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The Impact of Emotional Cues on Response Inhibition in Obsessive-Compulsive Symptoms

Ashleigh M. Harvey
University of Wisconsin-Milwaukee

THE IMPACT OF EMOTIONAL CUES ON RESPONSE INHIBITION IN OBSESSIVE-COMPULSIVE SYMPTOMS

by

Ashleigh M. Harvey

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ABSTRACT

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Ashleigh M. Harvey

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Response inhibition (RI; the ability to inhibit a pre-potent response) has been proposed as a cognitive vulnerability underlying obsessive-compulsive disorder (OCD). However, extant mixed findings about this purported relationship have raised questions of how robust this relationship might be, and whether other contextual factors may not be fully captured by existing study methodologies. Given rates of comorbid depression and real-world clinical observations of the effects of dysphoric mood on OCD, the present study examined the associations between RI, OCD, and dysphoric mood by utilizing an analogue sample and a cross-sectional, within-subjects design. Participants completed the stop-signal and go/no-go tasks to assess various facets of RI capabilities, and completed self-report measures to assess OCD symptom severity and other related constructs. Mood induction videos were used to elicit desired mood states, including dysphoric mood and a neutral/relaxed mood. Results suggested that RI performance did not vary across mood induction tasks. The most notable finding was the severity of concern for being responsible for harm, injury, and bad luck being a significant predictor of commission errors on the go/no-go task, with more severe symptoms relating to poorer performance. Clinical implications and directions for future research are discussed.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

A dissertation on its own is a major accomplishment. However, this dissertation went beyond that, having been completed in the midst of the COVID-19 pandemic. Originally proposed in late 2019, this project underwent major changes in light of the challenges an uncertain and changing world presented to implementation. From conception to completion, I lived in a total of three states: Wisconsin, Texas, and Washington. This information feels like important context to know as I acknowledge those who made this project happen; without them, this would not have been possible.

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Introduction

Response Inhibition

Response inhibition (RI) is considered to be a key characteristic of executive control and higher order functioning, broadly conceptualized as the ability to inhibit a prepotent response (Barkley, 1997). RI has been implemented as playing a role in a wide range of clinic conditions characterized by disinhibition. Developmentally, RI is considered to largely improve across childhood, with a very slight decline occurring across adulthood (i.e., from mid-forties onward) (Williams et al., 1999). While accuracy in responding on cognitive tasks designed to assess RI may not change significantly across the lifespan, both general response time and the ability to inhibit prepotent responses have been demonstrated to become significantly faster with age (Tamm et al., 2002). Researchers have posited that it is not only ongoing neural development in the prefrontal cortex that is responsible for improvements in RI capabilities, but also processes such as synaptic pruning and myelination through late adolescence and early adulthood that allow for RI capabilities to become faster and more efficient (Luna & Sweeney, 2004).

Constructs such as RI have risen to prominence in research due to the role they may play as cognitive vulnerabilities underlying other psychological conditions. Understanding vulnerabilities such as deficits in RI may help us to better understand the etiology, maintenance, and treatment of various mental disorders. This recent focus on cognitive vulnerabilities is highlighted in the National Institute of Mental Health's (NIMH) Research Domain Criteria (RDoC) initiative (Insel et al., 2010). RDoC proposes that rather than focusing on individual diagnoses, we may gain a richer understanding of mental health when examined through the lens of a multi-level framework. Given this conceptualization, the RDoC matrix consists of five research domains: negative valence systems, positive valence systems, cognitive systems,

systems for social processes, and arousal/modulatory systems. Within these five domains exist functional constructs and their corresponding constructs. These domains and constructs can be assessed using RDoC's seven units of analysis: genes, molecules, cells, neural circuits, physiology, behaviors, and self-reports. RI falls under the cognitive systems domain of the RDoC framework; within this domain, it falls under the cognitive control construct. The cognitive control construct is comprised of multiple subconstructs, including: goal selection, updating/representation/maintenance, response selection, response inhibition/suppression, and performance monitoring (NIMH, 2017). It has been proposed that RI itself can be broken down further into three distinct subprocesses (Barkley, 1997). First is action cancellation, which is the stopping of an already ongoing response. Second is action withdrawal or action withholding, which requires inhibiting an action without initiating it (i.e., correctly not responding). Third is interference control, which requires initiating a correct response in the presence of competing stimuli.

Assessment of Response Inhibition

In order to better understand and assess various components of RI, researchers have developed a wide range of paradigms, including those such as the stop-signal, go/no-go, flanker, antisaccade, Stroop, and Simon tasks (Nigg, 2000). The current study utilized two commonly used RI tasks: the stop-signal and go/no-go tasks.

When completing a stop-signal task, participants are instructed to respond as quickly as possible to a target stimuli, but should refrain from responding when a secondary stimulus is also presented (e.g., an auditory tone). Stop-signal tasks are often used to assess *action cancellation* because respondents are instructed to halt a previously initiated response (Zhang et al., 2017; Hamilton et al., 2015; Verbruggen & Logan, 2009). To further illustrate action cancellation, it can be thought of a train having left the station and barreling towards an unsafe, broken track. Successful action cancellation would be the train conductor stopping the train after it has left the station before an accident occurs. The primary outcome variable for the stop-signal task is typically a latent variable known as stop-signal reaction time (SSRT). The stop-signal delay (SSD) is the length of time between the presentation of the visual stimulus and stop signal, and is used in computing SSRT. SSRT is calculated by subtracting average SSD from average go reaction time (i.e., SSRT = mean go RT – mean SSD). The length of the SSD can be manipulated to make the stop-signal task more or less difficult. Early in the field of RI research, RI as a whole (but particularly action cancellation) was conceptualized as a "race model" in which stop and go processes are in competition with one another. According to this model, whether or not an individual responds in a particular situation is determined by which of these two processes reaches the "finish line" first (Logan et al., 1984). More impulsive individuals have been hypothesized to demonstrate poorer performance on the stop-signal task not due to faster prepotent responses, but rather, slower inhibitory responses (Logan et al., 1997).

In a go/no-go task, participants are directed to respond as quickly as possible to "go" trials but refrain from responding on "no-go" trials. These trials are presented in a random order, and different visual stimuli are typically used to differentiate between go and no-go trials. Go/no-go tasks are frequently utilized to assess *action withholding* or *action withdrawal* because they require respondents to inhibit an action without initiating it (i.e., correctly not responding) (Hamilton et al., 2015). To build off of the aforementioned train analogy, action withholding or withdrawal can be thought of preventing the train from leaving the station in the first place. Errors of commission are often used as the outcome variable for go/no-go tasks, as they suggest difficulties in appropriately refraining from responding.

Extant research supports RI being comprised of various subprocesses, and provide evidence for the importance of considering these subcomponents as distinguishable but overlapping constructs through the use of a wide range of cognitive tasks, both through neuroimaging (Sebastian et al., 2013) and behavioral studies (Harvey, 2018). In considering the design of the current study, *action cancellation* and *action withholding* (or *action withdrawal*) emerge as being particularly relevant when considering obsessive-compulsive disorder (OCD) symptomatology. Within OCD, disinhibition plays a role in a patient's ability (or rather, inability) to stop rituals, or prevent from initiating them to begin with. As such, assessing *action cancellation* and *action withholding* with a stop-signal and go/no-go task, respectively, is pertinent to better understanding the relationship between RI and symptoms of the disorder.

Current Findings on Response Inhibition and Obsessive-Compulsive Disorder

OCD is a disorder characterized by persistent and distressing intrusive thoughts and ritualistic behaviors aimed at alleviating anxiety evoked by the obsessive thoughts (American Psychiatric Association, 2013). RI has been proposed to play a role in the etiology and maintenance of OCD, given that the disorder is characterized by impulsivity and behavioral disinhibition. Put another way, individuals with OCD are unable to sit with anxiety or distress, instead performing ritualistic behaviors, whether or overt or covert; they are unable to inhibit compulsions. When considering moving obsessive-compulsive and related disorders (OCRDs) into their own classification cluster in the DSM-5, researchers highlighted shared cognitive deficits as a potential hallmark of these conditions (Stein et al., 2010), suggesting their potential underlying role in these disorders warrants further examination.

Given the proposed role RI deficits may play in OCD, researchers have examined the association between symptoms of OCD and RI capabilities. In a study examining both motor and cognitive inhibition in OCD patients and matched healthy controls, OCD patients were found to perform significantly worse on go/no-go, stop-signal, and motor Stroop tasks (Penadés et al., 2007). When compared to participants with panic disorder, those with OCD have been found to make more commission errors on a go/no-go task and have slower reaction times on interference trials of a Stroop task (Bannon et al., 2002). At the time of this study, OCD and panic disorder were both classified as anxiety disorders in the DSM-IV. These results lend support to differing cognitive deficits underlying anxiety disorders versus OCRDs. A recent meta-analysis investigating studies utilizing the stop-signal task across a wide range of psychopathology found OCD was the condition most typified by deficits in RI capabilities, even when compared to other disorders such as attention-deficit/hyperactivity disorder (ADHD) (Lipszyc & Schachar, 2010).

While many studies have found significant RI deficits in OCD samples, other researchers have failed to find such differences. Using an analogue sample categorized into "high OCD" versus "low OCD," researchers had participants complete a rigorous battery of neuropsychological tests, including go/no-go and Stroop tasks, to assess executive functioning (Hamo et al., 2018). Above and beyond state negative affect, no significant differences were found across major neuropsychological domains, with performance for both groups being in the normative range. In a study examining performance on a stop-signal task in both medicated and unmedicated OCD patients, as well as healthy controls, researchers found no significant differences in SSRT between OCD patients and healthy controls (Kalanthroff et al., 2017). Additionally, no significant differences in performance were found in OCD patients across medication status, even with larger standard deviations in SSRT in the medicated sample. These results suggest while OCD samples may demonstrate variable RI capabilities, RI deficits may not be universally present in those with OCD symptoms. A recent study by Harvey (2018) sought to examine the three RI subprocesses and their association with various OCRD symptoms in an analogue sample. Contrary to study hypotheses, no statistically significant symptom and RI associations were found for a majority of OCRD symptom categories, with the exception of a weak positive correlation between hoarding symptom severity and errors on a flanker task. In this same study, when examining overall RI capabilities through a composite score, this RI index was found to be a significant predictor of hoarding symptoms in individuals at or above the clinical cutoff on the relevant symptom severity measure. Further analysis of this subsample suggested that SSRT was likely the primary contributor to prediction of hoarding symptom severity.

Considering these mixed findings, the proposed association between RI and OCD (and OCRDs as a broader group) may not be as robust as claimed within the current body of literature. Further, they speak to the need to examine the proposed relationship between RI and OCD through various methodologies (e.g., online versus offline samples, self-report versus behaviorally assessed RI, etc.). These mixed findings not only complicate researchers' attempts at better understanding and treating OCD, but also possibly speak to the current replicability crisis faced by the field of psychology in which results of numerous landmark studies cannot be consistently reproduced by other research teams (Pashler & Wagenmakers, 2012). Do these varying results speak to possible errors in our conceptualization of RI and impulsivity as a constructs? Methodological issues of studies? Characteristics of the chosen sample? Other variables that researchers fail to take into consideration? The current study aimed to further assess the purported association between RI capabilities and OCD symptoms while also examining how manipulating mood (a potentially important contextual factor) may impact this association.

Dysphoric Mood and Response Inhibition

Typical research settings strive to create a sterile and controlled environment, but this is not representative of the world within which participants live and operate. Regardless of OCD diagnostic status, daily life includes emotions, both positive and negative. As such, it is important to understand how mood states may play a role in response inhibition abilities. Stemming from this question, researchers have examined how affect-laden stimuli impact RI performance. Using a non-OCD sample, researchers compared brain activation on a go/no-go task using letters and emotional faces as stimuli while using fMRI (Shafritz et al., 2006). Results suggested the letter-based version of the task activated the neural network commonly associated with RI (i.e., the dorsolateral prefrontal cortex, premotor cortex, Broca's area, dorsal striatum, and thalamus). However, in addition to activating these same regions, the emotion-based version of the task also showed activation in the paralimbic cortex and a specific region of the anterior cingulate cortex (ACC) that is an intersection of cognitive and emotional subareas. The researchers posited that responding in an emotionally-driven context not only involves additional emotional neural networks, but also draws on unique areas of the brain that specifically process demanding information through an emotional lens. A more recent investigation utilized event-related potentials to examine RI performance as assessed using a go/no-go task with an affect-laden pictorial background (Albert et al., 2010). Their findings suggested the task was more difficult when done in the context of positive affective valence than in the context of negative affective valence. Interestingly, this change in difficulty was not based on behavioral data, but on changes in electrophysiological data. These results suggest that the cognitive load associated with a task may vary based on affective valence.

In addition to impacting the ability to efficiently make a motor response, emotionally-laden stimuli have also been found to interfere with inhibiting motor responses. Contrary to the aforementioned study, emotionally-laden stimuli have also been found to increase SSRT (indicative of poorer performance) regardless of the valence of the emotion (Verbruggen & De Houwer, 2007). Other researchers have investigated how individual differences might account for mixed findings regarding affective stimuli and RI. Using a Stroop task utilizing task-irrelevant emotional distractors, researchers compared performance across low and high trait anxiety groups (Kalanthroff et al., 2016). Affectively-laden stimuli were presented before task-relevant stimuli to serve as an interference with proactive control, rather than diverting attention during the actual task. These affective stimuli were found to have a significant effect on task performance only for individuals high in trait anxiety. Researchers suggested individuals lower in trait anxiety may be better able to filter out irrelevant emotional stimuli, whereas more anxious individuals find this more difficult given their heightened awareness of emotionally-laden information. As such, it is important to extend this line of research into OCD samples to see how an emotional context may interfere with their ability to successfully inhibit responses.

Taken together, results of extant work examining affect and RI capabilities in non-OCD samples suggest that the presence of affective stimuli can impact performance on cognitive tasks. However, rather than just the presence of affective stimuli, what about inducing a particular mood state within participants? Writing about sad events as compared to everyday events has been found to result in poorer performance on a battery of response inhibition tasks (color-word Stroop, stop-signal, go/no-go), regardless of intensity of sad mood (King, 2020). Interestingly, a study examining emotional reactivity and response inhibition across mood induction tasks found that performance on a stop-signal task improved for highly reactive individuals as negative mood increased, suggesting that particular mood states may result in more intentional processing of information (Gabel & McAuley, 2020). Individuals reporting high state anxiety following a slideshow intended to induce negative mood were found to have more difficulties modulating response styles on a go/no-go task in the presence of angry face distractors (Pacheco-Unguetti et al., 2012). In considering how positive mood induction may impact aspects of cognitive control, positive mood induction (via a comedy video) as compared to a neutral mood induction (via an instructional video) resulted in impairment of working memory but not response inhibition (Martin & Kerns, 2011). Such mixed findings suggest further exploration is warranted of the association between mood and response inhibition capabilities.

Dysphoric Mood and Obsessive-Compulsive Disorder

Extant literature examining the relationship between depression and OCD has mixed findings. Pragmatically from a clinical standpoint, this could be because it is not always possible to tease apart whether depression is simply co-occurring or if it is stemming from impairment and distress associated with OCD (e.g., negative self-image due to unacceptability of intrusive thoughts, social withdrawal due to fears of being triggered around others). Some studies have implicated comorbid depression in poorer treatment outcomes specific to compulsions but not obsessions (Keijsers et al., 1994). A more recent meta-analysis examining potential moderators of treatment outcome found higher pre-treatment depression was not significantly associated with a lower CBT effect size, suggesting depression severity is not a strong predictor of treatment response (Olatunji et al., 2013). In reflecting upon real-world observations in a residential OCD treatment facility, many patients reported days during which they felt more “down” or “depressed” were days they had difficulties resisting compulsions; they reported feeling emotionally drained and therefore not having the willpower to exert effortful control over their rituals in response to elevated anxiety. However, limited work has examined dysphoric mood, OCD, and response inhibition altogether. Given the role that negative affect has been proposed to play in the etiology and maintenance of OCD (e.g., Calkins et al., 2013; Stern et al., 2014), we are interested in seeing how inducing a dysphoric mood state prior to RI task completion impacts participants' abilities to successfully inhibit responses Considering both extant literature and conceptual models of OCD, we predict that individuals with more elevated symptoms of OCD will display poorer RI capabilities on the included tasks when in a dysphoric mood state as compared to a neutral mood state.

Present Study

Extant literature in this area leaves numerous questions unanswered. First and foremost, more work is needed to better understand the possible relationship between RI capabilities and OCD. It is unclear if existing mixed findings can be attributed to differences in study methodologies, samples utilized, or other extraneous variables. More evidence is needed before definitive conclusions can be drawn about the potential casual role of RI deficits as an underlying vulnerability in OCD and related conditions. As a result of largely null findings from a previous study (Harvey, 2018), as well as aforementioned mixed findings in the literature, the question emerged of what other contextual factors may impact the tenuous association between RI and OCD. In particular, we were interested in better understanding potential associations between OCD symptoms, RI, and dysphoric mood. Participants completed self-report measures of OCD and other relevant constructs, as well as computerized cognitive tasks. Utilizing a within-subjects design, participants completed stop-signal and go/no-go tasks following dysphoric mood and neutral/relaxing mood induction videos (with order being randomized).

An analogue sample was used, as symptoms of OCD exist on a continuum and using such a sample allowed for a wide range of symptom severity. Analogue samples are often utilized in OCD research, given the disorder's low base rate of around 2-3% (Kessler et al., 2005). A recent review demonstrated that symptoms of OCD are found in the general population, these symptoms are dimensional as opposed to categorical, thematic content of symptoms are similar across clinical and non-clinical groups, and that the development and maintenance of OCD symptoms appear similar regardless of a clinical diagnosis (Abramowitz et al., 2014). Taken together, the use of an analogue sample in the proposed study was not only appropriate, but also enhanced feasibility in light of recruitment efforts taking place during the COVID-19 pandemic.

The following aims were proposed:

First, we aimed to examine how performance on computerized tasks of response inhibition differed based on mood induction (Aim 1). We hypothesized that participants would demonstrate poorer performance on two cognitive tasks (stop-signal and go/no-go) in a dysphoric mood state as compared to a neutral/relaxed mood state. Second, we investigated how OCD symptom severity might relate to RI deficits alongside dysphoric mood (Aim 2). We hypothesized that more severe symptoms would be related to poorer RI performance in the presence of dysphoric mood. We took an exploratory approach with regards to overall symptom severity versus symptom subtypes as predictor variables. For both of these aims, poorer performance was considered primarily by a longer SSRT on the stop-signal task and more commission errors on the go/no-go task.

Method

Participants

Participants were recruited through the University of Wisconsin – Milwaukee's undergraduate psychology student pool during summer and fall of 2021. A listing for the study was made available on the department’s Sona website. Inclusion criteria consisted of being age 18-60, being a fluent English speaker, and no uncorrected vision or hearing issues. Any participants that self-reported a history of psychosis, unmanaged bipolar disorder, or seizures or other neurological conditions were excluded.

One hundred and two potential participants completed the screening procedure; five participants self-reported a history of psychosis or unmanaged bipolar disorder and one self-reported a history seizures or other neurological conditions. Of these potential participants, 88 signed the main study consent with 66 participants completing all steps of the study procedures. Number of participants included in each analysis varied, given some participants did not complete all steps but still completed relevant tasks/questionnaires for certain analyses, as well as based on criterion used to filter out lower quality task data, including accuracy and expected deviations in scores. Within the completer sample, 26 participants performed in such a way that led to some or all of their RI task data being excluded from some or all analyses. Demographic measures were included midway through study procedures, and as such is not reflective of all those who signed the main study consent nor of those who completed all steps; participants were free to discontinue participation at any time and refuse to answer any questions they felt uncomfortable answering. Based on completed demographic measures (N = 72), mean age of the sample was 22.26 (SD = 4.52). Participants were allowed to self-report as many ethnicities as they identified with, including a self-described option. Sixty-seven participants identified as White or Caucasian, five as Black or African American, three as Asian, and four as American Indian or Alaskan Native, with no participants identifying as Middle Eastern or self-describing.

11.1% of the sample identified as Hispanic or Latino. The sample was 86.1% female, 12.5% male, and one participant self-described as "non+ binary."

Response Inhibition Tasks

The following two computerized cognitive tasks were used to assess RI capabilities. Tasks were hosted through the Inquisit platform. Each task included a practice block consisting of a few trials to ensure participants understood task instructions. Feedback regarding accuracy was provided during these practice trials, but was not provided during testing blocks.

Go/No-Go Task

A go/no-go task (adapted from Casey et al., 1997) was used to assess action withholding (the ability to inhibit a prepotent response). Participants were presented with target and distracter symbols, instructed to press the response key when the target object was displayed (i.e., go trials), but to refrain from responding when a distracter was presented (i.e., no-go trials). Participants were instructed to respond by pressing the space bar for all letters except for X (see Figure 1). Number of commission errors served as the primary outcome variable in this task. The testing block consisted of 140 trials, 75% of which were go trials and 25% of which were no-go trials.

Stop-Signal Task

A stop-signal task (adapted from Chamberlain et al., 2006, 2007) was used to assess action cancellation (the ability to inhibit an ongoing response). Participants were instructed to indicate the orientation of an arrow on the screen using response keys, but to refrain from responding when a stop-signal (i.e., an auditory beep) followed (see Figure 2). The length of time between the presentation of the visual stimulus and stop-signal is the stop-signal delay (SSD). Stop-signal reaction time (SSRT = mean go RT – mean SSD) is a latent variable that served as the primary outcome variable for this task. A tracking algorithm was utilized to adjust the SSD to maintain a 50% inhibition success rate on stop-signal trials. The initial SSD was 250 milliseconds long, with the value being adjusted by 50 milliseconds after each trial to maintain as close to the 50% success rate as possible. Minimum length of the SSD was 0 milliseconds, with the established value being carried over across testing blocks. Two testing blocks with 64 trials each (for a total of 128 trials) were utilized, with a 75% go/25% stop ratio.

Mood Induction Videos

Two separate mood induction videos were utilized, one for dysphoric mood and one for neutral/relaxing mood. Each video was five minutes long and consisted of affect-relevant pictures and music. Pictures were taken from Pixabay, a copyright free image sharing website. Thirty-two images were selected for each mood category, and then five doctoral student members of the Anxiety Disorders Lab at the University of Wisconsin – Milwaukee were asked to answer the question "how does this picture make you feel?" by rating all photos on two 9-point Likert scales (i.e., 1 = dysphoric, 5= neutral, 9 = pleasant; and 1 = relaxed, 5 = neutral, 9 = agitated). Scores across raters were averaged, with the 25 pictures rated as more dysphoric and less relaxing (reference Likert scale rating for interpretation of descriptive statistics) used for the dysphoric video (dysphoric rating: $M = 2.50$, $SD = 0.44$; relaxing rating: $M = 6.54$, $SD = 0.70$), and the inverse used for the neutral/relaxing video (dysphoric rating: $M = 7.47$, $SD = 0.36$; relaxing rating: $M = 2.21$, $SD = 0.41$).

In the final videos, pictures were displayed for 12 seconds each, for a total of 25 pictures per video (for length of five minutes total); affect-relevant music played in the background. Videos were hosted on YouTube (dysphoric video - https://www.youtube.com/watch?v=BEQntwmtpUg; neutral/relaxing video -

https://www.youtube.com/watch?v=4NzObGgJllY) and embedded in Qualtrics, with participants not being given the option to advance to the next Qualtrics screen until enough time had elapsed for the video to play. Participants were instructed to have their volume at a comfortable level so they could both watch and listen.

Dysphoric Mood

Images used in this video included those such as a closed casket in a hearse, an elderly person in a hospital bed holding someone's hand, and impoverished children begging for food. While images were upsetting, no violence or gore was depicted (both in efforts to avoid triggering participants, as well as to avoid eliciting an undesired mood state such as anger or disgust). The first five minutes of Samuel Barber's "Adagio for Strings, Op. 11" (as performed by The London Philharmonic Orchestra on "The 50 Greatest Pieces of Classical Music", 2009) were utilized as background music, as past studies have validated it as a dysphoric piece (Krumhansl, 1997; Baumgartner et al., 2006).

Neutral/Relaxing Mood

Images used in this video included those such as a rowboat on a lake, flowers in an open field, and stones on a beach. Images depicting people and animals were specifically excluded to attempt to make them as neutral as possible, given these pictures may serve as upsetting triggers for some participants. The first five minutes of Claude Debussy's "Clair de Lune" (as performed by the APM Orchestra on "Twilight: Original Motion Picture Soundtrack", 2008) were utilized as background music, as past studies have validated it as a neutral piece (Mitterschiffthaler et al., 2017).

Measures of Symptoms

The following self-report measures were used to assess OCD symptoms, both in terms of what symptom subtypes were present, as well as their severity.

Obsessive-Compulsive Inventory – Revised (OCI-R; Foa et al., 2002)

The OCI-R was used to assess for the severity of OCD symptoms. It is made up of 18 items rated on a 5-point scale from 0 (not at all) to 4 (extremely). It is particularly useful, given that it provides information about specific symptom subtypes. The OCI-R yields a total score and five subscales scores: checking, hoarding, neutralizing, obsessing, ordering, and washing.

Yale Brown Obsessive-Compulsive Scale – Self-Report (YBOCS-SR; Baer et al., 1993)

The self-report version of the Y-BOCS was utilized to assess OCD symptoms and their severity. Both the checklist and severity scales were used. The checklist includes a total of 58 items, which participants were asked to indicate if they experience currently and/or experienced in the past. The severity scale consists of 11 items rated on 5-point scales, with anchor points varying based on the content of the question. The severity scale yields three primary ratings: obsessions severity, compulsions severity, and total severity. An item assessing insight was also included. The clinician-administered Y-BOCS is widely considered the gold standard for assessing the severity of OCD symptoms.

Dimensional Obsessive-Compulsive Scale (DOCS; Abramowitz et al., 2009)

The DOCS is a 20-item measure that assesses OCD symptoms across four dimensions: concerns about germs and contamination; concerns about being responsible for harm, injury, or bad luck; unacceptable thoughts; and concerns about symmetry, completeness, and the need for things to be “just right.” Items are rated on a 5-point scale. Each dimension yields its own subscale score, which can be summed to produce one total score.

Other Self-Report Measures

The following self-report measures were also included in the questionnaire battery, to serve as potential covariates during data analysis.

Barratt Impulsiveness Scale (BIS-11; Patton et al., 1995)

The BIS-11 was used to assess general impulsivity. It contains 30 items rated on a 4-point scale from 1 (rarely/never) to 4 (almost always/always). It yields a total score, three second-order factors, and six first-order factors. These six first order-factors combine to produce the three second-order factors in the following manner: attention and cognitive instability items make up the attentional factor, motor and perseverance items make up the motor factor, and self-control and cognitive complexity items make up the non-planning factor.

State-Trait Anxiety Inventory (STAI; Speilberger et al., 1983)

Both trait and state subscales of the STAI were administered to assess both dispositional and state-dependent experiences of stress and anxiety. The STAI consists of 40 items rated on a 4-point scale from 1 (not at all/almost never) to 4 (very much so/almost always). Separate instructions are provided for each subscale, with the state subscale asking participants to describe how they feel “right now, that is, at this moment” and the trait subscale querying about how they “generally feel.”

Depression Anxiety Stress Scales – short form (DASS-21; Lovibond & Lovibond, 1995)

The DASS-21 assesses three components of negative affect: depression, anxiety, and stress. It is comprised of 21 items rated on a 4-point scale from 0 (did not apply to me at all – never) to 3 (applied to me very much, or most of the time – almost always). It yields subscale scores for each of the three components, as well as a total score. These can all be doubled for direct comparison to the original 42-item DASS.

Abbreviated Profile of Mood States (POMS; Grove & Prapavessis, 1992)

The abbreviated POMS assesses mood states utilizing a total of 40 items across seven subscales: tension, depression, fatigue, vigor, confusion, anger, and esteem-related affect. Items are rated on a 5-point scale from 0 (not at all) to 4 (extremely), with select items being reverse-scored. It yields seven separate subscale scores. For the purposes of the present study, the tension and depression subscales (comprised of six and seven items, respectively) were utilized to serve as a manipulation check for mood induction. These subscales of the POMS were administered immediately before and after each mood induction video to assess for in-the-moment mood state (i.e., administered a total of four times throughout the study).

Procedure

Potential participants signed up for a study slot through the online Sona recruitment system. Given recruitment occurred during the COVID-19 pandemic (i.e., August 2021 through December 2021), all study procedures were conducted on participants' home computers without any interaction with study staff. Any technical issues that arose and were brought to study staff attention were troubleshot via e-mail correspondence.

All forms and questionnaires were hosted on Qualtrics, with all tasks being completed on Inquisit. Potential participants first completed a pre-screening consent form, agreeing to complete two brief questionnaires as part of a screening procedure. The pre-screening consent outlined general inclusion and exclusion criteria and an overview of the full study. Participants who agreed to sign the pre-screening consent form were assigned a randomly generated participant ID code (used to match study responses across surveys and platforms) and were randomly assigned to one of four groups. This study utilized a within-subjects design, so this group number was used to randomize mood induction task order (dysphoric mood, neutral/relaxing mood), and within that, a randomized task order (stop-signal, go/no-go). They were then directed to the screening battery, which consisted of the Diagnostic History Scale (DHS; lab-created measure) and the OCI-R. The DHS is a list of diagnostic categories which participants self-report yes/no to indicate a history of particular groupings of disorders. It was utilized to screen out participants who self-reported exclusionary diagnoses. Upon completion of the screening battery, eligible participants were then directed to the main study consent, which outlined the full study.

After signing the main study consent, participants were directed to the Inquisit platform and instructed to download the Inquisit software and complete a brief system check to ensure sound and response keys were functioning properly. Depending upon their randomly assigned group order, participants either completed the dysphoric mood induction or neutral/relaxing mood induction task first. The POMS was administered immediately before and after each mood induction video, with the mood induction block being followed by both computerized RI tasks (order determined based on group number). In between each block of mood induction/cognitive tasks, participants completed a demographic questionnaire and the general reaction time task in an effort to reduce carry-over effects. Following this demographic questionnaire and reaction time task, participants then completed the remaining mood induction task, again flanked by the POMS and followed by the cognitive tasks.

Following the completion of all computerized tasks, participants then completed the questionnaire battery on Qualtrics. Study procedures took approximately one and a half hours to complete. Participants were compensated for completion in the form of extra credit equivalent to time participated (i.e., participants that withdrew from the study received partial credit based on portions completed). In addition, participants who completed all steps of the study also received a $10.00 digital Amazon gift card. An outline of study procedures can be found in Figure 3.

Results

See Table 1 for descriptive statistics of study measures and RI task indices.

Manipulation Check of the Mood Induction Procedure

Pairwise t-tests were first conducted to examine whether the mood induction tasks induced the intended emotions. This was done by examining scores on the tension and depression subscales of the POMs before and after each mood induction task, with higher scores on tension indicating feeling less relaxed and higher scores on depression indicating feeling more dysphoric. Following the dysphoric mood induction task, participants did not score significantly different on the POMs tension subscale (pre – $M = 6.82$, $SD = 5.44$; post – $M = 7.24$, $SD = 5.26$), $t(73) = -0.85$, $p = 0.40$. They scored significantly higher on the POMs depression subscale (pre – $M = 3.32$, $SD = 3.92$; post – $M = 6.91$, $SD = 5.65$), $t(73) = -6.23$, $p < .001$. These results suggest the dysphoric mood induction had the intended effect, elevating dysphoric mood but not general tension/anxiety. Following the neutral/relaxing mood induction task, participants scored significantly lower on the POMs tension subscale (pre – $M = 8.18$, $SD = 5.89$; post – $M = 3.46$, $SD = 3.94$), $t(71) = 9.22$, $p < .001$. They also scored significantly lower on the POMs depression subscale (pre – $M = 4.18$, $SD = 4.58$; post – $M = 1.81$, $SD = 2.86$), $t(71) = 5.53$, $p < .001$. These results suggest the neutral/relaxing mood induction task had the intended induction effect.

Cognitive Task Performance Across Mood Induction Tasks

Next, we were interested in whether performance on the cognitive tasks varied significantly across mood induction tasks. In order to filter out any task data that was suggestive of non-discriminant responding or misunderstanding task instructions, we utilized the following criteria to be met for inclusion based on recommendation from extant literature in the field (Verbruggen et al., 2019). For the stop-signal task, total accuracy needed to be at or above 80%. Additionally, we also required that the generated p-value for the stop-signal task was at or above 0.05, as p-values below this threshold indicated a participant's response style deviated significantly from the expected 50% overall accuracy. For the go/no-go task, go-trial accuracy needed to be at or above 80%.

Pairwise t-tests were conducted for outcome variables on both iterations of the task. Stop-signal reaction time did not differ significantly between the dysphoric mood induction condition (M = 219.14, SD = 91.15) and the neutral/relaxing mood induction condition (M = 219.44, SD = 81.00), $t(42) = -0.05$, $p = 0.96$. Commission errors did not differ significantly between the dysphoric mood induction condition (M = 7.93, SD = 4.50) and the neutral/relaxing mood induction condition (M = 7.57, SD = 4.68), $t(57) = 0.67$, $p = 0.51$. While the mood induction tasks induced intended emotional states, these results suggested they did not result in different performance on either RI task. Order was not found to have an effect, so we therefore analyzed the whole sample collapsing the order factor.

OCD Symptom Analysis – Dysphoric Mood Induction

We next conducted regression analyses to examine if OC symptoms contributed significantly to RI performance above and beyond general negative affect and impulsivity within the dysphoric block (see Tables 2 and 3). Negative affect was measured by DASS-21 total while impulsivity was measured by BIS-11 total. Analyses utilized planned outcome variables (i.e., SSRT on the stop-signal task, commission errors on the go/no-go task). The DOCS was chosen as the OCD symptom severity measure given it taps into four validated symptom domains (excluding hoarding, which is now considered a separate diagnosis), while simultaneously assessing for the severity of obsessions, compulsions, and avoidance separate from the number of actual obsessions/compulsions present (Abramowitz et al., 2010).

Stop-Signal Task and OCD Symptom Total

A hierarchical multiple regression analysis showed that negative affect (β = 0.10, t = 0.60, p = 0.55) and impulsivity (β = -0.08, t = -0.46, p = 0.65) in Step 1 did not significantly explain the variance in SSRT, R^2 = 0.01, F(2, 45) = 0.24, p = 0.79. In Step 2, after controlling for negative affect and impulsivity, DOCS total explained only an additional 0.4% of the variance, β = -0.08, t = -0.41, p = 0.69; ΔR^2 = 0.004, F_{change}(1, 43) = 0.17, p = 0.69. The regression model did not significantly explain the variance in SSRT, R^2 = 0.01, F(2,44) = 0.21, p = 0.82.

Stop-Signal Task and OCD Symptom Subscales

We then ran a similar hierarchical regression analysis with DOCS subscales in Step 2 in place of DOCS total, to examine if various symptom dimensions may explain RI performance on the stop-signal task. All predictors as a set were not significantly related to SSRT, R^2 = 0.13, F(6, 40) = 0.95, p = 0.47. After controlling for negative affect and impulsivity, DOCS concerns about contamination and germs (β = 0.12, t = 0.54, p = 0.59), DOCS concerns about being responsible for harm/injury/bad luck (β = -0.04, t = -0.18, p = 0.86), DOCS unacceptable thoughts (β = 0.21, t = 1.07, p = 0.29), and DOCS concerns about symmetry/completeness/"just right" (β = -0.34, t = -1.77, p = 0.84) were not significantly related to SSRT, ΔR^2 = 0.12, F_{change}(4, 40) = 1.33, p = 0.28.

Go/No-Go Task and OCD Symptom Total

A hierarchical multiple regression analysis showed that negative affect (β = 0.27, t = 1.78, p = 0.08) and impulsivity (β = -0.23, t = -1.49, p = 0.14) in Step 1 explained 7% of the variance in commission errors, R^2 = 0.07, F(2, 53) = 1.85, p = 0.17. In Step 2, after controlling for negative affect and impulsivity, DOCS total explained only an additional 0.3% of the variance, β = -0.08,

t = -0.43, p = 0.67; ΔR^2 = 0.003, $F_{change}(1, 52)$ = 0.19, p = 0.67. The regression model did not significantly explain the variance in commission errors, R^2 = 0.07, $F(3, 52)$ = 1.28, p = 0.29.

Go/No-Go Task and OCD Symptom Subscales

We then ran a similar hierarchical multiple regression with DOCS subscales in Step 2 in place of DOCS total, to examine if various symptom dimensions may explain RI performance on the go/no-go task. All predictors as a set were significantly related to commission errors, R^2 = 0.24, $F(6, 49)$ = 2.60, p = 0.03. After controlling for negative affect and impulsivity, the DOCS subscales in Step 2 explained an additional 18% of the variance in commission errors, ΔR^2 = 0.18, $F_{change}(4, 49)$ = 2.85, p = 0.03. When considering the contribution of individual predictors, only DOCS concerns about being responsible for harm/injury/bad luck made a significant unique contribution to predicting commission errors (β = 0.49, t = 2.89, p = 0.006). DOCS concerns about contamination and germs (β = -0.26, t = -1.56, p = 0.13), DOCS unacceptable thoughts (β = -0.09, t = -0.53 p = 0.60), and DOCS concerns about symmetry/completeness/"just right" (β = -0.21 t = -1.38, p = 0.17) did not.

OCD Symptom Analysis – Neutral/Relaxing Mood Induction

We then conducted additional regression analyses to examine if OC symptoms contributed significantly to RI performance above and beyond general negative affect and impulsivity within the neutral/relaxing block (see Tables 4 and 5). The same measures and outcome variables were utilized as those within the dysphoric block.

Stop-Signal Task and OCD Symptom Total

A hierarchical multiple regression analysis showed that negative affect (β = 0.18, t = 1.06, p = 0.29) and impulsivity (β = -0.02, t = -0.10, p = 0.92) in Step 1 did not significantly explain the variance in SSRT, R^2 = 0.03, $F(2, 45)$ = 0.67, p = 0.52. In Step 2, after controlling for negative affect and impulsivity, DOCS total explained only an additional 1.0% of the variance, $\beta = -0.14$, $t = -0.68$, $p = 0.50$; $\Delta R^2 = 0.010$, $F_{change}(1, 44) = 0.46$, $p = 0.50$. The regression model did not significantly explain the variance in SSRT, $R^2 = 0.04$, $F(3,44) = 0.60$, $p = 0.62$.

Stop-Signal Task and OCD Symptom Subscales

We then ran a similar hierarchical regression analysis with DOCS subscales in Step 2 in place of DOCS total, to examine if various symptom dimensions may explain RI performance on the stop-signal task. All predictors as a set were not significantly related to SSRT, $R^2 = 0.15$, $F(6, 41) = 1.21$, $p = 0.32$. After controlling for negative affect and impulsivity, DOCS concerns about contamination and germs ($\beta = -0.21$, $t = -0.99$, $p = 0.33$), DOCS concerns about being responsible for harm/injury/bad luck ($\beta = 0.01$, $t = 0.04$, $p = 0.97$), DOCS unacceptable thoughts ($\beta = 0.34$, $t = 1.70$, $p = 0.10$), and DOCS concerns about symmetry/completeness/"just right" ($\beta = -0.26$, $t = -1.42$, $p = 0.16$) were not significantly related to SSRT, $\Delta R^2 = 0.12$, $F_{change}(4, 41) = 1.46$, $p = 0.23$.

Go/No-Go Task and OCD Symptom Total

A hierarchical multiple regression analysis showed that negative affect ($\beta = 0.29$, $t = 1.90$, $p = 0.06$) and impulsivity ($\beta = -0.27$, $t = -1.77$, $p = 0.08$) in Step 1 explained 8% of the variance in commission errors, $R^2 = 0.08$, $F(2, 51) = 2.27$, $p = 0.11$. In Step 2, after controlling for negative affect and impulsivity, DOCS total explained only an additional 1.6% of the variance, $\beta = 0.17$, $t = 0.96$, $p = 0.34$; $\Delta R^2 = 0.016$, $F_{change}(1, 50) = 0.91$, $p = 0.34$. The regression model did not significantly explain the variance in commission errors, $R^2 = 0.10$, $F(3, 50) = 1.81$, $p = 0.16$.

Go/No-Go Task and OCD Symptom Subscales

We then ran a similar hierarchical multiple regression with DOCS subscales in Step 2 in place of DOCS total, to examine if various symptom dimensions may explain RI performance on the go/no-go task. All predictors as a set were significantly related to commission errors, R^2 = 0.24, $F(6, 47) = 2.53$, $p = 0.03$. After controlling for negative affect and impulsivity, the DOCS subscales in Step 2 explained an additional 16% of the variance in commission errors, ΔR^2 = 0.16, $F_{change}(4, 47) = 2.53$, $p = 0.053$. When considering the contribution of individual predictors, only DOCS concerns about being responsible for harm/injury/bad luck made a significant unique contribution to predicting commission errors ($\beta = 0.43$, $t = 2.58$, $p = 0.013$). DOCS concerns about symmetry/completeness/"just right" was trending towards significance ($\beta = -0.30$, $t = -1.94$, $p = 0.058$). DOCS concerns about contamination and germs ($\beta = -0.05$, $t = -0.29$, $p = 0.77$) and DOCS unacceptable thoughts ($\beta = 0.21$, $t = 1.36$, $p = 0.18$) did not make a significant unique contribution.

Discussion

Given the current body of literature examining purported relationships between RI and OCD symptoms is mixed, this present study was designed to examine how other factors may be at play when considering the association between these two constructs. We were particularly interested in the role that dysphoric mood might play, and how this specific mood state may alter RI capabilities. Better understanding how mood impacts the ability to inhibit prepotent responses could provide valuable information on ways in which to bolster current OCD treatment options, especially when considering both high comorbidity rates between depression and OCD (LaSalle, 2004), as well as ways in which co-occurring depression can interfere with adherence to OCD treatment (Wheaton & Gallina, 2019).

The current study examined the relationship between RI, OCD, and dysphoric mood utilizing a cross-sectional, within-subjects design and an analogue sample. We used computerized cognitive tasks (stop-signal and go/no-go) to measure RI capabilities, various psychometrically sound self-report measures to assess OCD symptom severity, and researcher-created videos for a mood induction task. Our first aim was to investigate how participants' performance on the RI tasks compared in a neutral/relaxed mood state versus a dysphoric mood state. While both mood induction tasks elicited the desired mood state, contrary to study hypotheses wherein we predicted poorer performance following the dysphoric mood induction task, participant performance did not vary significantly across tasks. In reflecting upon the study design, administering the POMS again following the completion of each RI task could have provided insight into whether the mood induction videos were potent enough that the associated mood state persisted through task completion. While some studies have demonstrated that a heightened negative emotional state can actually improve performance (Gabel & McAuley, 2020), our study did not find any such difference.

Our second aim was to examine how OCD symptom severity might relate to RI deficits alongside dysphoric mood, with our hypothesis being more severe symptoms would be associated with poorer RI performance in the presence of dysphoric mood. As previously outlined, we chose to utilize the DOCS as our measure of OCD symptom severity, taking an exploratory approach by using total and symptom subtype scores. From these analyses, the only significant finding that emerged was the DOCS subscale assessing being responsible for harm, injury, or bad luck being a significant predictor of commission errors on the go/no-go task, with more severe symptoms relating to poorer performance; this was true for both the dysphoric and neutral/relaxing mood induction tasks. Conceptually, this particular subscale largely taps into the concept of harm avoidance in OCD. Researchers have posited that OCD may be better captured not based on *what* a patient does, but rather *why* they do it (Ecker & Gönner, 2008; Summerfeldt et al., 2014; Bragdon & Coles, 2017). Two motivational core dimensions of OCD have been proposed, including harm avoidance (e.g., hyper-responsibility, inaccurately overestimating threat) and incompleteness (e.g., needing to do things until they feel "just right") (Ecker & Gönner, 2008). When considering why this particular cluster of symptoms might emerge as a significant predictor of commission errors, it is important to reflect on how these symptoms present clinically. Individuals endorsing harm avoidance obsessions tend to engage in compulsions such as repeated checking and reassurance seeking. While checking is certainly linked to both motivational dimensions of OCD – harm avoidance (e.g., "I need to make sure the door is locked so no one breaks in") and incompleteness (e.g., "I don't feel like I can move on until I check the door just one more time") – recent studies have found that harm avoidance was a more robust predictor of checking symptoms than incompleteness (Lee & Wu, 2019). Additionally, when compared to individuals with washing-related OCD symptoms, checkers have been found to perform more poorly on RI tasks (Leopold & Backenstrass, 2015). The go/no-go task taps into action withholding/withdrawal, which assesses an individual's ability to inhibit an action without initiating it (Hamilton et al., 2015). Anecdotally, many patients with harm avoidance OCD report feeling like they "just couldn't help" checking one more time, or "couldn't stop" themselves from asking a loved one for reassurance. As such, this significant finding fits common clinical presentations within harm avoidance OCD.

Reflecting on the original research question of why the current body of work about OCD and RI is so mixed, our results suggest that while overall OCD symptom severity appears to have a negligible association with RI capabilities, considering various dimensions of symptoms via the inclusion of subscales in analyses resulted in a significant increase in the amount of variance explained by OCD symptoms. As such, it is important to consider heterogenous symptom presentations within OCD when examining its association with RI; simply examining overall symptom severity may overlook significant links between more specific symptom manifestations and RI performance. Indeed, extant work has demonstrated that various symptom domains are more strongly linked than others. Poorer RI performance as assessed by the stop-signal task has been found to predict severity of compulsions in OCD, but not obsessions (Berlin & Lee, 2018). A recent meta-analysis found checkers performed poorer on tasks assessing RI as compared to washers, supporting the importance of considering heterogenous symptom presentations when examining the RI-OCD relationship (Leopold & Backenstrass, 2015). However, other investigations have failed to find significant differences in RI capabilities across symptom clusters (Koorenhof & Dommett, 2019). While there is limited (and somewhat mixed) data examining clinical heterogeneity in OCD alongside RI capabilities, there is growing evidence for the importance of studying differential RI associations across OCD symptom domains.

It is also important to note that the heterogeneity of OCD symptoms resulted in varying findings, but also that the heterogeneity of RI constructs also resulted in different findings; significant associations were found on the go/no-go task (which assesses withholding) (Hamilton et al., 2015) but not on the stop-signal task (which assesses action cancellation) (Zhang et al., 2017; Hamilton et al., 2015; Verbruggen & Logan, 2009). While these subconstructs do overlap, they are still conceptually – and neurologically – distinct aspects of overall RI. Within our sample, RI indices of separate tasks were not correlated with one another (see Table 6) providing further evidence for these distinctive subprocesses. Psychophysiological data has demonstrated that these tasks require distinct neural mechanisms, as well as different temporal order of involvement of those mechanisms (Raud et al., 2020). Thus, it is important that researchers not view these tasks as interchangeable, but should carefully consider what aspects of RI are associated with various OCD symptom presentations.

The present study should be considered in light of its limitations. First and foremost, numerous analyses are likely underpowered and therefore the significance of findings should be taken cautiously. While the initial sample size would have been sufficiently powered, online/remote administration of the study may have resulted in a sizable portion of task data being invalid. However, after applying stringent filters to sort out cases in which non-discriminant or inattentive responding appeared to be present, we still retained reasonably good quality data that was included in analyses. When considering how many participants' RI task data was filtered out due to accuracy issues, the question is raised whether instructions were not clear when self-guided. Perhaps an in-person study led by research staff would have resulted in more usable task data. Indeed, a major limitation of the present study was that it was completed entirely remotely and with study staff interaction limited to troubleshooting via e-mail. The ongoing COVID-19 pandemic during study recruitment undoubtedly impacted the study sample size, as well as the quality of some participants' data. While analogue samples have been demonstrated to be acceptable when researching OCD (Abramowitz et al., 2014), the use of a non-clinical sample is also a potential limitation. In particular, using an analogue sample may not capture a significantly sized sample of more severe OCD symptomology, which does not allow for analyses to be conducted with more versus less severe symptom levels. Future studies should also consider clinical heterogeneity within their study design, stemming from the significance of harm avoidance in the present study.

Looking to directions for future research, while the overall pattern of the present study's findings does not implicate mood induction in amplification of possible RI deficits, the question emerges of whether personally relevant variables or constructs rather than general emotional context should be explored. One such construct of particular interest is that of threat, with the presence of threat as it relates to RI capabilities has been explored in the current body of literature. Individuals with OCD are prone to make incorrect estimations of threat (Foa & Kozak, 1985), and as such, it is worth exploring the relationship that may exist between OCD symptoms and RI capabilities within the presence of threat. Further, individuals with OCD have demonstrated poor flexibility in beliefs related to threat, struggling to successfully learn new pairings in a fear reversal paradigm (Apergis-Schoute et al., 2017). While ERP is a well-supported treatment for OCD, it is challenging treatment modality, as it forces patients to confront stimuli they find threatening. Assessing this relationship via computerized tasks would allow for a better understanding of how threat impacts RI capabilities.

Researchers have raised the question of whether threatening visual stimuli impact RI capabilities due to competition for the same cognitive resources, or instead due to avoidance or freezing in the presence of threat (Pereira et al., 2010). One such study examined this question by having healthy individuals complete a go/no-go task in which images that were either neutral (i.e., flowers) or threatening (i.e., spiders) were used in place of a fixation cross on a screen, with the presence of threat distractors resulting in significantly more errors on no-go trials without significantly changing reaction time (Hartikainen et al., 2012). Because of this change in accuracy but not reaction time, the researchers posited diminished RI capabilities in the presence of threatening visual stimuli was not due to a freezing effect, but rather the result of strain on competing cognitive resources. Similarly, in another study, threatening visual stimuli (i.e., spider or snake) impaired both working memory and RI when compared to neutral stimuli (i.e., flower or mushroom) (Lindström & Bohlin, 2012). Threatening stimuli were found to increase both response time and error rate, impacting both working memory and RI, respectively. A notable limitation of studies that utilize threatening visual stimuli in their methodology is that these stimuli are not idiosyncratic. The use of something more objectively threatening such as shock may instead be a more potent way to manipulate threat in future studies in this area of interest. Considering how the role of overestimation of threat has been highlighted as a characteristic of OCD (Sookman & Pinard, 2002), as well as harm avoidance being a core dimension underlying OCD (Ecker & Gönner, 2008), better understanding the role of threat as it relates to RI capabilities is imperative. Ultimately, much remains to be understood about the potential association between OCD and RI, and considering clinical heterogeneity of OCD as well as other potential factors impacting the relationship between the two would be valuable in future work.

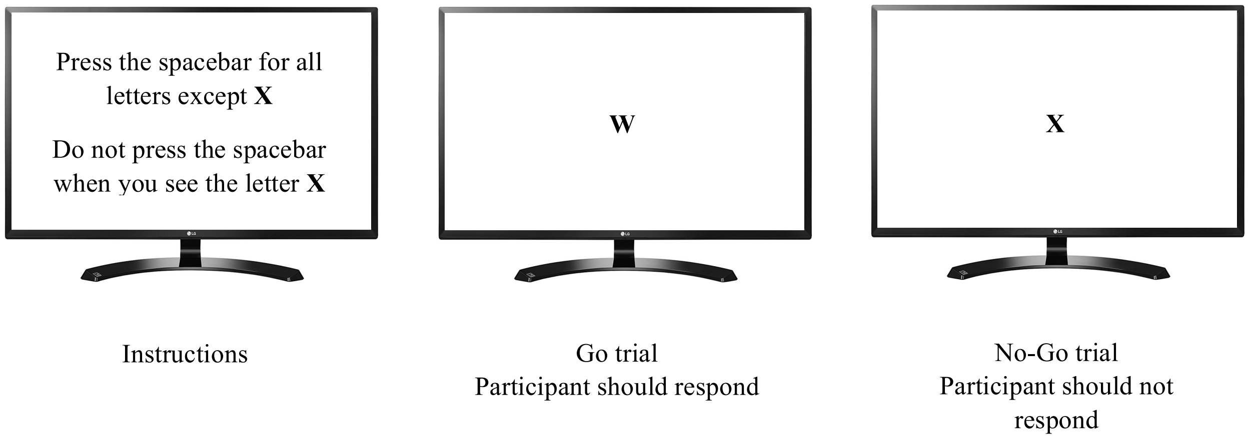

Figure 1. Schematic representation of go/no-go task. Participants are asked to press the spacebar for all letters except for X.

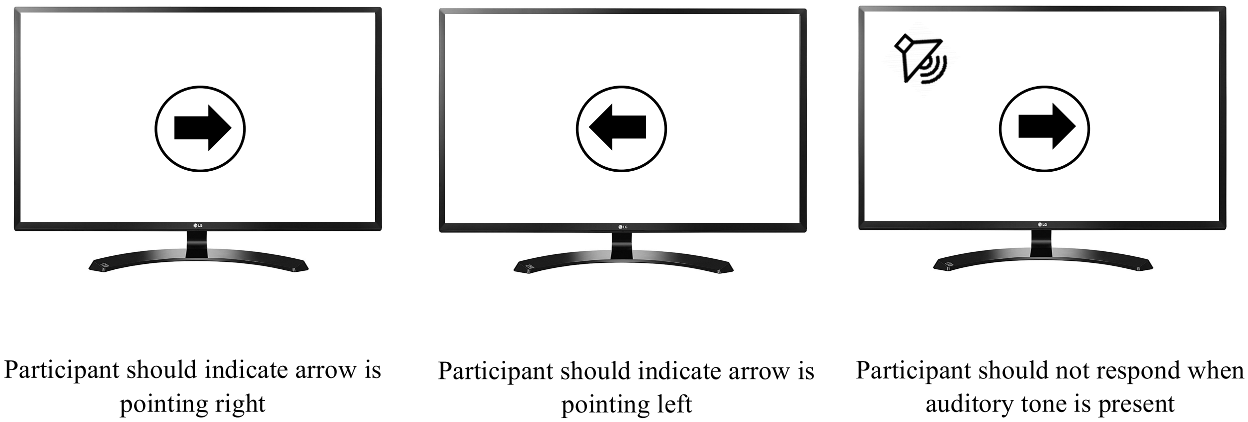

Figure 2. Schematic representation of stop-signal task. Participants should respond with orientation of arrow, except when an auditory tone is present.

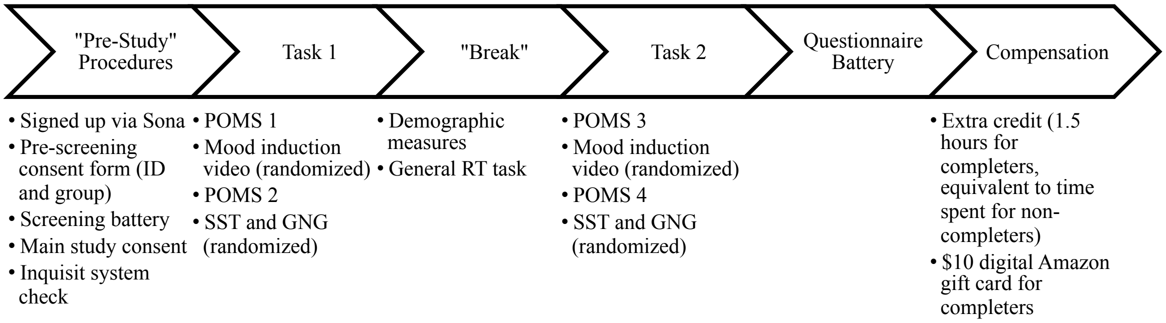

Figure 3. Study flow diagram outlining steps of study procedures.

Table 1

Descriptive Statistics of Study Measures and RI Indices

	N	Mean	Standard Deviation
Go/No-Go 1: Commission Errors	40	7.88	4.61
Stop-Signal 1: SSRT	40	223.89	92.27
Go/No-Go 2: Commission Errors	40	7.93	5.13
Stop-Signal 2: SSRT	40	221.28	83.55
OCI-R Total	40	18.35	15.52
YBOCS-SR Total	39	8.59	6.97
DOCS Total	40	16.63	12.53
Germs and Contamination	40	4.20	3.98
Responsible for Harm, Injury, Bad Luck	40	4.05	4.46
Unacceptable Thoughts	40	5.03	3.98
Symmetry, Completeness, "Just Right"	40	3.35	3.92
BIS-11 Total	39	64.87	10.16
STAI Total	40	45.78	10.87
DASS-21 Total	40	57.75	26.48

Note. Tasks labeled 1 = Dysphoric Block; Tasks labeled 2 = Neutral/Relaxing Block; SSRT = stop-signal reaction time; OCI-R = Obsessive-Compulsive Inventory – Revised; YBOCS = Yale-Brown Obsessive-Compulsive Scale – Self-Report; DOCS = Dimensional Obsessive-Compulsive Scale; BIS-11 = Barratt Impulsiveness Scale; STAI = State-Trait Anxiety Inventory; DASS-21 = Depression Anxiety Stress Scales – short form.

Table 2

Hierarchical Regression Analyses – Dysphoric Block, Stop-Signal Task

Predictors	Stop-Signal Reaction Time			
	ΔR^2	β	t	p
Step 1	0.01			
DASS-21 Total		0.10	0.60	0.55
BIS-11 Total		-0.08	-0.46	0.65
Step 2 – Symptom Total	0.004			
DOCS Total		-0.08	-0.41	0.69
Step 2 – Symptom Subscales	0.12			
Germs and Contamination		0.12	0.54	0.59
Responsible for Harm, Injury, Bad Luck		-0.04	-0.18	0.86
Unacceptable Thoughts		0.21	1.07	0.29
Symmetry, Completeness, "Just Right"		-0.34	-1.77	0.84

Note. DASS-21 = Depression Anxiety Stress Scales – short form; BIS-11 = Barratt Impulsiveness Scale; DOCS = Dimensional Obsessive-Compulsive Scale.

Table 3

Hierarchical Regression Analyses – Dysphoric Block, Go/No-Go Task

Predictors	Commission Errors			
	ΔR^2	β	t	p
Step 1	0.07			
DASS-21 Total		0.27	1.78	0.08
BIS-11 Total		-0.23	-1.49	0.14
Step 2 – Symptom Total	0.003			
DOCS Total		-0.08	-0.43	0.67
Step 2 – Symptom Subscales	0.18			
Germs and Contamination		-0.26	-1.56	0.13
Responsible for Harm, Injury, Bad Luck		0.49	2.89	0.006**
Unacceptable Thoughts		-0.09	-0.53	0.60
Symmetry, Completeness, "Just Right"		-0.21	-1.38	0.17

Note. DASS-21 = Depression Anxiety Stress Scales – short form; BIS-11 = Barratt Impulsiveness Scale; DOCS = Dimensional Obsessive-Compulsive Scale.
$*p < 0.05$, $**p < 0.01$.

Table 4

Hierarchical Regression Analyses – Neutral/Relaxing Block, Stop-Signal Task

Predictors	Stop-Signal Reaction Time			
	ΔR^2	β	t	p
Step 1	0.03			
DASS-21 Total		0.18	1.06	0.29
BIS-11 Total		-0.02	-0.10	0.92
Step 2 – Symptom Total	0.010			
DOCS Total		-0.14	-0.68	0.50
Step 2 – Symptom Subscales	0.12			
Germs and Contamination		-0.21	-0.99	0.33
Responsible for Harm, Injury, Bad Luck		0.01	0.04	0.97
Unacceptable Thoughts		0.34	1.70	0.10
Symmetry, Completeness, “Just Right”		-0.26	-1.42	0.16

Note. DASS-21 = Depression Anxiety Stress Scales – short form; BIS-11 = Barratt Impulsiveness Scale; DOCS = Dimensional Obsessive-Compulsive Scale.

Table 5

Hierarchical Regression Analyses – Neutral/Relaxing Block, Go/No-Go Task

Predictors	Commission Errors			
	ΔR^2	β	t	p
Step 1	0.08			
DASS-21 Total		0.29	1.90	0.06
BIS-11 Total		-0.27	-1.77	0.08
Step 2 – Symptom Total	0.016			
DOCS Total		0.17	0.96	0.34
Step 2 – Symptom Subscales	0.16			
Germs and Contamination		-0.05	-0.29	0.77
Responsible for Harm, Injury, Bad Luck		0.43	2.58	0.013*
Unacceptable Thoughts		0.21	1.36	0.18
Symmetry, Completeness, "Just Right"		-0.30	-1.94	0.058

Note. DASS-21 = Depression Anxiety Stress Scales – short form; BIS-11 = Barratt Impulsiveness Scale; DOCS = Dimensional Obsessive-Compulsive Scale.
*$p < 0.05$, **$p < 0.01$.

Table 6

Correlations of RI Indices

Variable	1	2	3	4
1. Go/No-Go 1: Commission Errors	1.00			
2. Stop-Signal 1: SSRT	0.11	1.00		
3. Go/No-Go 2: Commission Errors	0.65**	0.27	1.00	
4. Stop-Signal 2: SSRT	0.24	0.89**	0.26	1.00

Note. Tasks labeled 1 = Dysphoric Block; Tasks labeled 2 = Neutral/Relaxing Block.
*$p < 0.05$, **$p < 0.01$.

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