Virtual reality based attentional bias modification training for patients with obsessive compulsive disorder: a feasibility study

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Abstract

Background: Patients with obsessive-compulsive disorder (OCD) show attentional bias to symptom-related threat stimulus. Emerging evidence underscores the role of attentional bias in the maintenance of obsessive-compulsive symptoms (OCS). Attentional bias modification (ABM) training is widely implemented as an intervention to modulate attentional biases and alleviate clinical symptoms in OCD patients. However, there are some limitations such as task duplication and low ecological validity.

Objective: The virtual reality (VR) technology can provide a three-dimensional and realistic virtual environment, which can effectively make up for the limitations of traditional tasks. Hence, this study intends to develop a VR-based ABM (VR-ABM) program and preliminarily explore its feasibility and suitability.

Methods: Based on the standardized Chinese obsessive-compulsive symptom provocation picture system (COCSP-PS), the pictures related to compulsive washing were selected and three dimensions (3D)-transformed to establish a virtual environment. Then, by selecting the region of interest and inserting the target, the visual search task was combined with the virtual environment to build a VR-ABM. The study included 5 patients with OCD who completed 8 sessions of training twice a week. Symptoms and emotional states were assessed at baseline and the 4th week. Eye movement technique was used to measure attentional bias by combining free browsing and visuospatial working memory task. At the end of the 1st, 4th and 8th training sessions, we evaluated the patients' subjective attention concentration, task difficulty, degree of symptom provocation and adverse reaction. The changes were compared, and the feedback to the program was collected.

Results: The ABM program under the condition of symptom provocation was built in VR. The overall difficulty of VR-ABM was moderate. During the training process?this program can moderately provoke OCS and anxiety. As the training progresses, the accuracy of the 5 patients increased, the reaction time decreased, and OCS and anxiety were alleviated. Patients showed increased subjective attention concentration in tasks as well as in daily life. No adverse events were reported in all patients and recommendations were made for further improvement of the program.

Conclusions: In this study, a VR-ABM program was developed by combining compulsive washing-related virtual scenes with visual search tasks. All patients reported that the program was suitable in difficulty. It could moderately provoke OCS and anxiety without any side effects, providing a good sense of experience. And as the training progresses, patients can experience changes in subjective attention concentration and clinical symptoms. The feasibility and suitability of the VR-ABM program are preliminarily verified, which provides a basis for further exploring the effectiveness of the program. Clinical Trial: None

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Keywords: Obsessive-compulsive disorder; attentional bias; attentional bias modification training; virtual reality

1.1 Introduction

Obsessive-compulsive disorder (OCD) is a common mental disorder characterized by persistent, invasive, unnecessary obsession and repeated compulsion (American Psychiatric Association, 2013). Residual symptoms remain in 40% -60% of patients after medication and psychotherapy (Na Liu & Zhang, 2020). Therefore, it is crucial to explore effective adjunctive interventions that prioritize the aberrant threat-relevant information processing, such as attentional bias (Hezel & McNally, 2015), thereby optimizing the therapeutic efficacy of clinical interventions.

Numerous researchers have documented that individuals with OCD exhibit attentional bias towards stimuli, suggesting a potential correlation with obsessive-compulsive symptoms (OCS) (Amir, Najmi, & Morrison, 2009; Bradley et al., 2016; Hezel & McNally, 2015; Pengchong Wang & Li, 2017). Evidence indicates that attentional control may serve as a higher-order regulatory mechanism that modulates attentional bias towards threatening stimuli. Furthermore, it possesses notable plasticity, implying that it is subject to change and adaptation (Posner & Rothbart, 2007). Therefore, there has been a growing emphasis on investigating strategies to modulate attentional bias, with the aim of alleviate the influence of OCS.

At present, attentional bias modification (ABM) has been applied in many mental disorders, such as OCD (Habedank, Lennartz, Arslan, & Ertle, 2017), depression (Woolridge, Harrison, Best, & Bowie, 2021), social anxiety (Heeren, Mogoaşe, Philippot, & McNally, 2015), and eating disorders (Brockmeyer et al., 2019). However, ABM for OCD is primarily conducted in laboratory settings, utilizing images or words as stimuli. In such controlled environments, participants may exhibit a weakened perception of the threat posed by these stimuli, thereby limiting the allocation of attentional resources to high-threat materials (Beard, Sawyer, & Hofmann, 2012; Ma et al., 2019; Machulska et al., 2021). Furthermore, the laboratory context and the nature of the stimuli employed often result in lower ecological validity, thereby constraining the transferability of training outcomes to real-life situations (Boettcher, Berger, & Renneberg, 2012; Urech, Krieger, Chesham, Mast, & Berger, 2015).

These limitations may be effectively addressed through the implementation of virtual reality (VR) technologies. The VR based ABM training (VR-ABM) has the potential to immerse individuals with OCD in a more engaging, safe, and controlled environment, thereby enhancing the intensity of symptom provocation and improving

the ecological validity of the training (Lindner et al., 2017; Ma et al., 2020). VR-ABM is extensively employed to modulate attentional biases towards various stimuli, including threaten face (Ma et al., 2020; Ma et al., 2019; Urech et al., 2015), food (Schroeder, Lohmann, Butz, & Plewnia, 2016), smoking cues (Machulska et al., 2021) and pain-related stimuli (Rooney et al., 2025), while also alleviating self-reported anxiety resulting from stress(Wang, Zhang, Gao, Zhang, & Jiang, 2022). Although these studies have not shown significant changes in attentional bias, the corresponding behaviors and anxiety levels of the subjects have improved(Machulska et al., 2021; Urech et al., 2015). The initial findings concerning the observed changes in anxiety and behaviors documented in these studies provide encouraging evidence that underscores both the efficacy and acceptability of VR-ABM training as an adjunctive therapeutic approach for individuals with OCD.

Considering the current lack of extensive research on VR-ABM specifically targeting OCD, we conducted a study aimed at developing a VR-ABM program for patients with OCD. Our endeavor seeks to explore, at an initial stage, the feasibility and suitability of VR-ABM training in enhancing attentional bias and alleviating clinical symptoms under conditions that provoke symptoms. This research aims to offer a novel and effective adjunctive intervention for individuals with OCD and to establish a foundation for optimizing clinical intervention strategies.

2. Method

2.1 Participants

We recruited 5 patients with OCD from the outpatient department of Beijing Anding Hospital. The inclusion criteria for patients with OCD were: (1) age 18-60 years old, junior high school education or above; (2) meet the diagnostic criteria for OCD in DSM-IV; (3) Yale-Brown Compulsion Scale (Y-BOCS) total score ≥7; (4) have compulsive washing symptoms; (5) right-handed, normal vision or corrected vision, no color blindness and weak color; (6) voluntary participation in the study with informed consent. Patients should be excluded if they meet the diagnosis of schizophrenia, mood disorders and other mental disorders, have recently received physical therapy such as modified electroconvulsive therapy or neuromodulation, have a history of organic brain diseases and major physical diseases, have evidence of drug dependence and psychoactive substance use, or are pregnant, breastfeeding, claustrophobia and other subjects who cannot perform VR. Patient details are shown in Table 1.

Table 1 Patient condition

Patient	Gender	Age	Education	Medicine
1	female	32	Undergraduate	Sertraline
2	male	31	Junior college	Sertraline
3	male	36	Master's degree	Fluvoxamine, Aripiprazole
4	male	44	Junior college	Sertraline
5	female	42	Undergraduate	Sertraline

2.2 Measures

Mini International Neuropsychiatric Interview (M.I.N.I.) used to screen out other mental disorders (Sheehan et al., 1998). The Yale-Brown Obsessive-Compulsive Scale (Y-BOCS) was used to measure the severity of OCS (Yi Zhang, Fanqiang Meng, Yuhua Cui, Xiangdong Gan, & Guo., 1996). Obsessive-compulsive Inventory-Revised (OCI-R) assesses OCS from the dimensions of washing, obsessing, hoarding, ordering, checking, and neutralizing (Qinghuan He, Ziwen Peng, & Miao□, 2012). Beck Anxiety Inventory (BAI) (Kin-Wing, Chee-Wing, Kit-Ching, & Heung-Chun, 2002) and Beck Depression Inventory (BDI) (Zhen Wang et al., 2011) were used to assess the severity of anxiety and depression.

At the same time, we prepared our own ABM feedback form to evaluate the patients' reaction to ABM under VR, including the degree of subjective attention concentration, the difficulty of completing the task, the degree of OCS and anxiety provocation, the thoughts when completing the task, the more impressive scenes, and the feedback on the scene and the training.

2.3 VR-ABM

2.3.1 VR scene construction

Based on standardized Chinese obsessive-compulsive symptom provocation picture system (COCSP-PS) (Yifan Liu, Pengchong Wang, & Li, 2020), the pictures related to compulsive washing were selected and three dimensions (3D)-transformed to establish a virtual environment (VE). Rendering and baking in VE, using non-free perspective, the scene will lock the helmet to ensure that the scene synchronously follow the user's movement. In each scene, mark the area of each triggering element, add a physical collision mechanism, and assign physical attributes to objects in the interest area for

collision detection. Insert targets “E” and “F”, complete the randomization of the targets, and implement the interest area sample removal algorithm to avoid the region of interest, thereby correcting the user’s attentional bias in the VE. (Figure 1)

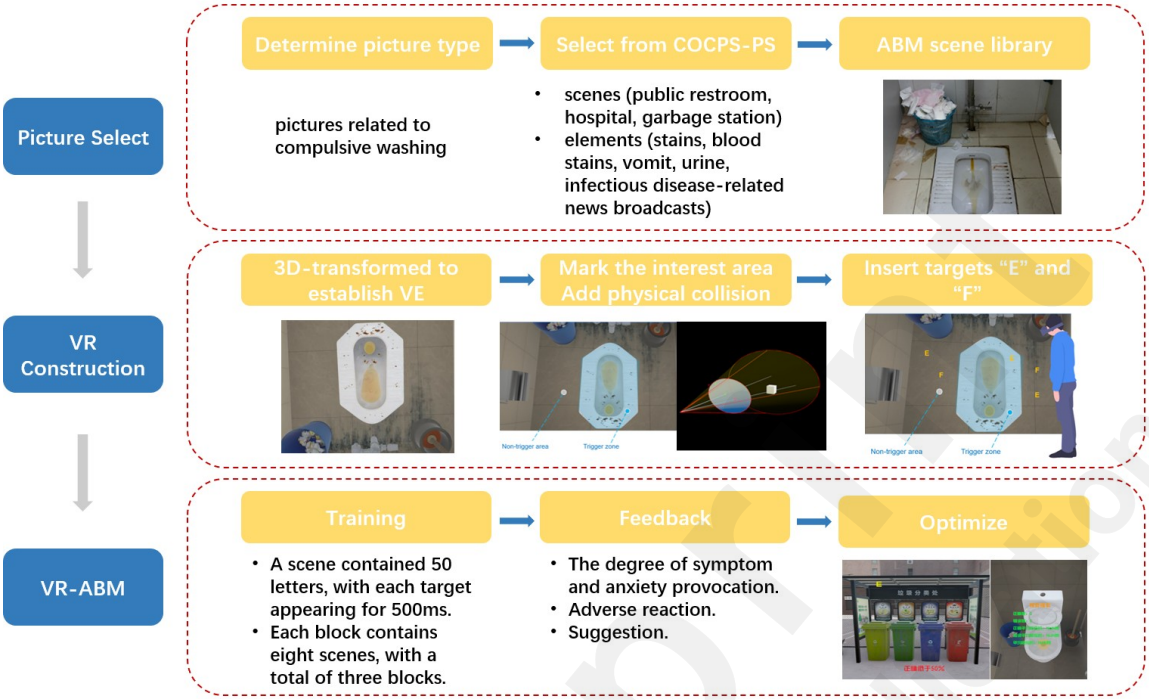

Figure 1 The specific process of VR-ABM program construction

2.3.2 Scene assignment

There are 12 VR-ABM training scenes. Each training session consists of 3 blocks, with each block containing 8 scenes. Table 2 and 3 show the scene contents and distribution.

Table2	Scene contents
number	contents
1	public restroom door handle with stains
2	toilet with blood stains
3	garbage station
4	ground with water stains
5	a hospital broadcasting HIV-related news
6	toilet with vomit
7	door of public restroom
8	a hospital broadcasting news about hepatitis
9	toilet with urine stains
10	toilet with poop
11	stained floor
12	a hospital broadcasting news related to coronavirus

Table 3	VR scene allocation		
trial	block 1	block 2	block 3

1	scene 1	scene 8	scene 4
2	scene 12	scene 9	scene 2
3	scene 3	scene 7	scene 5
4	scene 4	scene 2	scene 9
5	scene 6	scene 3	scene 11
6	scene 5	scene 6	scene 7
7	scene 11	scene 12	scene 10
8	scene 10	scene 1	scene 8

2.3.3 Training setting and process of VR-ABM

Patients should complete 8 sessions of training twice a week. In the first session, we explained the principles of attentional bias and the significance of ABM training, realized the conditions of the patients, and assessed the severity of symptoms and attentional bias at baseline. At the same time, let the patients get familiar with the operation of VR, and practice until the accuracy exceeds 50%. During formal ABM training, scenes that provoke OCS were presented on the screen as the background for the task. Target E and F appeared randomly on the screen. A scene contained 50 letters, with each target appearing for 500ms. If target E appears, click on the left handle panel, and if target F appears, click on the right handle panel. The screen showed whether patients clicked correctly or not and recorded the subjects' reaction time and accuracy. Each block contains eight scenes, with a total of three blocks. Training for each session takes about half an hour. At the end of each training, we sought feedback from the patients, including how they felt and whether they had any side effects.

After the 1st, 4th and 8th training sessions, the degree of subjective attention concentration, task difficulty and symptom provocation were also assessed. After the last training session, patients were asked to discuss and seek feedback on the overall 8-session training process, assess the changes in attentional bias and symptoms, and check whether there were adverse events and timely intervention. (Table 4, Figure 2)

The main indicators included accuracy, reaction time, self-reported degree of provocation, task difficulty, and attention concentration.

Table 4 VR-ABM program

Session	Content	Note
Session 1	Explain the principle of attentional bias and the significance of ABM & Practice When the accuracy is greater than 50%, formal training begins.	Assess baseline symptom severity and attentional bias
Session 2-7	ABM & feedback on self-perception and adverse reactions	Session 4
Session 8	ABM & summarize and feedback the whole process	Assess changes in attentional bias and clinical symptoms

Assess the degree of subjective attention concentration, task difficulty and symptom provocation

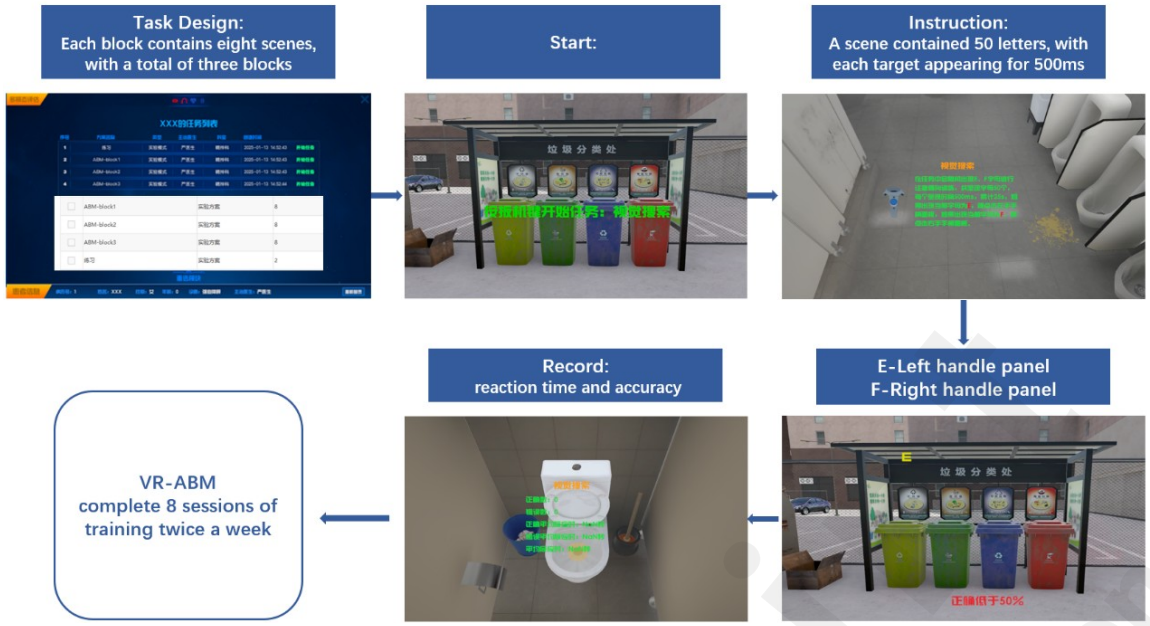

Figure 2 VR-ABM training flow chart

2.4 Attentional bias assessment task

In this study, a dual-task paradigm of picture free browsing combined with visuospatial working memory task was used (Figure 3). Both the obsessive-compulsive pictures and neutral pictures were taken from COCSP-PS. In the eye movement task, 16 pairs of compulsive-neutral picture, 16 pairs of neutral-compulsive picture, and 16 pairs of neutral-neutral picture were randomly selected.

There were 4 exercises before the formal experiment. The formal experiment consisted of 144 trials with 48 trials in each type of picture pair, presented in random order. The main eye movement indexes included the cumulated percentage of dwell fixations (CDF), the cumulated frequency of fixation (CFF), the initial fixation duration (IFD), and the direction of initial fixation (DIF).

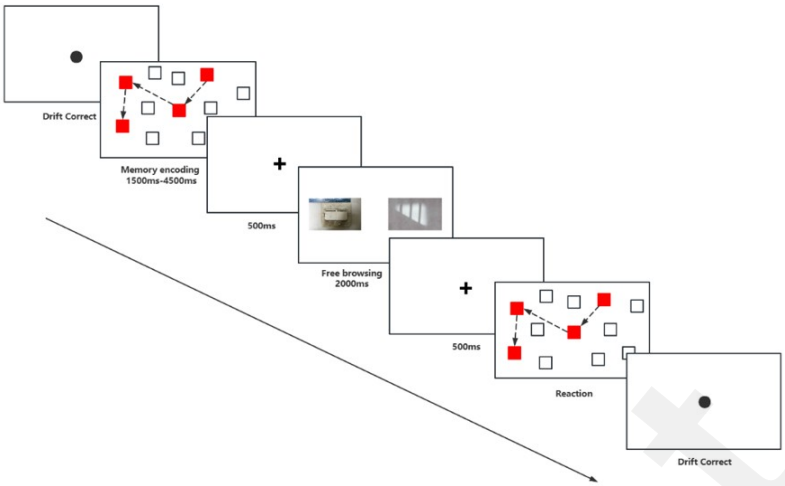

Figure 3 attentional bias assessment task

2.5 Equipment

Eyelink1000 produced by SR Research Company was used to collect eye tracking data of left eye, with a sampling rate of 1000 Hz, 60 cm away from the screen, a screen resolution of 1280 × 1024, and a pixel of 1027 × 768 for presenting pictures.

The treatment hardware is HTC VIVE-P130, which is a VR headset, containing two 3.5-inch OLEDs, with a resolution of 1440 × 1600 in one eye and 3K (2880 × 1600) for both eyes. The locator is the HTC VIVE, and the sensor is Steam VR tracking technology 2.0.

2.6 Data analysis

Data Viewer 4.3.1.0 and MATLAB were used to preprocess eye tracking data. The clinical data, eye movement data and VR data were descriptive statistical analyzed.

3. Results

3.1 Indicators related to VR-ABM training experience

Task difficulty was assessed by each patient after the first completion of ABM training (0-10 points, 0 for very simple, and 10 for very difficult), with an overall average of moderate difficulty (4.6 points). (Figure 4)

The accuracy of ABM training task was maintained above 50% for each patient. With the increase of training times, the average accuracy increased (change rate of 21.05%), and the average reaction time showed a decreasing trend (change rate of 5.41%). (Figure 5-8)

After completing ABM training for the first time, patients assessed the degree to

which VR scenes could provoke OCS and anxiety (0-10points, 0 being not provoked at all). The overall average degree of provocation was 4 points. (Figure 9)

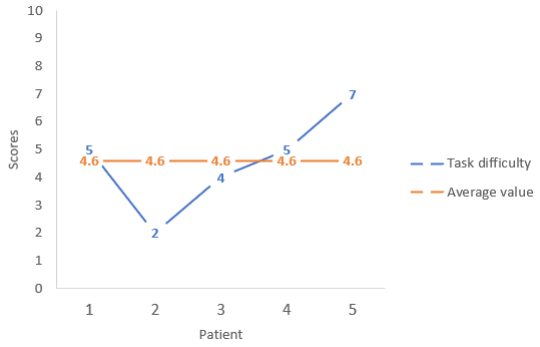

Figure 4 Task difficulty assessed by each patient

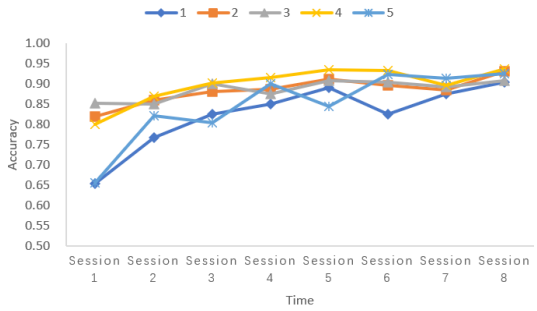

Figure 5 The accuracy of ABM for each patient

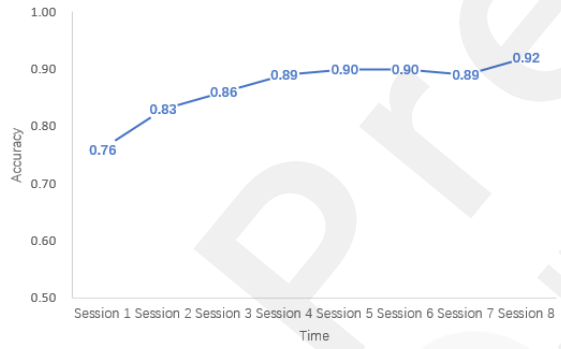

Figure 6 The average accuracy of each training session

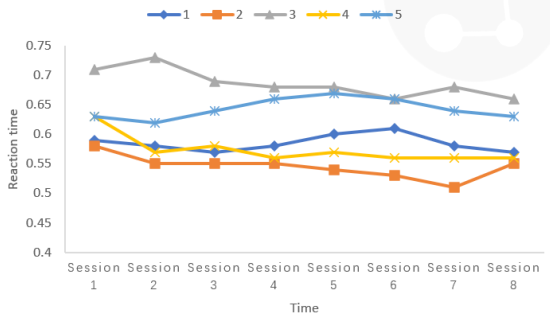

Figure 7 The reaction time for each patient

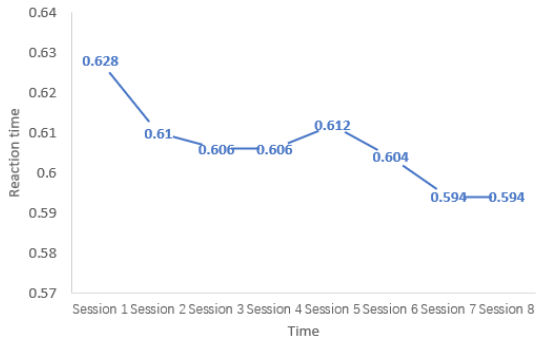

Figure 8 The average reaction time of each training session

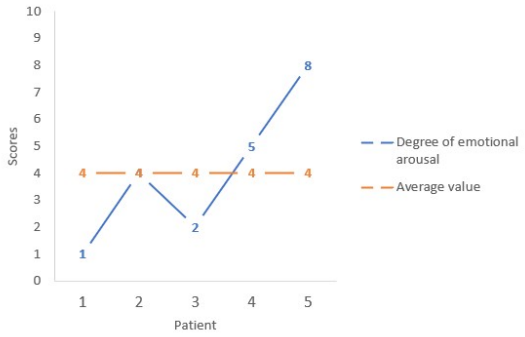

Figure 9 Degree of emotional arousal per patient

3.2 Objective and subjective reported indicators of attention

After the 1st, 4th and 8th training sessions, each patient was assessed for their subjective attention concentration in daily life. The degree of subjective attention concentration showed an upward trend. (Figure 10, 11)

After 4 weeks of training, the CFF of OCD patients increased. Four patients showed an increase in CDF, while one patient showed a decrease. For IFD, 3 patients decreased, and 2 patients increased. Two patients had a decrease in DIF, while 3 patients had an increase. (Table 5)

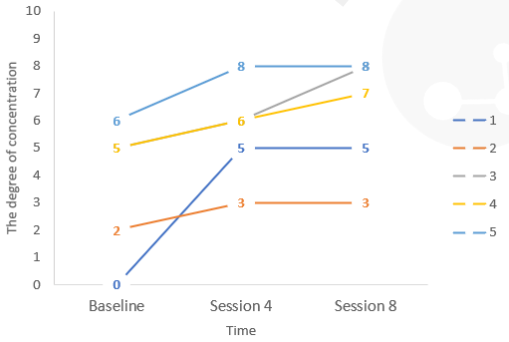

Figure 10 The degree of concentration of each patient

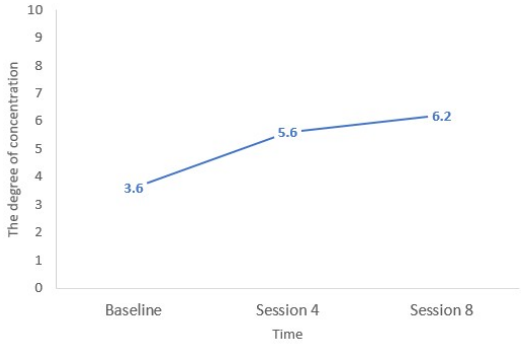

Figure 11 The average degree of concentration

Table 5 The characteristics of attentional bias at baseline and after training

patient	base				4w			
	CDF	CFF	IFD	DIF	CDF	CFF	IFD	DIF
1	-88.052	0.524	-37.417	0.604	174.617	0.566	-42.720	0.500
2	163.781	0.467	34.684	0.467	547.277	0.643	99.457	0.551
3	179.542	0.645	21.594	0.609	39.543	0.662	-8.441	0.697
4	228.677	0.567	53.033	0.593	393.292	0.589	52.862	0.500
5	183.490	0.515	21.750	0.652	204.349	0.694	38.531	0.682

Note: CDF: the cumulated percentage of dwell fixations; CFF: the cumulated frequency of fixation; IFD: the initial fixation duration; DIF: the direction of initial fixation.

3.3 Subjective feedback of VR-ABM

Similarly, we sought feedback from each patient on VR-ABM training after the first, fourth, and eighth sessions, including thoughts on the task, factors affecting accuracy, more impressive scenes, suggestions for training, and side effects. (Table 6)

Table 6 Patient feedback on VR-ABM training

patient	thoughts during the task	factors affecting accuracy	impressive scenes	suggestions	side effects
1	focused on the task	The accuracy was high when focused on the task. One mistake would lead to many mistakes.	toilet-related scenes	The olfactory experience could be more authentic.	no
2	thought of a real-life scene	The accuracy was high in cleaner scenes. News scenes with sound were less accurate.	toilet with vomit	It may be more effective to adjust perspective, add sound, and make the scenes dirtier.	no
3	guessed where the letters would appear and focus on the task	The accuracy was higher when the letters were in the middle. One mistake would lead to many mistakes.	stained floor, toilet-related scenes	If the scenes are dynamic, the effect may be better.	no
4	focused on the task and accuracy	The accuracy of news scenes with sound was low.	toilet-related scenes	The scenes were not dirty enough.	no

5	thought of a real-life scene	The accuracy was low when the mind was wandering and in the news scene with sound.	infectious disease related news scenes, toilet-related scenes	It would be better to have more scenes and elements.	no

3.4 Changes of clinical symptom-related indicators

The severity of OCS decreased in all 5 patients. The average reduction rates of Y-BOCS and OCI-R were 26.80% and 10.57%, respectively. The degree of anxiety increased in 1 patient and decreased in the others. The score-reducing rate of BAI was 32.47%. For the degree of depression, the BDI score decreased in 2 patients, unchanged in 2 patients and increased in 1 patient after training. And the average score reduction rate of BDI was 25%. (Table 7, 8)

Table 7 Clinical symptoms at baseline and after intervention

patient	base				4w			
	Y-BOCS	OCI-R	BAI	BDI	Y-BOCS	OCI-R	BAI	BDI
1	21	25	17	9	15	32	11	9
2	18	32	21	3	13	30	22	3
3	18	22	19	13	15	21	14	17
4	15	27	3	22	14	14	2	17
5	25	17	17	25	14	13	3	8

Note: Y-BOCS: The Yale-Brown Obsessive-Compulsive Scale; OCI-R: Obsessive-compulsive Inventory-Revised; BAI: Beck Anxiety Inventory; BDI: Beck Depression Inventory.

Table 8 The reduction rate of clinical symptom-related scales

patient	Y-BOCS	OCI-R	BAI	BDI
1	28.57%	-28.00%	35.29%	0.00%
2	27.78%	6.25%	-4.76%	0.00%
3	16.67%	4.55%	26.32%	-30.77%
4	6.67%	48.15%	33.33%	22.73%
5	44.00%	23.53%	82.35%	68.00%
mean	26.80%	10.57%	32.47%	25.00%

Note: Y-BOCS: The Yale-Brown Obsessive-Compulsive Scale; OCI-R: Obsessive-compulsive Inventory-Revised; BAI: Beck Anxiety Inventory; BDI: Beck Depression Inventory.

4. Discussion

To our knowledge, our study is the first to integrate contamination-related virtual scenes with a visual search task for attentional bias modification (ABM) training. We developed a VR-ABM training program to preliminarily assess its feasibility and suitability for application in patients with OCD. We found that the VR-ABM program exhibited a moderate symptom provocation effect (average degree of provocation = 4) and task difficulty (average difficulty = 4.6), and all patients were able to complete the

task with an accuracy rate above 50%, thereby suggesting its potential applicability. Following a four-week training period, participants exhibited a reduction in response times and an improvement in accuracy, with no significant adverse effects reported, lending preliminary support to its suitability. Moreover, changes in both subjective and objective measures of attentional processes were observed, indicating that the program may contribute to enhanced attentional allocation in individuals with OCD. However, the results concerning alterations in attentional bias were inconsistent, highlighting the need for further exploration. While this study was primarily designed to establish and validate the feasibility of VR-ABM as an intervention, we also noted a reduction in Y-BOCS symptom scores when VR-ABM was administered alongside pharmacotherapy, with a clinically relevant mean reduction rate of 26.80%. These initial insights provide a foundation for future research to refine and optimize this innovative approach for clinical application.

This study empirically selected scenes (public restroom, hospital, garbage station) or elements (stains, blood stains, vomit, urine, infectious disease-related news broadcasts, etc.) that were threatening to most OCD patients with washing as the main symptom dimension. As in previous studies, these VR scenes can effectively provoke OCS and anxiety in patients (Kasanmoentalib, Van Bennekom, Denys, & De Koning, 2014; Kim et al., 2008; Van Bennekom, de Koning, Gevonden, Kasanmoentalib, & Denys, 2021; Van Bennekom, Kasanmoentalib, de Koning, & Denys, 2017). Although the average level of symptom provocation in the training scene of this study was moderate, there was considerable heterogeneity in symptom provocation among patients. First, this is related to the introduction used during the training in this study. The therapist informed patients that they needed to respond more quickly and accurately to judgment tasks. For instance, patients with IDs 1 and 3 reported lower levels of symptom provocation, indicating that their thoughts during the task were “focused on the task”. In contrast, patients with IDs 2 and 5 reported higher levels of symptom provocation; both participants noted that they were thought of relevant real-life scenarios during the task. Overall, based on patients’ self-reports and clinical researchers’ observations, the level of symptom provocation remained within a relatively safe range (1-8). However, higher levels of provocation might increase the difficulty of the training and decrease patients’ compliance. This suggests that the symptom provocation level of scenes in our VR-ABM training can be managed through

introduction that encourage patients to concentrate more on the task, thereby avoiding excessive symptom provocation. To further enhance the scenes, based on patient feedback, it may be beneficial to consider increasing relevant stimuli in visual, auditory, olfactory, and interactive dimensions.

We investigated patients' feedback on task experience during training. Before starting the training, patients reported that they were unable to concentrate in daily life. They were more likely to notice symptom-related stimuli than others and found it difficult to shift their attention. The results of eye tracking tasks also reflected those patients had more fixation time and frequency on OCD-related pictures than on neutral pictures. After the first training session, three patients reported that they would associate real-life scenes related to compulsive washing when they saw stimuli when completing tasks. But patients were aware that they were completing the task and can quickly shift their attention from the symptom-related stimuli back to the target to continue with the task. After treatment, three patients had less difficulty in attentional disengagement, two patients had less attentional vigilance, and the degree of attentional avoidance decreased in all patients. At the same time, all patients reported an increase in concentration during tasks and daily life as training progressed. Robbins, Vaghi, and Banca (2019) suggests that OCD patients have an imbalance in habit and goal-directed system, associated with impaired top-down control. ABM may improve patients' top-down attentional control. A review compared changes in patients' brain networks during the ABM (G. Li et al., 2023). The results showed that ABM activated the dorsal attention network involved in top-down attention, and the executive control network involved in cognitive control and emotional self-management (Beevers, Clasen, Enock, & Schnyer, 2015; Corbetta & Shulman, 2002; H. Li et al., 2016). Therefore, it can enhance the patients' ability of active allocation of attention resources, promote attention to shift from negative stimuli, and improve the ability to focus on target stimuli. This echoes the plasticity of attentional control mentioned in the background. This change in attentional control was also initially observed in our study.

In this study, the severity of symptoms in one patient before training was mild, three were moderate, and one was severe, all of whom had been steadily taking selective serotonin reuptake inhibitors (SSRIs) for more than one month. Four patients reported emotional stability during the training period, three patients reported a decrease in time and frequency of cleaning than before, and one patient reported less

fear of pollutants in her life after training. After training, the average score reduction rate of Y-BOCS in five patients was 26.8%, and the severity of symptoms was reduced to mild. The reduction rates of BAI and BDI were 32.47% and 25%, respectively. This was consistent with previous meta-analysis studies showing small to moderate effect sizes for ABM on symptom and emotional relief (Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015; Mogoaşe, David, & Koster, 2014; Price et al., 2016). The results of seven existing VR-ABM studies have also shown a reduction in symptoms and corresponding emotions in participants after training. But there is no consensus on the effectiveness of ABM training. Rouel (Rouel & Smith, 2018) and Habedank (Habedank et al., 2017) performed a dot-probe task using OCD-related and neutral picture pairs, completing a single and six sessions of ABM training, respectively. The results showed a reduction in attentional bias, but there was no significant difference in symptom reduction compared with control group. This may be related to the different type of task and stimulus materials.

5. Limitations

First, this study is an exploratory pilot study with a small sample size, which can only preliminarily explore the feasibility of VR-ABM but cannot prove its effectiveness. Secondly, only the most common scenes related to compulsive washing are selected. The number of scenes is small, and there is no personalized allocation for patients. In the future, we should expand the sample size, carry out further randomized controlled studies to explore its effectiveness. At the same time, we will expand the scene library and conduct personalized training for patients' specific symptoms.

6. Conclusion

This study is based on COCPS. After modeling the images in 3D and combining them with visual search tasks, a VR-ABM program was initially developed. Five OCD patients completed eight training sessions. They believed that the program was of appropriate difficulty and could provoke OCS and anxiety moderately. As the training progressed, patients experienced a reduction in clinical symptoms and an increase in concentration during training and in daily life. No side effects were reported during the training. The overall experience of patients was good. And suggestions were made to improve the immersion and reality of the program. The feasibility and suitability of the

VR-ABM program are preliminarily verified in this study. In the future, we should enlarge the sample size and carry out randomized controlled studies to explore the effectiveness of the program, to further improve the program and optimize the clinical treatment plans.

7. Ethics statement

The studies involving human participants were reviewed and approved by Research Ethics Committee of Beijing Anding Hospital, Capital Medical University, Beijing, China. All patients/participants provided their written informed consent to participate in this study.

8. Author contributions

Pengchong Wang: designed the study, performed literature searches, drafted the manuscript, critically reviewed, and revised the manuscript, and as corresponding author. Zijun Yan: performed literature searches, collected dated, and drafted the manuscript. Zhanjiang Li: contribute to conceptualized and designed the study, reviewed, and revised the manuscript. All authors contributed to the article and approved the submitted version.

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10. Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relations

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