Development and Aging

Investigating behavior inhibition in obsessive-compulsive disorder: Evidence from eye movements

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We investigated the role of inhibition failure in Obsessive Compulsive Disorder (OCD) through an eye tracking experiment. Twenty-five subjects with OCD were recruited, as well as 25 with Generalized Anxiety Disorder (GAD) and 25 healthy controls. A 3 (group: OCD group, GAD group and control group) × 2 (target eccentricity: far and near) × 2 (saccade task: prosaccade and antisaccade) mixed design was used, with all participants completing two sets of tasks involving both prosaccade (eye movement towards a target) and antisaccade (eye movement away from a target). The main outcome was the eye movement index, including the saccade latency (the time interval from the onset of the target screen to the first saccade) and the error rate of saccade direction. The antisaccade latency and antisaccade error rates for OCDs were much higher than those for GADs and healthy controls. OCDs had longer latency and error rates for antisaccades than for prosaccades, and for far-eccentricity rather than near-eccentricity stimuli. These results suggest that OCDs experience difficulty with behavior inhibition, and that they have higher visual sensitivity to peripheral stimuli. In particular, they show greatest difficulty in inhibiting behavior directed towards peripheral stimuli.

Key words: Obsessive-compulsive disorder, behaviour inhibition, antisaccade, prosaccade.

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INTRODUCTION

Obsessive-compulsive disorder (OCD) is characterized by intrusive thoughts and ritualistic, repetitive, compulsive behaviors which are carried out intentionally (American Psychiatric Association [APA], 2000; Bohne, Savage, Deckersbach, Keuthen & Wilhelm, 2008). In recent years, research has focused on the mechanism behind this compulsive behavior. Evidence from neuroimaging studies suggests that OCD is associated with functional changes in the cortex-striatum-thalamus-cortices (CSTC) circuits (Calzà, Gürsel, Schmitz-Koep *et al.*, 2019). Specifically, indirect circuits associated with behavioral inhibition appear weaker than direct circuits associated with self-reinforcement. Humans have natural evolutionary concerns for safety and impulsions to check their surroundings. While adaptive healthy people are capable of controlling these thoughts and impulsions, OCD sufferers cannot (Milad & Rauch, 2012). One hypothesis is that people with OCD have significant difficulties with behavior inhibition. For example, Penadés, Catalán, Rubia, Andrés, Salamero and Gastó (2007), and Huang and Cai (2008) found that OCDs had significantly lower behavior inhibition levels than healthy controls in the traditional GO/NOGO task. Lipszyc and Schachar (2010) also found that OCDs experienced the same difficulty for the Stop-Signal task. On the other hand, some researchers have failed to find any evidence of behavior inhibition difficulty in OCDs. For instance, Bohne *et al.* (2008), and Morein-Zamir, Papmeyer, Gillan *et al.* (2013) used the traditional GO/NOGO task to examine the issue, but observed no significant difference in behavior inhibition between OCDs and healthy controls. Blom, Samuels, Grados *et al.* (2011) used the Stop-Signal Task and also failed to find evidence of behavior inhibition.

How can such contradictions be explained? Upon scrutiny, certain problems emerge among the existing studies: first, most of the subjects selected in the experiments had taken drugs or had experienced some kind of intervention for OCD. Second, most of the tasks adopted in the experiments were traditional GO/NOGO and Stop-Signal Task. Because these tasks may involve both promotion and inhibition processes, they cannot be relied on to measure the inhibition characteristics of OCD in isolation.

For example, although it might seem based on the task description that the GO/NOGO task measures behavior inhibition, it instead requires participants not to inhibit, but rather to ignore the NOGO stimuli (Rubia *et al.*, 2001). Compared with the GO/NOGO, the Stop-Signal paradigm seems to be "purer," as it only features GO stimuli. However, Dillon and Pizzagalli (2007) have argued that the sound cues used in the paradigm, and the computationally sophisticated horse racing models involved cast doubt on the model's objectivity (Dillon & Pizzagalli, 2007).

The cognitive demand characteristics of these experimental paradigms may well be responsible for the inhibition difficulty effect observed in OCDs. For example, in the GO/NOGO task, the red stimulus for GO and the green for NOGO run contrary to everyday experience (e.g., Green – green light – "go" GO; red – red light – "stop" NOGO). In order to reach a reliable conclusion about the role of behavior inhibition in OCD, a "purer" task is required.

In recent years, the analysis of antisaccades has been flagged as a potentially important paradigm for investigating behavior inhibition in OCDs (e.g., Lennertz, Rampacher, Vogeley *et al.*,

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2012; Tien, Pearlson, Machlin, Bylsma & Hoehn-Saric, 1992; Van der Wee, Hardeman, Ramsey *et al.*, 2006). The antisaccade task is carried out as follows: a fixation appears in the center of screen, and then a target appears on the left or the right of the fixation. Participants are required not to look at the target stimuli, but to look instead at the mirror image location. Eye movements can then provide a direct reflection of behavior inhibition, without any cognitive interference involving motion or language (Zhang & Barash, 2000). Typically, prosaccade indexes are compared against antisaccade indexes for evaluating inhibition function in participants. The experimental paradigm for recording prosaccades is broadly similar to that for antisaccades, the only difference being that participants are instructed to look directly at the target stimuli appearing around the screen (Klein & Foerster, 2001).

The spatial locations of target stimuli play an important role in evaluating the performance of participants in saccade tasks. The positions of the target stimuli are referenced relative to the center of screen on the horizontal (left and right) and vertical (up and down) level. When following the antisaccade paradigm, OCDs are asked not to look at the stimuli on the left or right of the screen, but instead, to gaze in the opposite direction. If they show difficulty in averting their gaze, it indicates a failure of behavior inhibition.

In addition, the positional eccentricity of target stimuli provides further information on behavior inhibition. As the eccentricity increases, participants need greater time to inhibit the wrong antisaccade and re-plan the correct prosaccade. The longer the process takes, the poorer the participant's inhibition ability. Eccentricity can be divided into two types: near eccentricity (i.e., stimulus position varies unexpectedly, far from the focus of attention) and far eccentricity (i.e., stimulus position varies unexpectedly, close to the focus of attention).

In clinical practice, OCDs tend to report higher than normal sensitivity to peripheral stimuli. For instance, OCDs are often overly sensitive to surrounding sounds. They may complain about the noise coming from the next-door office. Even the ticking sound of a clock can be an excessive noise for them. In other words, OCDs seem to be more sensitive to stimuli which are "far" from the focus of their attention. Could the same effect apply to visual stimuli? In order to answer this question, we used the antisaccade paradigm to explore behavior inhibition in OCDs, with a particular focus on visual sensitivity. In a large empirical study and a meta-analysis of 10 studies, Bey, Lennertz, Grützmann *et al.* (2018) found impaired antisaccade performance in OCD. Based on the above considerations, our research hypothesis is put forward: OCDs are more sensitive to the surrounding environment than healthy controls, as shown in the antisaccade paradigm, the saccade latency and error rate of OCDs are significantly higher than healthy groups.

Inhibition difficulty in behavior has been proposed as a common mechanism underlying both Generalized Anxiety Disorder (GAD) and OCD (Fan, Liu, Lei *et al.*, 2016; Hallion, Tolin, Assaf, Goethe & Diefenbach, 2017; Maack, Tull & Gratz, 2012). These two disorders have many common features, such as excessive fear of specific situations, the overestimation of threat, avoidance and safe seeking behavior, and high physiological arousal. Do individuals with GAD experience the same behavior inhibition difficulty as those with OCD? In order to offer clarification on the pathogenesis of these conditions, we recruited both GADs and healthy individuals as control groups in our study. Based on previous studies, we believe that there is also a behavioral inhibition difficulty in the GAD group, but there is a difference in the degree of behavioral inhibition in the GAD group and the OCD group.

This study has expanded on previous research as follows. First, while previous studies focused mostly on the symptoms of OCD (Miguel, Baer, Coffey *et al.*, 1997; Pigott, 1998), recent work has shown that behavior inhibition is significantly correlated with compulsive symptoms (Chamberlain, Fineberg, Blackwell, Robbins & Sahakian, 2006). Accordingly, this study explored the causes of OCD by exploring the emerging perspective of behavioral inhibition. Second, previous studies obtained contradictory conclusions by adopting the G/NG paradigm (Bohne *et al.*, 2008; Huang & Cai, 2008; Morein-Zamir *et al.*, 2013; Penadés *et al.*, 2007). In response, we adopted the alternative paradigm of using eye-tracking technology to explore the role of behavioral inhibition in OCD. Lastly, this study provided a new pathway to study OCD patients' sensitivity to surrounding stimuli, using the near-far paradigm. We believe that the key to alleviating OCD lies in addressing the difficulties associated with behavioral inhibition.

METHOD

Participants

Twenty-five OCDs participated in the experiment, including eleven males and 14 females, with an average age of 27.98 years. A structured interview with patients was conducted by psychiatrists and psychologists to ensure that patients with obsessive-compulsive disorder met the criteria of the *Diagnostic and statistical manual of mental disorders*, and had no co-occurring disorders for anxiety and depression. The scores in the Y-BOCS ranged from 18 to 24 points, indicating that all the subjects had moderate obsessive-compulsive disorder. Twenty-five patients with GAD participated in the experiment, including ten males and 15 females, with an average age of 29.06 years. A structured interview with patients were conducted by psychiatrists and psychologists to ensure that patients with GAD meet the criteria of the *Diagnostic and statistical manual of mental disorders*, and had no co-occurring disorders for obsessive-compulsive disorder and depression. The scores in the BAI ranged from 18 to 24 points, indicating that all the participants had moderate or near-intermediate anxiety symptoms. OCDs and GADs were mainly recruited from mental health centers, hospitals and professional psychological counseling centers. They had no brain damage, substance abuse problems or nervous system diseases. They had never received any psychological treatment or any medical treatment. The 25 healthy controls who participated in the experiment included 12 males and 13 females, with an average age of 28.63 years. There was no significant difference in age between the healthy, GAD and OCD groups ($F(2, 72) = 0.69$, $p > 0.05$). Healthy subjects were right-handed, with normal vision or corrected vision, and were aware of the experimental process and were willing to participate in the experiment. They were mainly drawn from colleges, enterprises and institutions. All healthy subjects were subjected to a DSM-IV structured clinical interview by a psychiatrist and a psychologist. The purpose of the interview was to ensure that selected subjects had no history of substance abuse, and did not suffer from mental disorders or neurological impairment.

The structured clinical interview based on DSM-IV is mainly compiled by the American Psychiatric Association (2000), and used to diagnose obsessive-compulsive disorder, anxiety disorder and the status of healthy groups. The structured clinical interview has been widely used and is consistent with psychometric characteristics.

Before the experiment, participants were interviewed and measured for symptom diagnosis, and were informed of the experimental content. They participated in the experiment one week later.

Ethical approval for this study was obtained from the Academic Board of Shandong Normal University. All of the procedures used in studies involving human participants were conducted in accordance with the ethical standards of the research committee of Shandong Normal University. All participants offered their informed consent and were informed that they could withdraw from the study at any time. The information provided by and generated by participants was anonymized and kept strictly secret.

Measures

The Yale-Brown Obsessive Compulsive Scale (Y-BOCS). The Y-BOCS is a test developed by Goodman, Price, Rasmussen *et al.* (1989) for quantifying OCD burden. It includes two main parts, namely a symptom checklist, and a scale for measuring symptom severity. The current study used the symptom severity scale. The scale is composed of two subscales to measure obsessions and compulsions, with each subscale containing five items. The 10 items are intended to assess the average severity of obsessive symptoms experienced over the past week. All items in the scale are scored on a five-point Likert-scale, ranging from 0 (no symptoms) to 4 (extreme symptoms). The higher the score, the more serious the symptoms. In general, a total score of less than 16 points indicates mild symptoms, 16–23 points indicates moderate symptoms, 24–31 points indicates severe symptoms, while a total score ≥31 indicates extremely severe symptoms. Existing research suggests that the scale has good reliability and validity (Baraby, Audet & Aardema, 2018; Kizilagac & Cerit, 2019; Özyurt & Besiroglu, 2018).

The Beck Anxiety Inventory (BAI). The BAI is a test compiled by Beck, Brown, Epstein and Steer (1988), and further developed by Beck and Steer (1993), for measuring the severity of anxiety. The BAI consists of 21 self-reported items to measure the occurrence and severity of anxiety disorder symptoms experienced by individuals over the previous week. All items are scored on a four-point Likert scale. The scores of the BAI range from 0 to 63. In general, total scores of 0–7 indicate minimal anxiety, 8–15 indicate mild anxiety, 16–25 indicate moderate anxiety, while 26–63 indicate severe anxiety. The reliability and validity of the inventory are well supported by existing studies (Bardhoshi, Duncan & Erford, 2016; Ma, Chen, Wong, *et al.*, 2019; Sanz, 2014).

Materials

Tasks.

Prosaccade task: a white fixation point "+" appeared at the center of the black screen. Its presentation time was varied randomly from 800 to 1300 ms in order to prevent participants developing expectations that could influence the results. We also ensured that participants started their eye movements from the center of the screen. When the "+" fixation disappeared, the target stimulus, specifically a white square, appeared randomly at one of four positions (far-left, far-right, near-left, near-right). Participants were instructed to prosaccade towards the square as soon as they detected it. The presentation time of target stimulus was 1,000 ms.

Following presentation of the target, the screen went completely black for a period varying randomly from 500 to 1,000 ms, followed by the next round of stimulus presentation. During the experiment, the background of screen was black, with white fixation points and targets, both with a size of 1°×1°. The near target stimuli lay in the parafoveal region, with a visual angle of 2.5°. The far target stimuli lay in the peripheral visual region, with a visual angle of 7.5° (see Evdokimidis, *et al.*, 2006; Tian, 2009).

Antisaccade task: the procedures of the prosaccade and antisaccade tasks were broadly similar. The only difference was that, for the antisaccade task, participants were instructed not to look at the target when they detected it, but instead to look at its mirror image position on the screen.

Apparatus. The apparatus used in the experiment included an iView X-RED eye tracker produced by SMI, an iView PC, an image display Stimulus PC, a camera, and two infrared light sources mounted beneath the computer. The iView PC was operated by the experimenter, with the stimuli displayed on the Stimulus PC, and the camera used to capture participants' eye movement images. These data were transferred to the iView PC in order to record and analyze participants' eye movements. The Stimulus PC, which was chiefly used to display the experimental materials, had a 19-inch monitor featuring a 1,024 × 768 pixel resolution, and a Windows XP SP2 operating system. The iView X-RED eye tracker had a sampling rate of 250 Hz and a tracking resolution of 0.03. Participants were allowed to move their heads freely in a 40 × 40 cm space and did not need to wear any additional equipment. They maintained the height of their eyes to be horizontal with the screen, at a distance of 80 cm from the screen.

Design

The experiment used a 3 (group: OCD group, GAD group and control group) × 2 (target eccentricity: far and near) × 2 (saccade task: prosaccade and antisaccade) mixed design. Among these, group was the between-subject variable, while target eccentricity and saccade task were within-subject variables. The dependent variable was the eye movement index, including the saccade latency (the time interval from the onset of the target screen to the first saccade) and the error rate of saccade direction.

Procedure

Before the experiment, participants were interviewed and surveyed for the diagnosis of symptoms. They participated in the experiment one week after having given informed consent. The experiment was conducted in an eye movement laboratory, which featured a sound insulation system to ensure an ideal environment. During the process of the experiment, the laboratory was kept quiet. Participants carried out the experiment one after the other. The specific operational procedure for each participant was as follows.

The experimenter allowed each participant to enter the laboratory, and familiarize themselves with the experimental environment. Subsequently, participants were asked to sit on the experimental chair in front of the Stimulus PC with their eyes 80 cm away from the screen. They were asked to try to keep their head as motionless as possible during the experiment.

The iView PC was operated by the experimenter. A 9-point calibration method was used to calibrate the eye tracker. At the beginning of this process, a white light spot with a red center appeared in the center of the screen. Participants were instructed to fixate on the center of the light spot, following it with their eyes while keeping their head motionless. The time taken to perform the calibration was about 30 s.

The experiment was started only if a participant was successful in calibration. To begin, participants were presented with following guidance: "Please complete the following four experimental tasks, two of which have the same requirements. Before each experiment, the experimenter will read detailed instructions to you. Please act as soon as possible according to the instructions." A trial taken from the experimental process is shown in Fig. 1.

Each participant completed two sets of tasks under the prosaccade and antisaccade paradigms, respectively, thus completing four sets of experimental tasks in total. The experiments used the ABAB-BABA design to counteract any sequential effects. Each set of experimental tasks included 60 formal trials (30 stimuli involving far-eccentricity and 30 stimuli involving near- eccentricity) and 16 practice trials. After completing the two sets of experiments, participants were allowed to rest for 3 min. Another calibration was needed before proceeding with the next two sets of experiments. In all, it took about 40 min for participants to complete the whole experiment.

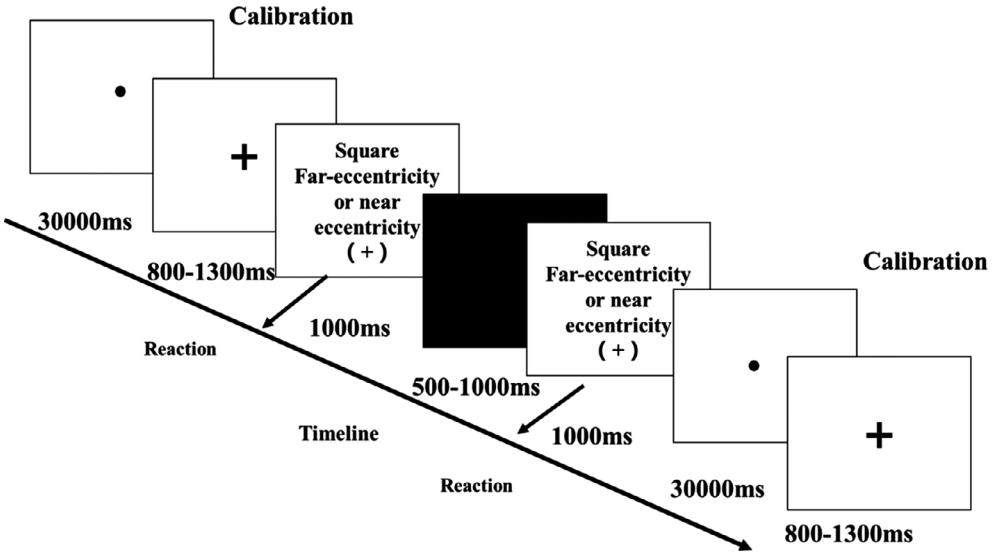

Fig. 1. Flow chart for each trial in the study.

Data management

During the experiment, all eye movement data were automatically recorded by the eye tracker, and a data file was automatically generated. When the experiment was over, the experimenter used the Be Gaze 2.5 analysis software provided by RED Eye Tracker to export the data for each participant into a.txt file, and then transferred the file to Microsoft Excel 2007 and SPSS 16.0 in order to analyze and manage the data.

RESULTS

Be Gaze 2.5 analysis software was used to divide the areas of interest on the screen. We focused our investigation on two areas of the screen, namely the area to the left of the gazing point, and the area to the right of the gazing point. Figure 2 shows the two conditions for distance between the target square (1° in size) and the fixation point, namely 2.5° (target 1) and 7.5° (target 2). There are two interest areas on the left and right sides of the fixation point, yielding four interest areas in total. According to Derakshan, Salt and Koster (2009), the separations between each of these areas exceeds the top 20th percentile of distances covered by single eye movements, thus supporting their distinctiveness.

If the first saccade was made to a position outside the screen, or if the latency of the saccade was below 80 ms or above 600 ms, the data were excluded. Any data without recorded eye movements were also deleted. The proportion of valid data was 93.3%.

Saccade latency

The mean (*M*) and standard deviation (*SD*) for saccade latency under all experimental conditions are presented in Table 1.

Using SPSS 16.0 to analyze the variance homogeneity of the data in Table 1, we found that the *p* values for OCDs, GADs

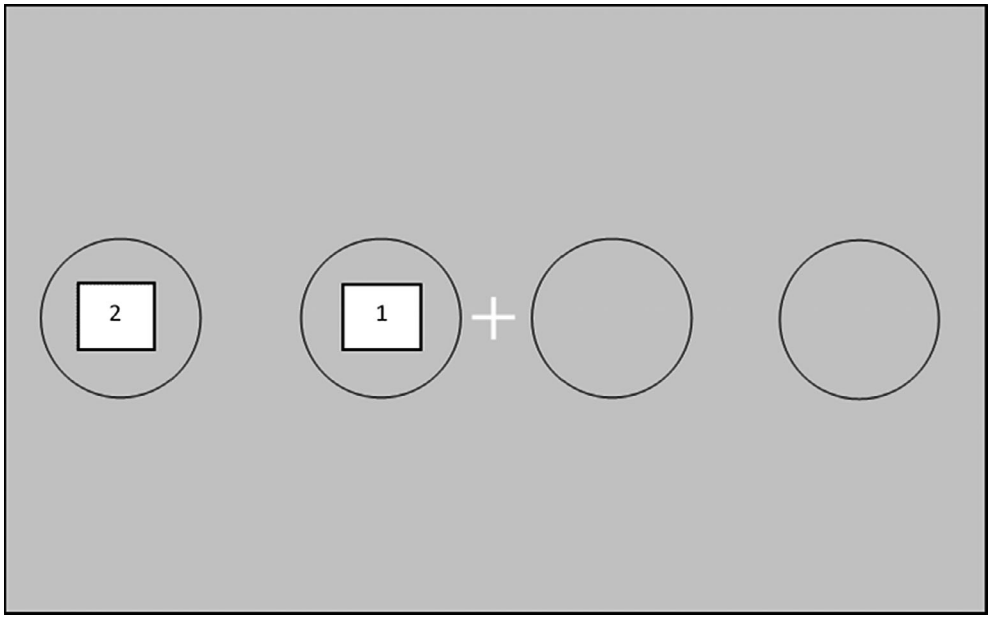

Fig. 2. Interest areas for the eye movement task diagram.

Table 1. *Mean and standard deviation of eye movement latency for each group under various experimental conditions (ms) (M ± SD)*

	Prosaccade		Antisaccade	
Group	Near-eccentricity	Far-eccentricity	Near- eccentricity	Far-eccentricity
OCD	295.96 ± 15.91	315.96 ± 14.58	535.04 ± 35.59	554.09 ± 34.39
GAD	329.14 ± 11.86	319.50 ± 12.05	504.36 ± 42.10	490.95 ± 42.40
Control	341.60 ± 10.73	327.56 ± 10.32	488.04 ± 42.31	477.52 ± 43.27

and the control group in Levene's test were all higher than 0.05, indicating that the variance was homogeneous. A 3 (group: OCD, GAD and control group) × 2 (target eccentricity: far and near) × 2 (eye task: prosaccade and antisaccade) ANOVA was conducted. The results showed that the main effect of the group was significant ($F(2, 67) = 4.78$, $p < 0.05$, $\eta p^2 = 0.13$). According to the least significant difference (LSD), there existed significant differences between OCDs, GADs and the control group. Specifically, the prosaccade latency of OCDs was shorter than that of GADs (d = 0.26) and healthy subjects (d = 0.31). The main effect of target eccentricity was marginal significant ($F(1, 67) = 3.00$, $p = 0.06$, $\eta p^2 = 0.14$), while the main effect of saccade task was also significant ($F(1, 67) = 1291.00$, $p < 0.001$, $\eta p^2 = 0.96$). Moreover, group and type of saccade task showed a significant interaction effect ($F(2, 67) = 27.29$, $p < 0.001$, $\eta p^2 = 0.45$) (see Fig. 3). Simple effect analysis showed that OCDs presented significant differences for saccade task type, ($F(2, 67) = 11.17$, $p < 0.01$, $\eta p^2 = 0.28$). Specifically, OCDs had much longer antisaccade latency than prosaccade latency (d = 9.04). In addition, the interaction between group and target eccentricity was significant ($F(2, 67) = 161.08$, $p < 0.001$, $\eta p^2 = 0.83$) (see Fig. 4). Further simple effect analysis showed that OCDs had significant differences in target eccentricity ($F(2, 67) = 18.22$, $p < 0.01$, $\eta p^2 = 0.33$). Specifically, OCDs had a longer prosaccade latency at far-eccentricity than that at near-eccentricity (d = 0.79). Neither the interaction between target eccentricity and task type nor the interaction of group, target eccentricity and task type were significantly different.

Antisaccade error rate

The antisaccade error rate is defined as the ratio between the number of times participants conduct a prosaccade to the peripheral stimulus versus the number of times they conduct an antisaccade. After eliminating the invalid data, we found that no participants had directional errors in the prosaccade task. Therefore, we only analyzed directional errors in the antisaccade task.

The mean (*M*) and standard deviation (*SD*) of the antisaccade error rates under all experimental conditions are presented in Table 2.

Using SPSS 16.0 to analyze the variance homogeneity of the data in Table 2, we found that the *p* values of OCDs, GADs and the control group in Levine's test were all higher than 0.05, indicating that the variance was homogeneous. A 3 (group: OCD, GAD and control group) × 2 (target eccentricity: far and near) ANOVA was conducted. The results showed that the main effect of group was significant ($F(2, 67) = 167.14$, $p < 0.001$, $\eta p^2 = 0.83$). According to the LSD, there were significant differences between OCDs, GADs and the control group. Specifically, the antisaccade latency of OCDs was much higher than that of GADs (d = 2.43) and healthy subjects (d = 5.70).

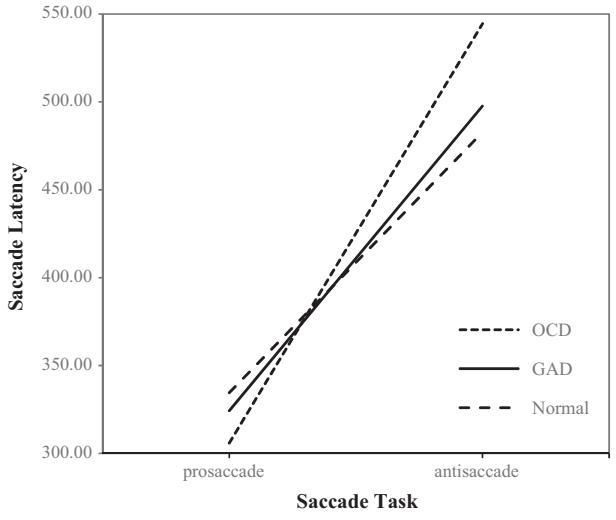

Fig. 3. Interaction between group and saccade task.
Note: The saccade latency time is the mean of the latency time at far-eccentricity and at the near-eccentricity.

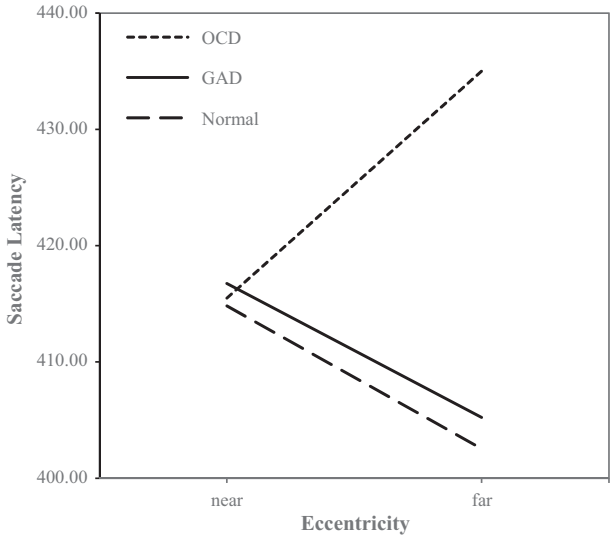

Fig. 4. Interaction between group and target eccentricity.
Note: The saccade latency time is the mean of the latency time of prosaccade and antisaccade.

Table 2. *The average and standard deviation of the antisaccade error rate for different groups and target eccentricity (%)*

	Near-eccentricity		Far-eccentricity	
Group	*M*	*SD*	*M*	*SD*
OCD	12.91	3.75	17.91	3.99
GAD	5.09	3.64	8.32	3.24
Control group	0.31	0.45	0.38	0.48

The main effect of target eccentricity was significant ($F(1, 67) = 528.11$, $p < 0.001$, $\eta p^2 = 0.89$). Moreover, group and saccade task type showed a significant interaction effect ($F(2, 67) = 148.50$, $p < 0.001$, $\eta p^2 = 0.82$) (see Fig. 5). Simple effect analysis showed that OCDs presented significant differences in the different types of saccade tasks ($F(2, 67) = 20.17$, $p < 0.01$, $\eta p^2 = 0.37$). Specifically, the saccade error rates of OCDs at greater eccentricities were higher than those at shorter eccentricities (d = 1.32).

DISCUSSION

Behavior inhibition difficulty in OCD

The current study used an antisaccade paradigm with target eccentricity variables (near and far) to evaluate the behavior inhibition of OCDs. Performing an antisaccade involves at least two steps: inhibiting a prosaccade which is directed towards a stimulus, and then consciously re-planning an antisaccade away from that stimulus. Superior inhibition ability will reduce latency at this task. Our results show that the latency of OCDs was significantly greater than that of GADs and the healthy group, suggesting that OCDs experience difficulty in inhibition. At the same time, we also found that the prosaccade latency of OCDs was shorter than that of the healthy group, as well as being significantly shorter than their own antisaccade latency. These results show that OCDs found it more difficult to inhibit the wrong prosaccade, revealing a strong sensitivity to target stimuli and a difficulty in inhibiting the dominant response.

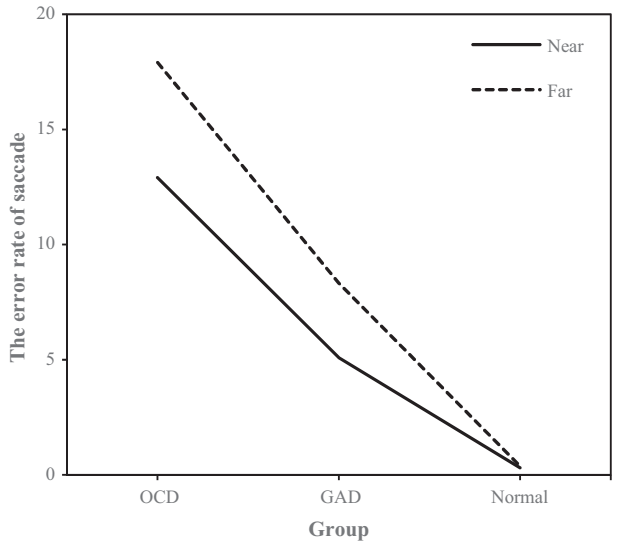

Fig. 5. Interaction between group and target eccentricity.

Periphery stimuli sensitivity in behavior inhibition of OCDs

Both error rates and latency in the OCD group were greater for the far-eccentricity antisaccade than for the near-eccentricity antisaccade stimuli. The difference between OCDs and the healthy group was also significantly higher than between GADs and the healthy group. The OCD group's prosaccade latency towards far-eccentricity stimuli was shorter than that of the other two groups, indicating that it was more difficult for OCDs to inhibit stimuli with far-eccentricity. Fu, Fan, Chen and Zhuo (2001) propose that focusing on the location of a target improves the visual information processing of that location. Behavior studies have also shown that, compared with processing information that appears in uncertain locations, individuals are more accurate and faster in processing information appearing in an exact location (Posner, 1980). Studies have shown that the issue of whether a stimulus appears in a central (near-eccentricity) or peripheral (far-eccentricity) location has an important influence on the subsequent processing of a target. It may take longer to pay attention to a center stimulus (Briand & Klein, 1987; Posner, 1980). A two-channel model has been used to explain this phenomenon: the information gained from centrally located stimuli may lead to slow control behaviors, while information from peripheral stimuli triggers fast automated behaviors (Juola, Koshino & Warner, 1995). Although this model can be used to explain the performance of GADs and healthy controls in our experiment, it does not explain the observed behavior of OCDs.

The reason for the divergence may be that OCDs are more distracted by peripheral stimuli than central stimuli. Their visual sensibility range may be wider than that of healthy controls, so that they can pay more attention to events unfolding within a wider range. A study by Ivarsson and Winge-Westholm (2004) on the traits of children with OCD yielded results consistent with our findings. In their study, through comparison with a healthy group, they concluded that children with OCD have a higher level of shyness and a lower level of activity. Individuals with higher levels of shyness are less likely to be in contact with people, indicating that they experience negative reinforcement from frequent contact with others. Having higher sensitivity to peripheral stimuli may mean that OCDs are more tuned in to the behaviors of the people around them. This constant distraction may impose a drain on their cognitive resources, leading them to avoid social interactions. Tackling the issue of heightened peripheral attention may provide a theoretical basis for the treatment of OCD, especially for the application of behavior therapy.

The behavior inhibition comparison of OCDs and GADs

In order to benchmark inhibition in OCDs, the current study selected GADs as a control group. Aside from pure phobia (which is rarely encountered in clinical practice), GAD is the most common subtype of several anxiety disorders, being the form most prevalent in the primary medical system and the one consuming the most medical resources (Wittchen, 2002). Studies

have shown that GAD may also overlap with OCD on a genetic basis (Radua, van den Heuvel, Surguladze & Mataix-Cols, 2010). In order to reduce the heterogeneity of samples and render the results more representative, we included both GADs and OCDs in our study. The results revealed that the antisaccade error rate and the prosaccade latency of OCDs were both much higher than for GADs. The difference between OCDs and healthy controls was also significantly higher than that between GADs and the healthy group. This is consistent with Kim, Christensen and Ruggieri *et al*.'s (2019) study on adolescents, which found that adolescents with OCD had impaired planning skills compared to GAD and healthy groups. The specific finding in this case was that it takes OCDs more time to solve the SOC stimulation task presented at multiple levels, and they require more actions. In addition, a recent study showed that generalized anxiety disorder does not impair cognitive control in patients, but, rather, cognitive control ability is enhanced under negative interference conditions (Hallion, Tolin & Diefenbach, 2019). This shows that behavior inhibition failure is not a shared mechanism of GAD and OCD. Instead, it is a mechanism which is particular to OCD. This distinction is reflected by the definition of OCD provided in the *Diagnostic and statistical manual of mental disorders* 5th edition (DSM-5). In DSM-5, OCD is no longer classified as one of the anxiety spectrum disorders. Our results, which support an underlying condition-specific mechanism, reinforce the idea that OCD should be treated as an independent disorder.

Limitations and future direction

Different subtypes of OCD have different clinical manifestations. The current study did not take such subtypes into account (e.g., obsessive ideas versus compulsive behaviors). Differences may exist in the internal phenotypes of these subtypes, warranting further investigation. Furthermore, although the current study confirmed the high visual sensitivity of OCDs, especially sensitivity to peripheral stimuli, we only examined the visual sensibility of target stimuli in the horizontal field of vision (left and right). Future studies might investigate whether the same effect is observed for the sensitivity of OCDs in the vertical field of vision.

CONCLUSIONS

The current study yielded the following findings: first, OCDs have difficulty in behavior inhibition, a symptom which may underlie the condition's pathogenesis. Second, comparison between OCDs and GADs suggests that behavior inhibition is an idiosyncratic characteristic feature of OCDs, rather than a comorbidity. Third, OCDs have more difficulty in inhibiting peripheral stimuli than central stimuli, indicating that they have higher visual sensitivity to peripheral stimuli. This sensitivity may reflect a disorder of selective attention.

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