completed by the participants.	The VR game includes the OCD subtypes contamination fear and cleaning compulsions, doubt and checking compulsions and symmetry obsessions and ordering compulsions.	The VR game includes the OCD subtypes contamination fear and cleaning compulsions, doubt and checking compulsions and symmetry obsessions and ordering compulsions.
Software Availability/ systems	Environments resembled the average Korean home and were designed to induce the checking impulse	3D-MAX (Discreet, Autodesk, Montreal, Canada), were converted to A6 GameStudio Engine (Conitec, Germany)	Computer-based assessment of checking behavior virtual environment specifically ordinary home environment	Game based video images where the participant walks through a house with OCD-related items	Dell Alienware X51 running Windows 10, with an Intel Core i5-6400 (3.3 GHz speed) and 16GB DDR4 RAM.	4 virtual environmental head-mounted display and handheld tracking controllers.	VR video game simulation to provoke anxiety when user walk through the house

Description	Studies						
	Kim et al. 2008	Kim et al. 2010	Kim et al. 2012	van Bennekom et al. 2017	McCabe-Bennett et al. 2020	Inozu et al. 2021	Van Bennekom et al. 2021
Hardware Requirements	An IBM-compatible computer and an SVGA color head-mounted display with a 3-degrees-of-freedom tracker were used for testing and a speaker for auditory feedback	An IBM-compatible computer; an SVGA color; HMD with 3-df tracker standard joystick (Microsoft, Redmond, WA) and tracker (Intersense, Bedford, MA); speaker	IBM-compatible computer and an SVGA color; Head Mounted Display (HMD). Participants received auditory feedback from a computer-connected speaker.	Run on a computer screen, specifications include a Pentium 4 processor and an Intel graphics driver. Lenovo G505s laptop; a mouse and a stereo headphone	Oculus Rift consumer-release version head-mounted display (HMD), model number 301-00200-03; Nvidia GeForce GTX 970 with 4GB GDDR5 RAM	-	The VR game provokes more OCD symptoms in patients compared to healthy controls; The severity of VR game provoked symptoms correlates with severity of OCD symptoms.
Resolution	-	High resolution graphics, dynamic light, and 3-dimensional	-	-	1,080 in resolution, 90 Hz refresh rate, and six degrees of freedom	-	
Field of View	1 <sup>st</sup> person perspective view	1 <sup>st</sup> person perspective view	1 <sup>st</sup> person perspective view	1 <sup>st</sup> person perspective view	-	-	
User Interaction with VR	A joystick and tracker to move through the virtual environment	High (using a joystick)	High (head tracker & joystick)	-	Series of 360 photographed environments of the same living room that became progressively more cluttered over nine images, mimicking the CIR	-	
Psychometric properties	-	Construct validity tested- correlation with Yboocs scale; Good ecological assessment	Test-retest reliability of response not mentioned; Good ecological assessment	-	-	-	
Side effect	--	-	No side effect	-	-	-	

		Studies					
Description	Kim et al. 2008	Kim et al. 2010	Kim et al. 2012	van Bennekom et al. 2017	McCabe-Bennett et al. 2020	Inozu et al. 2021	Van Bennekom et al. 2021
Outcomes	OCD had significantly higher anxiety in the virtual environment than did healthy controls, and the decreased ratio of anxiety in participants with OCD was also higher than that of healthy control and correlated with r symptom score and immersive tendency score. e OCD group revealed significantly longer checking time than did control	Patients with OCD reported a considerably higher frequency of checking behaviors than HCs (3.88 times in OCD; 0.96 times in HC);	OCD checkers demonstrated longer duration of checking behaviors than OCD controls or HCs.	OCD patients also showed higher scores on the intensity of emotional responses compared to baseline	The hoarding group preferred slightly more cluttered VR settings, but they also had a higher level of claustrophobic dread than the control group	The VR tasks successfully induced anxiety, disgust, and the urge to wash in both the HCF and LCF groups.	Higher levels of VR-provoked anxiety (U = 179.5, p = 0.004) and compulsions in OCD patients compared to healthy controls (p = 0.001).
Note : - Not mentioned; VR=virtual reality; Y-BOCS=Yale-Brown Obsessive Compulsive Scale; ITQ=The Immersive Tendency Questionnaire; BAI=Beck Anxiety Inventory; GAF=Global Assessment of Functioning; STAI=The Spielberger State-Trait Anxiety Inventory; PWSUR=The Padua Inventory-Washington State University Revision; PQ=The Presence Questionnaire							

2009; Van Bennekom et al. 2021; van Bennekom et al. 2017). All assessments utilised specific software designed by the researcher of study as well as an interactive method provided using joystick and head tracker which able to make participants highly connected and immersed in the virtual environment. Only one study (van Bennekom et al. 2017) assessed the side effects of this VR as assessment tool, which was difficult since all the studies utilised different procedures. In addition to this, a majority of study showed good ecological assessment; however, whether there was a practice effect associated with patient performance was not explored.

The assessment for checking behavior begin after practice with the task, and participants were free to check (a frequent OCD habit) after the training and distraction periods, just as they would in the real world. This VR behavioral assessment was able to induce anxiety among OCD patients, as well as differentiate between OCD checker with OCD patient and healthy control. Using their real-world office contexts, fewer OCD participants (n = 11) reported obsessive checking desires, whereas more OCD checker (n = 22) reported compulsive checking urges in their real-world home environments. This supported personalised and ecological assessment for OCD. They also found that positive correlations between task performance and both self-reported and clinician-rated measures revealed construct validity with the higher checking behavior, longer gazing time and longer path taken during task

completion, with the users able to achieve navigation through two virtual environments using joystick and head-mounted display.

In 2021, van Bennekom et al. (2021) tested a novel game virtual environment in a pilot study to achieve high immersion. Throughout the experiment, they found that VR elicited an emotional response as Subjective Units of Distress Scale (SUDS) which was rated higher in OCD patients compared to healthy people. Their earlier study also shows no side effects following VR assessment.

A study from Turkey in which the researcher adapted a western scenario to assess contamination OCD found VR assessment induced higher contamination fears in high contamination OCD than low contamination OCD (Inozu et al. 2021). It was not only VR able to develop good ecological validity, it was also able to differentiate performance between high and low contamination OCD among OCD patients (Inozu et al. 2021).

## DISCUSSION

In comparison to computer-assisted screening tools, the current paper examined the role of VR in assessing OCD symptoms. Based on the review, both computer-based assessment tasks and computer generate stimulation were able to assess OCD symptoms. Virtual reality is suggested as a more promising tool to be used to assess anxiety associated with OCD symptoms as compared to computer-based tasks due to the tasks

resembling real-life situations. Using the behavior assessment paradigm, virtual environments can be designed and tailored to specific symptoms such checking, contamination and hoarding, personalised to individual needs and customised to certain cultural and religious aspects. Virtual reality not only gives the user the ability to interact with stimuli using joysticks and high-resolution features with appropriate sound presented in speakers; it enables the individual to be immersed and presence in the surrounding similar with real life situation (Nazemi & Gromala 2012). It had been found that the size and quality of the display had a substantial impact on task completion time, with the greatest results coming from a large, high-resolution monitor (Bowman & McMahan 2007). Virtual reality offers an exact measurement of performance on a controlled and virtual environment by quantifying patterns of behavior task that can be repeated compared to computer-based task (Kim et al. 2010). Instead of using the same behavior assessments for all OCD patients, VR-based behavioral assessment allows individuals to create personalised virtual worlds (Kim et al. 2010). A recent study of accessing OCD using video games showed that VR game was capable of provoking more anxiety and virtual compulsions in patients with OCD compared to healthy controls and monitored patients' responses to intervention (van Bennekom et al. 2017). Incorporating real situations or surroundings; using 8GB RAM for headset monitor higher total pixel count, and usually at higher refresh rates; body or head tracking the

viewers' eye points' dynamic optical location; and physically precise stereo perspective viewing matrices support the benefits in using VR more than a computer screen alone (Deering 1992).

It is interesting to note that healthy participants were used to test suitability of computer-based tasks to generate profile psychiatric symptoms rather than tested by psychiatry who questioned the psychometric properties of the questionnaire (Handal et al. 2018; Sunderland et al. 2017). Reliability and validity (psychometric properties) are crucial elements that determine the suitability of a questionnaire or assessment to be used to diagnose a disorder. Ecological validity refers to the ability of a study's findings to be used in naturalistic contexts, such as therapeutic practice in everyday life (Andrade 2018). This validity has two types, namely veridicality and verisimilitude (Parsons 2015). Veridicality is defined as the ability of a patient's performance on a construct-driven test to anticipate some aspect of the patient's day-to-day functioning, as indicated in some of studies which was reviewed in this study. The requirements of a measure and the testing conditions should be similar to those found in a patient's daily activities; this is known as verisimilitude (Parsons 2015). A majority of studies that have been reviewed described as valid indicate a correlation between behavioral performance with OCD questionnaires, as well as similar with patients' real-life situations (Kim et al. 2008; Kim et al. 2010; van Bennekom et al. 2017) supporting both ecological, convergent and discriminant validity

(Parsons 2015). Only one study adapted a western virtual scenario to assess contamination and finding showed similar ecological validity (Inozu et al. 2021). A meta-analysis study which compared between VR assessment (Virtual Reality Classroom Continuous Performance Test) with traditional continuous performance tests (CPT) among Attention Deficit Hyperactive Disorder (ADHD) patient, it is showed that, virtual classroom CPTs appear to be successful in distinguishing persons with ADHD than a traditional CPT test approach (Parsons et al. 2019). Furthermore, the testing conditions which are similar to those encountered in the real world (verisimilitude) indicated Virtual Reality Assessment had good ecological validity (Franzen & Wilhelm 1996; Parsons et al. 2019). In another study, although Virtual Apartment Stroop tasks had good construct validation, it failed to show divergent validity with no correlation with California Verbal learning test (Parsons & Barnett 2018). Furthermore when compared to computerised Stroop tasks, Virtual Apartment Stroop had similar traditional test modalities and better reaction time accuracy that was able to differentiate between *prepotent* response inhibition and distractor inhibition resistance among college students (Parsons & Barnett 2018). Construct validity was commonly used to assess the validity of computer-based questionnaire (Huff & Sireci 2001). Opposite to ecological validity, construct validity determines the new scale's relationship to other variables and measures of the same construct through correlation result



the new scale with other measures (Loewenthal & Lewis 2018). Rabin et al. (2007) stressed that some OCD measures are still based on antiquated technology (e.g., paper and pencil tests; static stimuli) that have yet to be verified in terms of real-world performance (Rabin et al. 2007). According to Parson (2015), several studies have sought to verify the validity of these settings by comparing them to well-established paper and pencil as well as computer automated platforms and the results showed that they must be used with caution. The degree to which virtual environments offer less expensive method and modalities that are free of technology and simulator sickness issues must be carefully examined by researchers if VR is to be used as a diagnostic tool (Parsons 2015).

In addition to this, although VR is thought to be a better tool to assess OCD behavior and performance due to the immersed environment, the results of virtual studies are difficult to compare due to variability of method used, cultural elements and OCD subthemes. A majority of samples are small, bringing into question the generalisability of the findings. Little information regarding to the side effect of VR in assessing OCD symptoms. Only one study included the side effects on VR where they found that no side effects despite OCD patients also showed higher scores on the intensity of emotional responses compared to baseline (van Bennekom et al. 2017). In addition, no available information of VR to assess OCD in religious, sexual or homicidal symptoms which are

common in Asia country and hard to detect. Furthermore, suitability of the immersive, semi-immersive or fully-immersive simulations in detecting OCD symptoms are needed in future study. As stated by one researcher, computational psychometrics encompasses all psychological measurements with advanced methods and tools, including computer-based tests, VR, psychophysiological recordings, computerised behavioral analysis, social network analysis, simulation-based methods and other modeling science are crucial during the COVID-19 (Cipresso & Riva 2015). There is a need to understand underlying levels and processes that allow usage of developing technologies (Cipresso & Riva 2015). Based on the review, there was a wide variety of softwares were utilised with no standard equipment procedure had been developed, posing difficulties for replication as well as bringing questionable generalisability to other cultures and religions.

Although computers have been used in many health managements, the efficacy of computers as a tool for detecting and managing illness is still limited. Possible explanation for this, a lot of financial is needed as wide range of multiple disciplines and expertises are needed, as well heterogeneity and course of the illness and large sample size is needed to support the efficacy of computer stimulation-based task for health management. More reliable, cost effective and acceptable in terms of size and appearance will produce an effective VR testing. It is also crucial to determine the tolerability of VR among

OCD patients which had not been studied in major study in this review. It is documented that exposure to VR via head mounted display induces headaches, nausea and other side effects (Caserman et al. 2021). This side effects may influence the validity of VR as assessment tool.

There are few important limitations to this study. First, the review only used the source i.e. Pubmed and Google Scholar to generate and retrieve studies, which may indicate a lack of rigor and thoroughness. There may be concerns about the quality and reliability of these types of evaluations since we did not use other sources, such as Psycinfo which is a trusted index of psychological science sources due to financial issue. Another limitation is that the review did not include gender and age factors towards the effects of type of VR. Lastly, because of the various analytical procedures used by each investigation, reliable quantitative analysis were unattainable.

Further research should be conducted to see whether VR can incorporate other behavioral assessment paradigms such as self-monitoring, psychophysiology, and self-report in assessing OCD symptoms. This information will be crucial in helping clinicians to design effective intervention or augment traditional psychotherapy techniques, such as cognitive behavior therapy, to treat all OCD subtypes.

## CONCLUSION

In conclusion, this review has shown that VR act as an instrument for

assessing anxiety in patients with OCD, constitutes a tool to induce anxiety in this clinical population and therefore, supports its usefulness as a technique of exposure. Moreover, VR permits the repeated delivery of the same scenarios while allowing the anxiety to attenuate, and can be graded with different difficulty and customised for each specific patient. In addition, it offers a wide variety of advantages, such as easy access to stimuli and greater control over them. Currently, there is very little evidence and research to support the usefulness of VR as an assessment for all OCD symptoms and themes, since the reviewed research utilised small number of participants. Therefore, a greater number of studies with variety of OCD themes and larger samples are needed to validate and generalise the effectiveness of this assessment tool in a larger population. In addition, it is necessary to carry out investigation with young people, since there is still no study among this population group. More advanced technology can enhance VR connectivity and a higher degree of immersion can be achieved by implementing higher resolution hardware tools and for all age groups. People nowadays is depending on smartphones or the internet, the usability of VR can be utilised to suit current lifestyles. From our point of view, the VR approach is more applicable compared to computerised or imaginative experience, despite the little evidence on the usefulness of VR as an OCD assessment tool.

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