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Executive Control of Attention in Individuals with Contamination-Related Obsessive-Compulsive Symptoms

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Abstract

Background—In the present study, we examined executive control of attention in individuals with contamination-related obsessive-compulsive (OC) symptoms using a modified version of the Eriksen flanker task. The task indexes one's ability to resolve attentional conflict between different responses and to ignore task distracters.

Methods—For the present study, we modified the original flanker task using affective words to examine the effect of threat-relevant stimuli on executive control of attention. Consistent with research on information processing biases in individuals with OC symptoms, we hypothesized that the flanker interference effect (i.e., difference in response latencies between incongruent and congruent flanker trials) will be greater for threat-related flankers in individuals with OC symptoms ($n = 32$), relative to a control group ($n = 36$).

Results—Results of our study were consistent with our hypothesis: The interference effect for threat flankers was greater in individuals with OC symptoms than in those low in symptoms. Moreover, there was no differential interference effect in the low and high symptom groups for neutral flankers.

Conclusions—These findings suggest that the presence of threat-relevant distracters disrupts executive control of attention in individuals with contamination-related OC symptoms. These results are consistent with extant research on attentional biases in individuals with clinical and sub-clinical symptoms of OCD.

Keywords

obsessive-compulsive disorder; attention; executive function

Cognitive models of obsessive-compulsive disorder (OCD) emphasize the role of dysfunctional beliefs [1, 2, 3] in the etiology and maintenance of the disorder. Nevertheless, others have proposed that OCD symptoms may be the result of aberrant information processing [4, 5, 6]. For example, selective attention to threatening information may heighten anxiety and anxiety-related avoidance. With few exceptions [7, 8], several studies have reported an attentional bias towards OCD-relevant material in individuals with clinical and subclinical OCD symptoms [9, 10, 11, 12].

It is now widely agreed that attention is not a unitary construct but rather is composed of distinct components [13]. The studies listed above, however, do not distinguish between the different components of attention. One possibility is that individuals with OCD lack executive control of attention. Attentional control is the ability to use attentional resources to constrain one's cognitive and affective responses to emotional stimuli [14, 15, 16, 17]. Recent evidence suggests that attentional biases may be moderated by attentional control such that greater attentional control allows an individual to inhibit involuntary attention to environmental cues (e.g., threat cues) and behavioral responses to those cues, while low attentional control does not [18, 19]. Moreover, there exists some evidence to suggest that attentional control depends on an executive system that inhibits response tendencies and conceptual associations while regulating involuntary attentional responses [20, 18]. Indeed, the executive system is not a unitary system, but instead refers to a collection of correlated but separable control processes that shape complex behavior [21]. The three most frequently studied executive functions are set shifting, updating working memory, and response inhibition [21]. The third function, the capacity to exercise inhibitory control, is likely involved in psychopathology. For instance, response inhibition is related to attentional difficulties in childhood and adolescence [22], ADHD, and substance use disorders [23, 24].

Given the difficulty patients with OCD have in inhibiting unwanted intrusive thoughts and images, it may be the case that deficits in response inhibition play a role in the etiology or maintenance of this disorder. For instance, McNally, Wilhelm, Buhlmann, and Shin [25] found marginal support for impaired negative priming in patients with OCD, suggesting a possible deficit in the ability to minimize the processing of irrelevant threatening information. Such failure to inhibit the processing of irrelevant disturbing stimuli automatically may result in the individual being bombarded with unwanted intrusive thoughts and images [5].

In the present study, we examined the response inhibition component of executive attentional control in individuals with obsessive-compulsive (OC) symptoms. To examine this component of executive attentional control, we used a modified version of the Eriksen flanker task [26], which indexes one's ability to resolve attentional conflict between different responses and to ignore task distracters. The Eriksen flanker task has been used extensively in previous studies examining response inhibition [27,28, 29]. In this task, the participant responds to a target stimulus while ignoring flanking stimuli. Flankers are presented on either side of the target and require either the same response or a different response than the target. Typically, participants have faster response latencies when all stimuli require the same response (i.e., are congruent) than when the flanking stimuli are different (i.e., are incongruent) than the target stimulus. In the original Eriksen flanker task [26], participants were instructed to identify the center letter in a string of seven letters. Thus, the original flanker task did not assess the influence of stimulus meaning on attentional allocation.

To examine the influence of affect on response inhibition in non-clinical individuals, Fenske and Eastwood [30] used stylized facial stimuli in a flanker paradigm. They found that frowning target faces elicited a smaller flanker incongruency effect than did smiling or neutral target faces. The authors discussed these results as evidence for the influence of

affective stimuli on the constriction of attention. Hortsman, Borgstaedt, and Heumann [31] replicated the finding that a positive face flanked by negative faces suffers more interference than a negative face flanked by positive faces. However, they concluded that the flanker incongruency effect with affective faces cannot be unambiguously attributed to emotional differences and may instead be due to perceptual differences between the stimuli.

Circumventing the use of affective faces, Ochsner, Hughes, Robertson, Cooper, and Gabrieli [32] used affective words in a modified Eriksen flanker task. Participants were presented with three words and were instructed to indicate whether the center word was positive or negative. They found that participants took longer to respond to trials in which the target stimulus was affectively incongruent with the flanking stimuli (e.g., torture triumph torture) than to trials in which the target and flanking stimuli were affectively congruent (e.g., torture murder torture).

In summary, these studies suggest that the modified Eriksen flanker task can be used to examine the effect of valence on executive control of attention. For the present study, we modified the original flanker task using affective words to examine executive control of attention in individuals with contamination-related OC symptoms. We included words specific to contamination-related threat (e.g., infection, filthy). Consistent with research on information processing biases in individuals with OC symptoms, we hypothesized that the flanker interference effect (i.e., difference in response latencies between incongruent and congruent flankers) will be greater for trials with threat-related flankers in individuals with contamination-related OC symptoms, relative to a control group. Moreover, no such differences should exist for trials with neutral flankers.

Method

Participants

Participants were 101 individuals recruited with an advertisement for individuals who “have concerns about germs, dirt, or contamination.” These participants were drawn from a pool of undergraduates at a large university and received course credit for their participation. Participants were classified as high contamination (HC, $n = 32$) if they scored 4 or higher (top 25% of the sample) on the washing subscale of the Obsessive-Compulsive Inventory Revised (OCI-R) [33] or a low contamination control group (LC; $n = 36$) if they scored 1 or less (bottom 25% of the sample).

Self-Report Measures

The Obsessive Compulsive Inventory Revised (OCI-R) [33] is an 18 item measure comprising statements about everyday experiences that are relevant to general obsessive compulsive symptoms. Using a 5 point scale ranging from not at all to extremely, participants rate how distressed they would feel by the experience described in the statement. The OCI-R comprises 6 subscales: washing, checking/doubting, obsessing, mental neutralizing, ordering, and hoarding. The scale has been shown to have good psychometric properties [33]. More specifically, the OCI-R has been shown to have good internal consistency with student populations, with Cronbach's alpha coefficients of 0.88 for the total score and 0.76 for the washing subscale [34]. In the present study, Cronbach's

alphas for the total sample were 0.87 and 0.84 for the total OCI-R scale and the washing subscale respectively. Participants also completed both the state and trait versions of the Spielberger State-Trait Anxiety Inventory (STAI-S/T) [35]. The STAI-S/T has adequate psychometric properties. Participants also completed the Beck Depression Inventory II (BDI-II) [36], a reliable and well-validated, self-report measure of symptoms of depression.

Procedure

After giving informed consent, participants completed a demographics questionnaire and other self-report questionnaires (OCI-R, STAI - S/T, BDI-II), followed by the modified Eriksen flanker task.

Modified Eriksen Flanker Task—Based on the procedure outlined by Fan, McCandliss, Sommer, Raz, and Posner [37], each trial began with a fixation cross presented in the center of the computer screen for 400-1600ms. Next, the cross was replaced by either a blank screen or by asterisk cues that appeared above, below, or both above and below, the location of the cross for 100ms.¹ Next, a row of three words appeared either above or below the location of the fixation cross. In the test trials, the center word was flanked by words that were either congruent in valence (e.g., contaminate feces contaminate) or by words that were incongruent in valence (e.g., tomato feces tomato). The words remained on the screen until the participant responded (see Figure 1).

Participants were given the following instructions:

Your task is to simply make a decision about the emotional valence of the middle word. That is, if the word in the middle is threat related (meaning, it is a negative word for you) press the left mouse button. If the word in the middle is neutral press the right mouse button. That is, regardless of the other words, press the left button if the center word is negative for you and press the right button if the center word is neutral for you. For example if you see “apple danger apple” you would press the left mouse button if “danger” has a negative meaning for you. Please try to respond as fast as possible, but make sure your responses are accurate.

Participants first completed 12 practice trials. Next, they completed a total of 80 test trials comprising 4 presentations of each combination of cueing condition (5: none, center, double, upper, and lower), valence of center word (2: threat or neutral), and congruency between center word and flankers (2: congruent or incongruent). Trials were presented in a new random order to each participant.

The stimuli used in the task were derived from words used in previous studies of attentional bias in OCD [9, 10, 11]. Threat-related words (e.g., filthy, feces, infection) were matched in frequency and length [38] to neutral words (e.g., handwriting, guppy, tomato). In a separate investigation, the words used in the current study were rated by an HC (n = 99) and an LC (n = 95) group. Participants were asked to rate the emotionality, from -3 (“How disturbing is the word *for you*, not for people in general”) to +3 (“How pleasant is the word *for you*, not for people in general”) of each word. As expected, the threat-related words were rated as

¹For the hypotheses examined in the current study, we collapsed data across the cueing conditions.

significantly more personally disturbing than the neutral words by both the HC group [threat-related $M = -2.49$, neutral $M = .32$, $t(98) = -22.88$, $p < .001$] and the LC group [threat-related $M = -2.11$, neutral $M = -0.14$, $t(94) = -12.72$, $p < .001$]. All stimuli were presented in black against a grey background in 12 point Arial font. Participants sat approximately 30 centimeters away from the screen. The computer program for this experiment was written in Delphi (Borland Inc., 2005).

Results

Demographics and Self-report Symptoms

The LC and HC groups did not differ in demographic variables, depression, or general anxiety. As expected, the groups differed significantly on total OCI-R score and on the washing subscale of the OCI-R. Table 1 summarizes these results. For the HC group, the mean total OCI-R score ($M = 24.28$, $SD = 11.83$) and the washing subscale score ($M = 6.66$, $SD = 2.46$) is comparable to the mean score for clinical samples of patients with contamination-related OCD (e.g., in an investigation of the psychometric properties of the OCI-R, Huppert [39] report a total OCI-R score of $M = 29$, $SD = 13.4$, and the washing subscale score of $M = 7.0$, $SD = 3.7$ for patients identified by a clinical interview to have contamination as their primary symptom of OCD).

Modified Eriksen Flanker Task

Trials with incorrect responses were removed from analysis. Mean accuracy did not differ significantly for the LC (93%) and HC (91%) groups, $t(66) = 1.27$, $p = .21$. Response latencies less than 200ms and greater than 3000ms were excluded as outliers (3.12% of correct trials). Response latencies ± 2 SD from each participant's mean response latency were also eliminated from analysis (4.86%).

Threat-Related Bias in Flanker Effect: Threat vs. Neutral Flankers—Consistent with research on information processing biases in individuals with OC symptoms, we predicted that flanker interference would be greater for threat-related flankers in the HC group, relative to the LC group. Moreover, we predicted no such differences for trials with neutral flankers. To test this hypothesis, we submitted response latencies to a 2 (Group: HC, LC) $\times$ 2 (Trial Type: congruent, incongruent) $\times$ 2 (Flanker Type: threat, neutral) ANOVA with repeated measures on the second and third factors. Results revealed a significant Group $\times$ Trial Type $\times$ Flanker Type interaction, $F(1, 66) = 5.33$, $p < .03$, $\eta^2 = .08$. The Group $\times$ Flanker Type interaction was significant, $F(1, 66) = 5.25$, $p < .03$, $\eta^2 = .07$. All other main effects and interaction effects were not significant ($ps > .19$).

To simplify presentation of the results, we submitted flanker interference scores (i.e., difference in response latencies between trials with incongruent flankers and trials with congruent flankers) to a 2 (Group: HC, LC) $\times$ 2 (Flanker Type: threat, neutral) ANOVA with repeated measures on the second factor. As expected, results revealed a significant Group $\times$ Flanker Type interaction, $F(1, 66) = 5.33$, $p < .03$, $\eta^2 = .08$ (see Figure 2). The main effects of Group and Flanker Type were not significant ($ps > .44$). Within-group simple effects analyses revealed no significant difference in flanker interference between

trials with threat flankers and trials with neutral flankers for the LC group, $t(35) = 1.37, p > .17$. However, for the HC group, flanker interference was marginally significantly greater for trials with threat flankers than for trials with neutral flankers, $t(31) = 1.84, p < .08$. Between-group simple effects analyses revealed no significant difference between the LC and HC groups in flanker interference for trials with neutral flankers, $t(66) = 1.31, p > .19, d = .32$, whereas for trials with threat flankers, the HC group showed significantly greater interference than did the LC group, $t(66) = 2.26, p < .03, d = .56$.

Threat-related Bias Indices—We computed a bias score (Flanker Bias) to index the degree to which the flanker interference effect is biased by threat, as compared to neutral, flankers: Flanker Bias index = RT difference between incongruent and congruent trials with threat flankers minus RT difference between incongruent and congruent trials with neutral flankers.

As predicted, an independent samples *t*-test showed that the Flanker Bias index for the HC group was significantly higher ($M = 85, SD = 263$) than for the LC group ($M = -53, SD = 230$), $t(66) = 2.31, p = .02, d = .57$.

Discussion

To our knowledge, this is the first study to examine executive control of attention in individuals with OC symptoms. Results of our study suggest that the presence of threat-relevant distracters disrupts executive control of attention in individuals with contamination-related OC symptoms, indicating a bias towards threat-relevant information. In our study, the flanker interference effect (i.e., difference in response latency between incongruent and congruent trials) for threat flankers was greater in individuals with contamination-related OC symptoms than in those low in symptoms. Moreover, there was no differential interference effect in the low and high symptom groups for neutral flankers. These results are consistent with extant research on attentional biases in individuals with clinical and sub-clinical symptoms of OCD.

Our findings are also consistent with the notion that emotion processing is determined by distinct mechanisms that are responsible for attention regulation and emotion evaluation/generation [20, 40]. Individual differences in symptoms likely affect emotional reactivity to threat-relevant information (bottom-up processes) and the ability to use attentional resources likely controls cognitive responses to this information (top-down processes). Consistent with this view, a recent study by Reinholdt-Dunne, Mogg, and Bradley [19] demonstrated that cognitive interference effects, as measured by an emotional Stroop task, were a function of trait anxiety as well as executive attentional control, as measured by the Eriksen flanker task with neutral stimuli.

Our study has limitations. First, our findings are in a non-clinical sample and therefore may not generalize to individuals with a clinical diagnosis of OCD. Furthermore, since we did not administer diagnostic assessments in the current study, we cannot rule out the possibility that participants met criteria for other disorders that may impact attentional control. Second, we did not include non-contamination, negatively-valenced words in our design and thus

cannot rule out the possibility that our effects may be due to negativity in general and not to contamination per se. Third, to enhance internal consistency of our experimental design, we restricted our sample to the contamination subtype of OCD. It may be the case that our results generalize more readily to other forms of specific fear than to other symptoms of OCD. Additional research with the various OCD subtypes is needed to determine the generalizability of our findings for this heterogeneous disorder.

The above limitations notwithstanding, our study is the first to demonstrate that the presence of threat-relevant distracters disrupts executive control of attention in individuals with obsessive-compulsive symptoms. This disruption likely interferes with their focus on daily tasks as their attentional resources are consumed by irrelevant emotional information. Although differences among individuals in their executive functions are almost entirely attributable to differences among them in their genes [21], extremely high heritability values (e.g., 99% for response inhibition) do not mean that the capacity is immutable. That is, training can modify a person's performance, and hence the population mean, irrespective of the variance among people. Over the past few years, researchers interested in information processing have developed attentional training programs that have yielded positive outcomes for the treatment of various anxiety disorders [41, 42, 43, 44, 45, 46]. A series of studies have shown that training participants to direct attention away from threatening information reduces symptoms across various emotional disorders. According to Derryberry and Reed [18], the "control of voluntary attention may allow anxious persons to limit the impact of threatening information" (p. 202). Thus, it may well be the case that individuals with poor attentional control may be particularly likely to benefit from such attentional training procedures.

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Figure 1.
Example of a modified Eriksen Flanker trial.

Figure 2.

Flanker Interference (i.e., Difference in Response Latencies between Incongruent and Congruent Trials) by Group and Flanker Type.

Table 1

Demographics and questionnaire data

	Group		
	LC (n = 36)	HC (n = 32)	
% Female	77.8	78.1	$\chi^2(1) < .01, p > .97$
Age	19.44 (2.75)	18.53 (1.19)	$t(66) = 1.74, p > .08$
Education	13.56 (1.61)	12.97 (0.91)	$t(65) = 1.79, p > .07$
OCI-R Total	9.19 (7.62)	24.28 (11.83)	$t(66) = 6.32, p < .001$
OCI-R-Contamination	0.42 (0.50)	6.66 (2.46)	$t(66) = 14.90, p < .001$
STAI-State	34.94 (10.37)	38.81 (11.35)	$t(66) = 1.47, p > .14$
STAI-Trait	37.58 (9.72)	41.56 (11.92)	$t(66) = 1.52, p > .13$
BDI-II	10.14 (7.21)	12.34 (7.24)	$t(66) = 1.26, p > .21$

OCI-R = Obsessive-Compulsive Inventory Revised; STAI = Spielberger State/Trait Anxiety Inventory; BDI-II = Beck Depression Inventory