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Enhanced action tendencies in high versus low obsessive-compulsive symptoms: An event-related potential study

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ABSTRACT

Obsessive-compulsive disorder (OCD) is an anxiety disorder characterized by repeated thoughts and behaviors. Inhibitory deficits are presumably related to the onset and maintenance of this disorder. The present study investigated whether obsessive-compulsive (OC) symptoms are related to enhanced response tendencies in reaction to external stimuli. Our goal was to search for direct evidence of an early response preparation process by examining the event-related potential (ERP) component of the readiness potential (RP). An enhanced response tendency might underlie inhibitory deficits in OCD. Response to novel stimuli was studied using a dishabituation paradigm in which a small number of schematic faces (angry or neutral) were presented. An analog sample of healthy subjects was divided into groups of high and low OC levels and high and low trait anxiety levels. The high OC group presented with a greater RP slope gradient that was enhanced under negative valence, compared to the low OC group. No such effect was found in the high versus low trait anxiety groups or in behavioral reaction times (ms). Results support the hypothesis that a stronger *readiness for action* might characterize subjects with OC symptoms, especially in the presence of threatening stimuli. This finding, specific to OC symptoms and not to anxiety symptoms, may underlie habitual and embodiment tendencies in OCD. This study suggests that early stages of motor preparation might be important to the etiology and maintenance of OC symptoms.

1. Introduction

Obsessive-compulsive disorder (OCD) is an anxiety disorder characterized by persistent, intrusive, and distressing obsessions and/or compulsions, and associated with marked impairments in quality of life (Eisen et al., 2006; American Psychiatric Association, 2013). Neuropsychological studies of OCD patients indicate that they show deficits in executive functions (Abramovitch et al., 2011). Response inhibition is one of the most extensively investigated functions that has been found to be impaired in OCD patients. Response inhibition refers to the ability to voluntarily select a task-appropriate, goal-directed response while suppressing a more compelling – but task-inappropriate – response (e.g., Verbruggen and Logan, 2008; Luna et al., 2010).

The literature regarding the executive function of response inhibition in relation to OCD is quite diverse. On the one hand, some research shows evidence of inhibitory deficits in OCD patients and their first degree relatives in measures such as stop response latencies in the stop signal task and higher interference in the Stroop task (Bannon et al., 2002; Chamberlain et al., 2006; Menzies et al., 2007; Penades et al., 2007; for review, see Abramovitch et al. (2013)). On the other hand, other research has found no deficits in behavioral response inhibition in OCD patients (Maltby et al., 2005; Roth et al., 2007; Krishna et al., 2011). Findings in both directions (both supporting and disputing inhibitory deficits in OCD) are focused on stages pertaining to the inhibition of the executed response. However, earlier stages of stimulus processing and their relation to response initiation (before inhibition of the response) have been far less studied (Greenberg et al., 2000; Okasha et al., 2000; Hajcak and Simons, 2002; Gilbert et al., 2004). Possibly, it is not solely the inability to stop a response that impairs inhibition. Perhaps, the early and more intense initiation of a response to a stimulus impairs inhibitory processes as well.

Indeed, preliminary evidence found in the electrophysiological and functional imaging literature suggests that a more intense connectivity between stimulus perception and motor response initiation may be an additional characteristic of OCD symptomology. For instance, Yucel et al. (2007) have shown that OCD patients have a greater relative activation of the supplementary motor area compared with control participants. Another study using transcranial magnetic stimulation (TMS) has shown that subjects with OCD have a lower threshold of motor-evoked potential and an increased intra-cortical disinhibition in comparison to healthy

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control subjects (Greenberg et al., 2000). The hypothesis of an enhanced motor response initiation has yet to be investigated in relation to specific motor responses to external stimuli. However, event-related potential (ERP) studies have shown subjects with OCD to have higher amplitudes in different components (Okasha et al., 2000; Hajcak and Simons, 2002), generally considered to indicate a stronger reactivity of stimulus processing.

Stronger action tendencies in reaction to external stimuli would most likely be manifested in enhanced motor preparatory processes. A well-known electrophysiological correlate of such a preparatory process is the readiness potential (RP), which seems to be the most suitable indicator for assessing brain reaction related to motor activity in response to external stimuli (for a review, see Colebatch (2007)). Therefore, the aim of the present study was to investigate whether OC symptoms are related to enhanced response tendencies in reaction to environmental stimuli. In the current study, the RP component was specifically tested within a simple cognitive dishabituation task in which participants were required to respond to novel stimuli.

We expected subjects with higher OC symptoms to exhibit faster reaction times and greater RP than subjects with lower OC symptoms. This hypothesis relied on research that has shown greater activation of motoric areas, lowered threshold of motor-evoked potentials, and higher ERP amplitudes in various components related to stimulus processing in OCD relative to control subjects. (Greenberg et al., 2000; Okasha et al., 2000; Hajcak and Simons, 2002; Yucel et al., 2007). Furthermore, since OC symptoms demonstrate comorbidity with anxiety disorders (Nestadt et al., 2001; Klein Hofmeijer-Sevink et al., 2013), it was important to establish the specificity of our findings to OCD and to preclude the alternative explanation that trait anxiety explained our results. We expected our effects to be specific to OC symptoms relative to trait anxiety symptoms. Relying on research that indicates higher self-sensitivity and increased vigilance to affective stimuli – specifically danger cues – in OCD (e.g., Doron and Kyrios, 2005), we also expected this effect to be exacerbated in a negative emotional context.

2. Methods

2.1. Subjects

This study involved 14 undergraduate students who received course credit for participation in this experiment (mean age = 23; S.D. = 1.2; 13 females, one male). Exclusion criteria included a history of neurological disorders, current use of medication, head injury, learning disabilities, and left-hand dominance. The study was approved by the Helsinki Ethics Board of Soroka University Medical Center and the Ethics Committee of the Ben-Gurion University of the Negev Psychology Department. All participants provided written and signed informed consent, and were informed that they might be asked for feedback on their questionnaire scores and performance at the end of the experiment.

OCD symptoms were evaluated using the Obsessive-Compulsive Inventory-Revised (OCI-R; Foa et al., 2002). Subjects were divided into two groups according to the OCI-R: high versus low, according to the median OCI-R score (median OCI-R score = 12). In addition, subjects were redivided based on their scores on the State-Trait Anxiety Inventory (STAI; Spielberger, 1983) according to the median STAI score (median STAI score = 37). The high OCI-R group included seven participants (six females, one male, mean OCI-R score = 23.29, S.D. = 10.61, mean STAI score = 36.86, S.D. = 8.8) and the low OCI-R group included seven participants (all females, mean OCI-R score = 5.71, S.D. = 3.95, mean STAI score = 38, S.D. = 7.66). The groups did not differ in age ($t[12]=1.12$, $p=0.142$, one-tailed, mean age = 23.01, S.D. = 1.21). It is important to note that these OCI-R scores were well within the normal range for college students (Sulkowski et al., 2011). Please see Supplementary Table for demographic data.

The high anxiety group included seven participants (all females, mean STAI-trait score = 43.14, S.D. = 6.09, mean OCI-R score = 15.57, S.D. = 14.82) and the low anxiety group included seven participants (six females and one male, mean STAI-trait score = 31.71, S.D. = 4.79, mean OCI-R score = 13.43, S.D. = 9.27). The groups did not differ significantly in age ($t[12]=0.65$, $p=0.27$, mean age = 23.07, one-tailed, and S.D. = 1.21) (Table 1).

2.2. Experimental task

A numerical quantity change task was designed that was similar to the one used by Cantlon et al. (2006). In each experimental trial, subjects were presented with a sequence of stimuli of the same numerical quantity (the habituation stage) followed by a sequence-breaking stimulus of a different numerical quantity (the dishabituation stage) to which subjects were asked to respond with a key press (see Fig. 1). The numerical quantities used were within the subitizing range (1–4) and the stimuli were schematic faces (either angry or neutral, in separate blocks). The length of the habituation sequence was either six or nine slides. In the dishabituation stage, the subjects were presented with a new numerical quantity and were asked to respond with a key press according to the new numerical quantity (e.g., "Press key one when the new numerical quantity is one"). The new numerical quantity would then become the new habituated numerical quantity for the following trial. Each subject was presented with 480 experimental trials. Once subjects pressed any of the four keys indicating the detection of a numerical quantity change, the trial was terminated and the responded-to numerical quantity then became the numerical quantity presented throughout the following set. Each slide was presented for a duration of 600–800 ms followed by a break of 200–400 ms in which the subjects were presented with a black screen.

The stimuli were schematic faces – angry and neutral – created for the purpose of this experiment. Schematic faces were chosen on the assumption that similar neurological mechanisms stand at the base of real-face and schematic-face perception. Further, schematic faces are perceived by an early visual perception mechanism resembling that of threat detection (Sagiv and Bentin, 2001). Each experimental trial consisted of one emotional valence (i.e., angry or neutral)

Table 1
Age, gender, OCI-R score and group (high or low), anxiety score and group (high or low) and values of the readiness potential (RP) slope gradient for each of the 14 participants.

Participant	Age	Gender	OCI-R score	OCI-R group	STAI score	STAI group	RP slope gradient
1	22	Female	25	High	53	High	−0.02856
2	25	Female	24	High	37	Low	−0.01620
3	22	Female	15	High	33	Low	−0.02576
4	21	Female	44	High	37	High	−0.02602
5	23	Male	12	High	29	Low	−0.01892
6	23	Female	26	High	27	Low	−0.05248
7	23	Female	17	High	42	High	−0.04546
8	23	Female	1	Low	46	High	−0.02673
9	24	Female	8	Low	39	High	0.02569
10	24	Female	8	Low	48	High	0.02913
11	24	Female	2	Low	34	Low	−0.01205
12	25	Female	6	Low	37	High	−0.02425
13	22	Female	12	Low	37	Low	−0.02311
14	22	Female	3	Low	25	Low	−0.02771

OCI-R, Obsessive-Compulsive Inventory-Revised. STAI, State-Trait Anxiety Inventory.

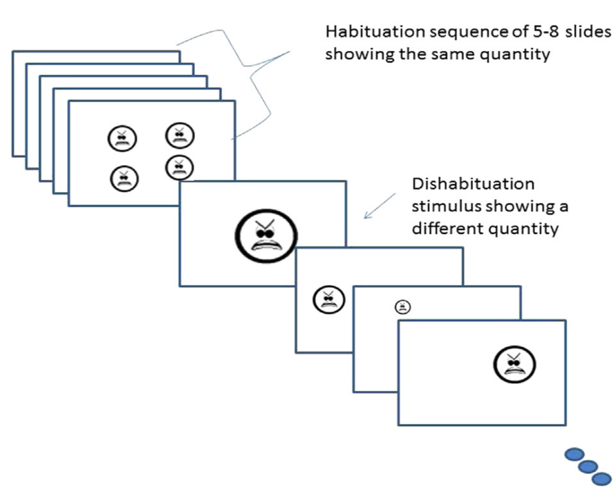

Fig. 1. Example of an experimental trial: habituation to the quantity of four followed by a dishabituation step in which the quantity of one appears and later becomes the new habituated quantity.