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Theories contradict each other by predicting either facilitative or detrimental effects of sad mood on cognitive outcomes. For instance, affect-as-information models hold that sad mood encourages detailed and analytical processing styles, thereby improving cognitive abilities; and resource allocation models predict that sad mood harms cognitive abilities due to sad thoughts that tax limited resources such as attention and working memory. The present study explores these questions by exploring sad mood and one type of cognitive ability—response inhibition (RI). The few studies examining the link between RI and sad mood are mixed in outcome. Understanding whether and how sad mood affects RI will help determine the veracity of theories that predict different cognitive performance outcomes during sad mood, contribute to understanding psychological problems that involve deficits in RI, and inform our ability to measure cognitive constructs such as RI accurately. Further, the strength of a person's ability to regulate their own emotions affects the degree to which emotional states affect their behavior. Thus if sad mood affects RI, emotion regulation may moderate the strength of this effect. This study examines how sad mood and emotion regulation affected RI in a sample of 273 undergraduate psychology students. About half of participants went through a neutral induction where they wrote about a typical day, and the others went through a sad mood induction where they wrote about a sad event they experienced. Emotion regulation was measured with a questionnaire, and an RI composite score of three computerized tasks (Stroop color-word, Stop Signal Task, and Go/No-go) was calculated using Principal Components Analysis. The first hypothesis predicted that sad mood would either increase or decrease RI. The second hypothesis predicted an interaction: that poor emotion regulation would increase this

association in the direction of the main effect (or in either direction if there is no mood main effect). These a priori hypotheses were not supported, but results from post hoc analyses showed that though self-ratings of sad mood did not affect RI, writing about sad events (the experimental condition) seems to worsen RI—perhaps due to participants being distracted by sad thoughts. This result is consistent with cognitive load theories and literature suggesting that cognitive loads, rumination, and mind-wandering are detrimental to cognitive functioning. Further, it extends these findings from well-established areas such as working memory to the less-established area of response inhibition.

SAD MOOD AND RESPONSE INHIBITION

by

Jake Slater King

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Approved by

____
Committee Chair

To Patricia Earley King

APPROVAL PAGE

This dissertation written by Jake Slater King has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Chair ______________________
Rosemery Nelson-Gray

Committee Members ______________________
Kari M. Eddington

____
Michael Kane

____
Stuart Marcovitch

____
Date of Acceptance by Committee

____
Date of Final Oral Examination

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CHAPTER I

INTRODUCTION

Existing theories attempt to explain how information-processing and affective systems interact and operate together. The research literature has not converged on a model, and existing theories suggest different answers. One theory predicts that sad mood distracts people and lowers cognitive abilities, and other theories predict that sad mood aids in cognitive abilities for various reasons. This project examines this question by exploring the interplay between response inhibition and sad mood. Empirical studies on response inhibition and affect are quite sparse, and most existing studies have small samples or are not designed to answer the present research questions. Further, learning about these variables can increase our understanding of problems that involve them such as depression. Also, knowing how sad mood affects response inhibition also has implications in measurement: affective states can be one of the various confounds that can skew a person's score on a cognitive test to be less representative of true ability. The present study sheds light on these questions by manipulating and measuring sad mood and determining whether it affected performance on three response inhibition tasks. Further, whether this association was stronger for those with poor emotion regulation skills was explored.

This introduction begins by discussing theories pertaining to how emotion and cognition interact with one another. Executive functions are then introduced, along with the executive function that is focused on in this project: response inhibition. Examples of the relationship between response inhibition and depression are reviewed to demonstrate this variable's clinical importance, followed by discussion of theories more specific to executive functions. Emotion regulation is then described and considered for its potential to play a role in cognition-emotion interactions. Finally, affect and mood inductions are reviewed with respect to "hot" (emotionally laden) and "cool" (devoid of emotion) response inhibition tasks.

Cognition-Emotion Interaction

Rather than functioning independently, cognition and emotion affect each other in a bidirectional relationship (Ochsner & Phelps, 2007). Huntsinger and Schnall (2013) describe mood as a "diffuse affective state" that does not result from an appraisal, emotion as an affective state that does result from an appraisal, and affect as a more broad term that encompasses both emotion and mood. They describe well-developed literatures showing that affect is essential in determining perception, memory, and perspective; in the other direction, they explain that cognition is key in the forming, experiencing, and regulating of emotions. So in cognition and emotion, one is not "above" or "primary" relative to the other, rather they are intertwined and critical in the proper functioning of the other. Following are brief discussions of some of the ways in which emotion and cognition have been theorized to interact; only a small proportion of this massive literature is reviewed, as the intent is only to demonstrate that these interactions occur and to form a foundation from which to discuss more specifically how mood and executive functions may interact. Also note that these various models are not necessarily mutually exclusive and that they are likely identifying different valid properties of cognition and emotion. Cognition-emotion interactions are complex and are likely mediated and moderated by numerous processes and variables.

Spreading Activation Models

Spreading activation models offer an intuitive explanation for how affect influences cognition, though evidence for them is limited (Huntsinger & Schnall, 2013). These models assert that the thoughts that one has are partially a function of their affective state. For example, Bower's associative network model (1981) asserts that moods are stored in memory and when activated, they spread to associated memory content. In other words, current mood acts as an affective prime that biases recall of thoughts and memories toward those of similar valence. However, Huntsinger and Schnall (2013) concluded from the literature that these effects are weak and only happen in certain situations. They further reason that some mood-congruent recall effects may be explained by people's encoding being influenced by current mood rather than current mood biasing recall toward mood-congruent content. Huntsinger and Schnall (2013) assert that emotions likely are not stored in memory, and that memories are instead reconstructed upon recall, and valenced based on how the memory is interpreted. Forgas and Koch (2013) judge this model more favorably, framing the data as representing boundary conditions rather than limitations: the reliability of mood congruent recall and thought is greatest when the moods are intense and meaningful, when the task at hand is self-referential, and when people use open and elaborate thinking. Other models help to describe these interactions more fully.

Embodiment

The embodiment perspective (or, grounded cognition) offers an additional mechanism through which emotion and cognition affect each other and are affected by the physical world (Barsalou, 2010; Winkielman & Kavanagh, 2013). This perspective stands in contrast to the traditional view of amodal processing, which interprets mental processes as being generated from semantic networks, and does not take sensory and motor features of stimuli into account in describing how the stimuli affect cognition and emotion. Rather, the embodied perspective considers the effects of the body, the body's interactions with the physical world, and sensory modalities on emotion and cognition. For example, vision and bodily states have been found to affect mood and cognition. Participants listing features of a watermelon were more likely to say "red" and "seeds" if they were asked to think about a "half watermelon" compared to if they were asked to think about a "watermelon," indicating that their visualization of the same object, cut in half, affected cognition by changing the features they noticed (Wu & Barsalou, 2009). This effect extended to naming features of a new concept—"glass car"—compared to "car."

Embodiment extends to affective contexts. Havas, Glenberg, and Rinck (2007) had participants place a pen in their teeth or lips to approximate a smile or a frown, respectively. In determining whether a sentence was positive or negative in valence, those "smiling" identified positive sentences faster and those "frowning" identified negative sentences faster. When embodied facial emotions matched the sentence valence, it affected the speed at which participants comprehended and rated the sentence; this is an example of an affective state, or at least an embodiment of an affective state, influencing cognition. Evidence is strong that the somatosensory and motor sides of emotional experiences—such as facial expressions—affect how emotions are processed (Winkielman & Kavanagh, 2013). Work from another perspective supports the possibility of affect itself representing a kind of modality, similar to how the senses have separate modalities. Some researchers found that, when a stimulus was presented via a different sensory modality than the stimulus previously presented, participants took longer to judge whether the stimulus was presented on their left or right side; this modality-switching cost effect was larger when participants switched away from the tactile modality to the hearing or vision modality (Spence, Nicholls, & Driver, 2001). Perhaps there is a reaction time cost in switching away from the “affect modality” (e.g., feeling sad) in order to attend to a sensory modality, thus harming the efficiency of cognition requiring use of the senses.

The aforementioned embodiment research is a small sampling of this impressive literature, which altogether convincingly drives home the notion that embodied cognition belongs in any comprehensive model of cognition. Within the embodiment area, there are numerous potential mechanisms through which emotion and cognition may affect each other.

Affect-as-Information Models

Affect-as-information models have garnered strong empirical support and numerous emotion-cognition interactions can be understood using this framework. A fundamental concept to these models is the Affective Immediacy Principle which holds that affective reactions are subjectively interpreted as pertaining to thoughts that are presently occurring in the mind (Clore, Wyer, Gasper, Gohm, & Isbell, 2001). The affect-as-information models hold that the affect an individual feels communicates information pertinent to areas such as the environment or internal events like thought. For instance, current mood has been observed to affect judgments to a greater extent than thoughts about the object of judgment. In a classic study, participants surveyed on sunny days compared to rainy days indicated greater life satisfaction, presumably due to a more positive mood being used as information in their consideration of their level of life satisfaction (Schwarz & Clore, 1983). Other judgments are also affected by mood and the apparent information it provides, such as feelings of fear and anxiety increasing perceived risk, disgust lowering perceived value of objects, and anger raising the tendency for one to blame others (Huntsinger & Schnall, 2013).

Mood affects memory as well. While some interpret mood-congruent memory recall as the result of mood triggering greater activation of mood-associated content (Forgas & Koch, 2013), others see it as the result of thoughts that have been brought to mind via mood manipulation (perhaps the thoughts are congruent with mood because they caused the mood change, instead of the other way around; Huntsinger & Schnall, 2013). Evidence for such mood priming mood-congruent thought is mixed (Wyer, Clore, & Isbell, 1999). For instance, Rholes, Riskind, and Lane (1987) found that of two mood induction techniques that decreased mood equally, only the one that involved directly triggering mood-consistent content using evaluative statements actually caused mood-congruent recall; the participants who read statements of somatic states often accompanying mood states had a weaker effect on the time it took to recall life experiences. Storbeck and Robinson (2004) compared semantic and affective priming, and concluded that semantic priming is more robust than affective priming. Jiang et al. (2016) reviewed this mixed literature and offered some results of their own: affective priming is prominent over semantic priming under some conditions, for instance, when stimuli are presented quickly and stimulus onset asynchrony is not long enough to eliminate the priming effects. This area is relevant to the debate about the strengths and weaknesses of spreading activation and affect-as-information models of emotion-cognition interaction; with the mixed findings, a review of this topic does not come down clearly on one side of the other. It is likely that both types of priming are important, as there is evidence supporting each.

Most relevant to the present study, affect has been theorized to affect cognition by bringing about associated cognitive processing styles. For instance, Martin and Clore (2001) described positive affect as often co-occurring with a broader focus of attention and a heuristic processing style. By increasing reliance of general knowledge rather than focusing on details, one can consume fewer cognitive resources and instead apply them to other means or tasks (Bless, 2001). This positive affect tendency represents a different allocation of cognitive resources (for instance, toward creative thinking), and not necessarily a reduced use of cognitive resources overall. Negative affect, on the other hand, has been theorized to serve as a signal that people attend to that indicates that there is a problem with the environment—such as too little reinforcement, negative outcomes, or threats to goal attainment (Bless, 2001). In turn, this encourages a finer focus on the details of the situation, which allows the individual to use that knowledge to improve the situation. In other words, a happy person may feel more confident employing the lower-resource-intensive general knowledge structures to a situation, and, toward the end of improving a problematic situation, a sad person may focus more closely on the currently available data rather than relying on general knowledge structures that increase the risk of overlooking meaningful details.

Gasper and Clore's (2002) experiments supported the idea that mood changes thinking style; specifically, those inducted into a sad mood focused more on the fine details of geometric figures and those in happy moods focused more on the general features of the figures. Follow-up work suggests that rather than sad and happy moods directly triggering a focus on "the trees" and "the forest," respectively, that instead positive mood encourages a focus on whichever scale is more accessible (typically, global), with negative mood encouraging a focus on whichever scale is less accessible (typically, local; Huntsinger, Clore, & Bar-Anan, 2010). Said differently, positive mood encouraged the target of focus (global vs. local) that was dominant at the time, such that the focus that was utilized was the one that was most recently primed.

Others have suggested that affect influences cognitive processing by serving as feedback about the value of thoughts currently in mind. Clore and Huntsinger (2007) offer the explanation that affect, in the form of bodily and experiential information, informs the individual about the value of current thought, such that positive affect confers a high value to the thoughts and thus encourages favorable judgements of the thoughts, and negative affect confers a low value to the thoughts and thus discourages favorable judgements of the thoughts. In a later paper (2009), they add that positive affect serves as a kind of "green light" for the cognitive processing strategies that are most accessible, and negative affect serves as a kind of "red light" for these highly accessible strategies (similar to Huntsinger & Schnall's [2013] above description of the role of valence in impacting whether a local or global focus is used). The effect of positive and negative affect on thinking styles likely also impacts cognitive performance. For example a finer focus resulting from a sad mood may improve performance in some situations and worsen it in others.

Effects of Emotion on Cognition

Clearly, emotion and cognition interact in a multitude of ways. This interaction, considered broadly, is complex. Emotion can have an adaptive or maladaptive effect on cognition depending on an array of factors, including intensity of the emotion, type of cognitive process, context, and the degree to which a person is trying to control their emotions (Dolcos, Wang, & Mather, 2014). Emotion's influence on attention and memory are two well-documented examples of this interaction. Emotionally salient stimuli are more likely to be attended to and remembered. This effect can be adaptive for a task or context that requires attending to and remembering these emotional stimuli, yet maladaptive in contexts in which the emotional stimuli distract from the task goal.

Similarly, a certain affect can be adaptive or maladaptive depending on the situation, task, or quality of the affect itself. Two critical components of affect are arousal (with "feeling quiet” and “feeling active” at the extremes) and valence (from “feeling pleasant” to “feeling unpleasant,” Kuppens, Tuerlinckx, Russell, & Barrett, 2013). Available evidence points to a weak V-shaped model where—in aggregate—arousal tends to increase as valence becomes more negative or positive (Kuppens et al., 2013). Arousal and valence may influence cognition in adaptive and maladaptive ways depending on the situation. Lee, Itti, & Mather (2012) had participants identify a line that is tilted to a different slope than the other lines on the screen, where the target line was very different in slope for half of participants (high perceptual saliency), and only slightly different in slope for the other half (low perceptual saliency); all participants completed two types of blocks in counterbalanced order, one block with neutral pictures preceding most trials, the other block with negative pictures preceding most trials (these negative pictures were rated by others as negative in valence *and* high in arousal). Participants in the low saliency condition selected the correct line less often during the negative-picture block compared to during the neutral-picture block, and participants in the high saliency condition selected the correct line more often during the negative-picture block compared to during the neutral-picture block. Authors concluded that arousal improved salient perceptual learning but impaired learning of non-salient stimuli.

Sutherland and Mather (2012) found the same pattern of negative valence and high arousal stimuli increasing detection ability of salient stimuli, except the arousal trials were noises rather than pictures, and the task involved recalling displayed letters rather than judging line slopes. Participants were better able to recall letters that were displayed in high salience, and they were able to recall even more of these letters on negative and high-arousal trials. These results similarly suggest a facilitative effect of negative-valence, high-arousal stimuli in remembering perceptually salient stimuli. Emotion also seems to aid in the recall of prioritized memories, but have the reverse effect on non-prioritized memories. Sakaki, Fryer, and Mather (2014) showed a series of neutral object pictures to participants. When participants were asked to prioritize the object presented before a "perceptual oddball" (distinguished by its frame), they were more likely to recall this object when the oddball was negative vs. neutral in valence; when they were asked to prioritize the oddball picture itself, they were less likely to recall the object before the oddball when the oddball was negative vs. neutral in valence. Overall, emotional arousal increased the ability to remember prioritized content, and decreased the ability to remember less important non-prioritized content. The adaptive function of these effects may be that people in high emotional arousal more easily forget irrelevant details so they can better remember relevant details.

These results are consistent with the arousal-biased competition theory's prediction that arousal increases the mobilization of cognitive resources toward high-priority stimuli, whether the stimuli are determined to be high-priority through bottom-up mechanisms (e.g., perceptual salience), top-down mechanisms (e.g., goal-relevant stimuli), or combinations of the two (e.g., surprise, emotional relevance, or social relevance, Mather & Sutherland, 2011). High arousal and negative affect do not impair performance across the board; instead, these affective states have differential effects depending on the demands of the task.

Executive Functions and Emotion

Executive Functions and Psychopathology

The previous section described emotion and cognition as intertwined in how they function. Existing along with numerous other facets of cognition, executive functioning has been shown to impact a host of important variables. Executive functions have been defined as "a collection of correlated but separable control processes that regulate lower level cognitive processes to shape complex performance" (Friedman et al., 2008, p. 201). There are a few important features of this definition. These processes are distinguishable from each other (i.e., separable), yet their functioning is related to the functioning of other processes (i.e., correlated). They are top-down control processes in that they govern simple cognitive processes such as selecting stimuli to attend to, inhibiting a response, or manipulating data in working memory (thus, this collection of processes is also referred to as cognitive control, executive attention, and attentional control). Zelazo and Carlson (2012) add that executive functions consciously direct thought, action, and emotion in order to reach goals. Further, Schmeichel (2007) provided strong support for the hypothesis that use of executive functions leads to an impaired ability to use executive functions shortly afterward. This is in line with a depletable resource model of executive functions and it suggests that executive functions—though often viewed as stable traits—likely have state components that are malleable to some variables. This opens the possibility of affect triggering state-like changes in people's executive functioning. Response inhibition (RI), one of the executive functions, is the focus of the present study. RI is the ability to suppress dominant or automatic responses that may be inappropriate, unsafe, no longer required, or interfering with goal-directed behavior (Chambers, Garavan, & Bellgrove, 2009; Mostofsky & Simmonds, 2008). There are large literatures devoted to exploring how RI functions in the context of other cognitive processes, such as working memory and attention; this is not a focus of this experiment, but it should be understood that RI never occurs in isolation. For example, successful inhibition of an inappropriate response indicates successful functioning of response inhibition, but this success also may depend on the individual paying attention to relevant stimuli that indicate that the response was inappropriate.

Snyder, Miyake, and Hankin (2015) discuss the relevance of executive functions in mental illness, and how poor executive functioning is associated with transdiagnostic constructs including worry, rumination, and poor emotion regulation. The evidence for executive functioning impairment in mental illness is strong. Meta-analyses have found inhibition and other executive function deficits in schizophrenia (Mesholam-Gately, Giuliano, Goff, Faraone, & Seidman, 2009), major depressive disorder (Snyder, 2013), bipolar disorder (Mann-Wrobel, Carreno, & Dickinson, 2011), obsessive-compulsive disorder (Snyder, Kaiser, Warren, & Heller, 2015), and substance use disorder (Smith, Mattick, Jamadar, & Iredale, 2014), and attention-deficit/hyperactivity disorder (Walshaw, Alloy, & Sabb, 2010).

The executive function link with depression is most pertinent here, due to sad mood being a frequent symptom of major depressive disorder. McIntyre and colleagues (2013) described the role of cognitive functioning in affecting the outcomes for people with major depressive disorder. They report that these cognitive deficits are reliably found and ranging in effect size from small to medium, and that deficits in executive functioning are among the most replicated findings. They qualify that in considering the field’s reliance on mean-level analyses, these effect sizes may be underestimated in that they do not account for people with superior cognitive ability that experience a relative decline in their cognitive skills due to depression, but not to the degree where they would be considered impaired overall. In a review of cognition and depression research, authors stated that those with depression have inhibition deficits, especially when it comes to inhibiting distracting stimuli that are congruent with their depressed mood (Clasen, Disner, & Beevers, 2013). Snyder (2013) conducted a meta-analysis of 113 studies that compared those with major depressive disorder to controls using one or more executive functioning measures. Overall, individuals with depression performed reliably worse on executive functioning measures, and results suggested that higher depression severity was associated with worse performance.

Focusing on RI, a meta-analysis found that participants with depression had worse RI than controls whether measuring RI with tasks lacking in emotional content or with tasks that included emotional content (non-emotional weighted mean effect size = .32 [n = 13 studies], emotional effect size = .22 [n = 7]; Wright, Lipszyc, Dupuis, Thayapararajah, & Schachar, 2014). Participants with bipolar disorder also exhibited worse RI compared to controls (non-emotional effect size = .54 [n = 14], emotional effect size = .47 [n = 6]). A meta-analysis by Epp, Dobson, Dozois, and Frewen (2012) is in line with these findings. They found a large effect size showing worse RI (higher color-word Stroop interference scores) among the clinically depressed compared to controls (Hedges $g = .86$; n = 14 studies; fail-safe $n = 502$). Depression involves many more symptoms besides sad mood, but these associations offer some clues for the impact of sad mood on cognition.

Executive Functions and Mood Theories

Emotion-cognition interactions affect numerous aspects of human experience. Zooming in closer to the topic of this study, Mitchell and Phillips (2007) discussed theories that predict how mood states would affect a family of cognitive activity—executive functioning processes. Seibert and Ashbrook (1988) presented the resource allocation model, which posits that sad mood could act as a distracting cognitive load by encouraging mood-related thoughts that compete with thoughts about the task at hand; this theory has similarities with the spreading activation models discussed above. They predict worse performance on memory tasks during sad mood. They outlined two outcomes for the effect of sad mood on memory task performance. First, sad mood could consume some cognitive capacities such as attention, yet not consume enough to affect task performance. This outcome is more likely if the task requires minimal cognitive capacity or if the mood state is mild. The other outcome is that the sad state consumes so much capacity that it leaves less available to commit to the task, resulting in worse performance. The likelihood of this outcome is increased if the mood state is strong and if the task requires more cognitive resources (Seibert & Ashbrook, 1988).

Mitchell and Phillips (2007) discussed two theories that predict facilitative effects of negative mood on cognition, rather than detrimental effects. One is a type of affect as information theory. It predicts that negative mood tends to trigger a more analytic processing style (Schwarz & Bless, 1991). Authors theorize that the analytic state encourages attention to detail, systemic analysis of information, and logical consistency. Further, they propose that negative mood can indicate that there is a problem in the environment such as there being too few positive outcomes or too many negative outcomes. This may be a mechanism for mood to urge the person to intervene to improve the situation—analytical thinking aids in determining an effective response. In contrast to the heuristic-driven thought style the authors theorize to occur during positive moods, the analytic style from a negative mood is likely to improve one's cognitive abilities. This improvement may be due to greater attention and analysis toward how to perform actions and tasks more effectively; Schwarz and Bless (1991) suggest that when a mechanism activates analytic processing to engage in a task, this processing style is then more likely to be used on other tasks that are carried out, including cognitive tasks. Storbeck and Clore (2005) found just this, with those in sad moods providing fewer false memories than those in happy and neutral moods, perhaps because the analytical thinking style associated with sad moods is less susceptible to false memories compared to the gist processing common among those in happy moods.

A third theory, Mather and Sutherland's arousal-biased competition (2011), does not make specific predictions for executive functions and affect, but extrapolating the theory seems to support facilitative effects of sad mood on response inhibition. As discussed above, the theory predicts that arousal increases selective attention toward stimuli deemed high-priority through any of a variety of mechanisms. The priority-conferring mechanisms most relevant here are surprise and goal-relevance. Stimuli that allow a person to achieve current goals have an attention-grabbing advantage over stimuli that are not helpful in reaching goals. A person in a sad mood (and also probably an aroused state, based on evidence of the "V" shaped arousal-valence association) would experience a higher priority for goal-relevant stimuli and thus be able to respond to them more effectively. For example, they may notice no-go trials more quickly and refrain their response to them more consistently, they may be more in-tune to ink color and more able to ignore the task-irrelevant word text in incongruent Stroop trials, and they may inhibit their response more efficiently to the stop signal in the stop signal task. Also, arousal can increase selective attention toward surprising stimuli; such stimuli in response inhibition tasks include infrequent no-go trials, infrequent stop signals, and incongruent color-word Stroop trials that involve a modality contradiction. These unexpected stimuli may have enhanced priority among sad individuals because perceptual input clashes with prior knowledge, thereby increasing their competitiveness relative to other stimuli (Mather & Sutherland 2011). In short, high arousal (which is correlated with sad mood) increases processing ability for salient stimuli such as infrequent perceptual events or incongruent/surprising stimuli, thus improving response inhibition ability. Note that if this effect is found, it would only hold for response inhibition tasks that involve salient stimuli, for if they were non-salient stimuli, response inhibition ability would decrease.

Altogether these theories predict a variety of affective outcomes on cognition. The general trend in the literature is for affective valence and arousal to impact cognitive ability conditionally based on the situation and task. This makes it challenging to predict the direction of mood effects on a specific cognitive ability such as response inhibition. Regardless of the interplay between these processes, one's capacity to alter and modulate the influence of affect may change the course of how these variables operate together.

Emotion Regulation

Some have approached emotion-cognition interaction questions with an individual differences perspective by considering the impact of emotion regulation capacity. Emotion regulation is a core piece of subjective affective experiences; some reason that almost every affective experience is influenced by efforts of emotion regulation (Kuppens, Oravecz, & Tuerlinckx, 2010). Emotion regulation is a construct that may be relevant in predicting whether sad mood affects response inhibition. Considering the complex and broad nature of the emotion construct, emotion regulation is a similarly complex and broad construct. For instance, Suri, Sheppes, and Gross (2013) see emotion regulation as a process that has an impact on when a person feels emotion, which emotions they feel, how the emotion is experienced and expressed, and what happens when a person has a goal to modify emotion. Guided by Marwaha et al.'s (2014) exploration of emotion regulation definitions in the literature, emotion regulation is defined here as the ability to regulate the onset, course, and intensity of both positive and negative emotions and their behavioral consequences. To integrate this with previously discussed definitions, emotion regulation is conceptualized here as applying to mood and, more broadly, affect. If emotions affect executive functions and if emotion regulation is a key element in the trajectory of emotions, then one's ability to regulate their emotions likely plays a role in the emotion's effect on executive functions. Supporting this, Blair et al. (2007) found evidence that brain processes associated with emotion regulation are used when a task involves emotional distracters. Emotion regulation is a complex process with a number of features to consider.

Emotion regulation is multifaceted. In a seminal paper, Gross (1998) outlines five processes in his process model of emotion regulation, which have helped in understanding the sizeable and complex emotion regulation literature. (1) Situation selection is when people bring themselves into or avoid certain situations as a way influence their emotions. (2) Situation modification involves attempting to change a situation to influence emotion. (3) Attentional deployment is when a person focuses their attention on certain aspects of a situation in order to manage their emotion. (4) Cognitive change is at work when an individual changes how they interpret a situation. (5) Response modulation refers to managing the urges to engage in various behaviors that are a result of the experienced emotion. Attentional deployment and cognitive change are perhaps the most cognitive of the emotion regulation types (Suri et al., 2013).

Emotion regulation is dimensional. Emotion regulation is more complex than an on-off switch. Emotions themselves vary by arousal, valence, and approach-avoidance; likewise, emotion regulation is best described dimensionally (Koole, 2010). Attempts to regulate an emotion vary by the amount of effort in the attempt, degree of success, and the attempted regulation method.

Emotion regulation can be carried out automatically or with effort. These two forms are well-represented on a continuous scale with conscious, effortful, controlled processes on one end and unconscious, effortless, and automatic regulation on the other (Gross & Thompson, 2007). Gyurak, Gross, and Etkin (2011) refined this notion by introducing a dual-process framework intended to help integrate findings on effortful and automatic emotion into a single model. They define effortful emotion regulation as processes requiring conscious effort to begin, some amount of monitoring while they are carried out, and involving some amount of insight and awareness; and they define automatic emotion regulation as processes that are triggered by the stimulus, are carried out and completed without monitoring, and can happen even without the individual's insight or awareness.

Emotion regulation and emotional reactivity are different. Though the experience of an emotion and the regulation of that emotion are not entirely discrete processes, emotional reactivity and emotion regulation are distinguishable. Gross and Thompson (2007) acknowledge that whether emotion and emotion regulation are separable is a difficult question, but they also acknowledge the value of a two-factor view for analyzing basic processes, individual differences, and for designing clinical interventions. Koole (2010) explains that primary and secondary emotional responses can differ qualitatively. For the regulation of an emotion to have a target to act upon, the emotion the person wants to change in some way must first be present. This unregulated emotion is the primary response to a situation and the efforts to change it in some way constitute the emotion regulation effort, leading to the regulated emotion. A unidimensional conceptualization of emotional difficulties is often incomplete; emotion regulation deficits make it harder to manage the emotion that is already there, but more extreme emotional reactivity leads to the generation of more extreme emotions to begin with. Stronger emotions take more emotion regulation to influence, and weaker emotion regulation skills can make even moderate emotional reactions difficult to manage. The emotion regulation construct used here is admittedly intertwined with emotional reactivity, but sorting out these two constructs is outside the scope of this project. Regulation of an emotion changes the course of that emotion's impact on behavior and other outcomes; considering individual differences in the ability to regulate emotions has potential to explain some of the emotion-cognition interaction phenomenon.

Executive Functions and Sad Mood

Hot and cool cognition. Before diving into executive function studies and affect, it is important to differentiate between hot and cool tasks. Zelazo and Carlson (2012) have described executive functioning tasks as either "hot" or "cool." Cool tasks make use of abstract problems that lack context and have minimal if any affective or motivational components. Hot tasks also involve top-down processes, but these processes occur in contexts that encourage greater motivation or emotion due to higher stakes. These situations include tasks or environments with affective stimuli (i.e., emotionally significant), also situations that can result in reward or punishment (i.e., motivationally significant). Similar to how executive functions are entwined in some ways and separable in others, hot and cool executive functioning share some overlap by operating together, but are also governed by some distinct mechanisms (for instance, orbitofrontal area for hot and lateral-prefrontal area for cool executive functioning). This is shown in lesion studies, in which depending on lesion location, people can be impaired in hot, cool, or both forms of executive functioning (Zelazo & Carlson, 2012).

Gutiérrez-Cobo, Cabello, and Fernández-Berrocal (2016) considered hot and cool cognition in regard to emotional intelligence—an individual differences construct that includes emotion regulation as part of its definition, but also emotion-perception, -appraisal, -expression, -understanding, and -use in aiding thought (Mayer & Salovey, 1997). Gutiérrez-Cobo and colleagues (2016) reviewed studies involving cognitive tasks and emotional intelligence, finding that participants exhibiting greater emotional intelligence on performance-based metrics tended to perform better on various hot cognitive tasks; however, there was great variability in the measures used to assess emotional intelligence and cognition. To address this limitation, in a follow-up study they administered hot and cool go/no-go tasks and emotional intelligence measures to 187 psychology undergraduates (2017). The results most relevant here were that those with poor emotional intelligence made more false alarm errors on the hot go/no-go task (i.e., worse response inhibition), but did not make more of these errors on the cool go/no-go. This shows a beneficial relationship between emotional intelligence (a measure related to emotion regulation) and superior performance on hot response inhibition tasks.

Response Inhibition and Sad Mood

Hot RI tasks. Though part of the variance measured by hot RI tasks is the participants' responses to affective content, it is relevant to review some of these studies because other portions of the variance corresponds to RI performance. To examine the relationship between emotional lability and RI, researchers administered several types of go/no-go tasks to 45 undergraduates (Lee, Turkel, Woods, Coffey, & Goetz, 2012). Two of the go/no-go tasks were emotionally neutral (using body-related words and household item words as stimuli, or using male faces and female faces as stimuli), and two of the go/no-go tasks were emotionally valenced (angry vs. happy faces and positive vs. negative words). Using hierarchical regression, two subscales from the Affective Lability Scale – Short Form, Depression-Anxiety and Anger, were not predicted by any RI metrics. However, a scale measuring the tendency to switch between the depression and elation moods was predicted by the commission-error-based RI metric from both the emotional faces and emotional words tasks, as well as the reaction-time-based RI metric from the emotional faces task. No RI metrics from non-emotional go/no-go tasks predicted affective lability scales. So, the emotional RI tasks were better predictors of affective lability than non-emotional RI tasks. Authors interpret these results to mean that a greater degree of changes between feelings of depression and elation seems to be associated with a lower ability to use inhibitory control in emotional contexts. These results should be interpreted with caution due to the small sample size and sampling procedures: 16 people scored high on a questionnaire measure of borderline personality disorder and 29 people scored low. While this yielded a normal distribution of borderline traits which met the normality assumption of the regression analyses they conducted, it limits the extent to which these findings can be generalized to the population of people who have a moderate degree of borderline traits. In another study, researchers administered emotional (happy and sad faces) and non-emotional (green and red circles) go/no-go tasks to the same participants, and more commission errors were made on the no-go trials of the emotional version (Schulz et al., 2007). Others also found that emotional stimuli impaired go/no-go performance (De Houwer & Tibboel, 2010).

Verbruggen and De Houwer (2007) found that emotional content in the Stop Signal Task also worsened RI, though their study lacked an individual differences perspective. Twenty-three undergraduates completed a modified Stop Signal Task where positive, neutral, or negative images appeared briefly before each trial. Stop signal reaction time scores were longer for both negative- and positive-image trials, indicating worse RI; scores did not differ between positive- and negative-image trials. The emotional content embedded in the task reduced RI abilities. This was also the case for researchers who used emotional content as the actual target stimuli in the Stop Signal Task, rather than simply displaying them before the trials (Rebetez, Rochat, Billieux, Gay, & Van der Linden, 2015). Participants had a longer stopping process on trials requiring them to determine the gender of emotional faces, compared to neutral face trials. On another task, emotional trials caused participants to demonstrate poorer inhibition in the form of more proactive interference. Herbert and Sütterlin (2011) reached a similar finding—their participants had longer stop-signal reaction times on trials involving positive or negative words compared to neutral words. Similarly, participants in another study had longer stop-signal reaction times on trials following negative pictures (Kalanthroff, Cohen, & Henik, 2013). Pessoa, Padmala, Kenzer, and Bauer (2012) found facilitative effects of fearful and happy faces in a Stop Signal Task, and detrimental effects of threatening stimuli that had been paired with electric shocks. Consistently, the arousal and/or valence of emotional stimuli has an effect on response inhibition.

Imbir and Jarymowicz (2012) administered the emotional Stroop task to 100 students, and found evidence for the emotional Stroop effect: reaction times for color-naming of neutral words was significantly shorter than reaction times for color-naming of negative words. Gilboa-Schechtman, Revelle, and Gotlib (2000) found greater interference (i.e., worse response inhibition) with negative compared to positive Stroop words. In a sample of 87 undergraduates, Martin and Thomas (2011) found a greater emotion Stroop effect among those who scored low on a measure of emotional intelligence, suggesting that people with greater emotional intelligence are better able to disregard the irrelevant emotional stimuli. Coffey, Berenbaum, and Kerns (2003) obtained a somewhat different result: those self-reporting that they attend more to their emotions exhibited a greater emotional Stroop effect, maybe because they attended more to the emotion words in the task. Overall, evidence is mixed that negative moods impair RI when it is measured using hot tasks.

Cool RI tasks with mood induction. Studies employing hot measures of response inhibition are mixed in whether negative emotion causes detrimental effects on RI ability. Cool tasks offer a different perspective. For instance, Patterson and colleagues addressed a question that cannot be answered with hot RI tasks. They wondered whether emotional experiences may affect RI in a lasting manner, such that they affect RI performance even after the emotional stimuli are not present (Patterson et al., 2016). If RI deficits persist after emotional stimuli have been withdrawn, this would suggest that negative affect can have a lingering detrimental effect on top-down control. They found this effect in a sample of 52 community participants who completed the stop signal task: RI performance (stop-signal reaction time) was significantly worse when participants had viewed a block of negative images before the task. Their work demonstrates that for affect to impact RI performance, the affect-triggering stimuli need not be present within the task itself (as in hot tasks), but instead may be presented before the emotion-lacking task begins (cool tasks). Hot tasks may harm cognitive performance via divided attention, but the effects of emotional stimuli may linger long enough to affect a cool cognitive task.

Other researchers have investigated the effects of a mood induction on RI. Researchers examined RI and emotion responding by administering the stop-signal task to 67 participants, then manipulating their moods to be either neutral, angry, or anxious using autobiographical recall (Tang & Schmeichel, 2014). They found that individuals with worse response inhibition exhibited higher increases in anger after the anger induction. The authors proposed that those with stronger inhibition scores were more successful in regulating emotional states, even after controlling for reactivity-related personality traits. This supports the prediction that RI and emotion regulation are related.

Brand, Verspui, and Oving (1997) found decreased Stroop errors and increased reaction time in a group of 60 participants that received a depressed film clip induction, but no interference differences; the decreased errors may be a reflection of the hypotheses that those in a sad mood have a greater focus on details or on more salient content. Hale and Strickland (1976) failed to find interference differences between a group of 20 people who received a neutral induction and 20 who received a sad induction, and others failed to find sad-mood performance differences in go/no-go or Stroop among 33 participants (Chepenik, Cornew, & Farah, 2007). Smallwood, Fitzgerald, Miles, and Phillips (2009) found that, compared to participants induced into a positive mood, those induced into a negative mood made more errors on a go/no-go task, reported more off-task thoughts, and were less efficient in re-directing attention to the task after an error. These differences did not emerge when comparing those in a negative mood to those in a neutral mood. Imbir and Jarymowicz (2012) administered to 81 university students the antisaccade task. The participants made fewer errors after reading neutral statements compared to reading negative statements.

Few studies have investigated RI and mood state, and most of them suffer from small sample sizes. In searching the research literature, no studies were found that used a composite RI score to investigate affect; rather, they used scores from individual RI tasks. This is important because combining RI scores into a latent variable lessens the task-impurity problem of cognitive measurement and creates a tighter measure of the construct by reducing the amount of random error measurement (Friedman & Miyake, 2017). Thus, little confidence can be placed in these mixed results due to the minimal amount of research that has been done on this research question. Only one study came close to addressing the present research question involving current mood, emotion regulation, and RI (Lee, Turkel, Woods, Coffey, & Goetz, 2012), but they examined the effect of emotional content within the RI tasks (hot tasks), rather than the effect of current mood on cool RI tasks. Further, it is unclear whether RI tasks with emotional content are measuring RI to the same extent that cool RI tasks are. In sum, Mitchell and Phillips' (2007) complaint that there is a lack of research on mood and inhibitory functioning remains true.

These limitations of the existing literature highlight that the relationship between sad mood and response inhibition has not been satisfactorily explored. Understanding this relationship is important for two main reasons. First, it is another test of the various theories predicting mood effects on cognition; does sad mood reduce cognitive efficiency by encouraging a distracting cognitive load, or does it increase cognitive efficiency by encouraging a more analytic thinking style or biasing attention toward goal-relevant stimuli? Understanding the relative value of these theories, and how sad mood and cognition affect each other, can also help us have a deeper understanding for mental illness and how to treat it. Knowing the conditions under which affect and cognition interact to reduce functioning or increase unpleasant or disruptive symptoms may help us to develop more effective treatments.

Hypotheses

Hypothesis One

The first hypothesis is not novel, but it reflects an important association that has not yet been satisfactorily investigated: sad mood is associated with changes in response inhibition. Broadly, this hypothesis concerns whether an affective state impacts a cognitive process. Contrary to independence accounts of affect and cognition, evidence strongly supports an interactive model. Associations between affect and cognition are prevalent in the literature; for instance, emotional stimuli are more likely to be attended to and remembered. More specifically, this hypothesis concerns whether a more transient mood state can affect an executive function. Supporting this premise, negative stimuli have been found to improve cognitive performance in some situations and worsen it in others (Forgas & Koch, 2013). Also, those suffering from mood disorders involving frequent sad mood, such as major depressive disorder, tend to perform worse on executive functioning tasks (e.g., Epp et al., 2012). If emotion and mood affect cognition, and more specifically if mood affects the efficiency of executive functions, then it is likely that sad mood has some influence on another executive function—response inhibition. Though the literature on sad mood and response inhibition is scarce and mixed, there is evidence for the premises on which this hypothesis depends. In the present study, this hypothesis will be supported if a linear multiple regression reveals that sad mood ratings significantly predict the RI score in either direction. If this effect is found, its direction will lend support to some emotion-cognition interaction theories but not others; sad mood impairing response inhibition could be explained by the resource-allocation model, where sad mood and the thoughts that come with it consume cognitive resources, leaving fewer resources to efficiently perform the response inhibition tasks. Sad mood facilitating response inhibition could be explained by the affect-as-information model, where the manipulated sad mood encourages attention to details ("the trees") with the goal of improving the situation, which in turn improves response inhibition performance.

Hypothesis Two

The second hypothesis is that sad mood will have a greater effect on RI scores among those who have more difficulties in emotion regulation. For emotion regulation to impact the sad mood-RI relationship, there must be some capacity for sad mood to affect RI. Further, if this hypothesis is true, emotion regulation ability should show a pattern of moderating other affect-cognition associations, for example by strengthening the effect of affective states on cognitive variables among those unskilled at regulating their emotions (consider Lee, Turkel, Woods, Coffey, & Goetz, 2012). In the present study, this hypothesis will be supported if a linear multiple regression reveals that sad mood ratings and high emotion dysregulation interact to predict RI in the direction of the mood main effect, or in either direction if there is no mood main effect. If there is no mood main effect yet mood and emotion regulation interact to predict RI, it could mean that mood does affect RI, but only in the context of poor emotion regulation.

CHAPTER II

METHOD

Participants

A total of 304 undergraduate psychology students from the University of North Carolina at Greensboro participated in the Fall 2015 and Spring 2016 semesters. All data from 25 people were discarded due to research assistant error, from three people because they did not follow instructions, and from two people due to technical errors. A crude check was used to gauge the sincerity of mood self-reports; to encourage honest responses, participants first read that they have completed the experiment and that they will receive course credit no matter how they answer the following question: “You were asked to rate your mood four times. Did you try to rate your mood honestly?” Options were “Yes” and “No,” but participants were asked to “please explain what you mean” if they answered “No.” Data were deleted for participants who (1) replied “No,” (2) did not indicate any degree of honest responding in the text box, *and* (3) indicated that their reports were inaccurate, for example due to lack of effort or dishonesty. These criteria for data retention were purposefully forgiving so that only the blatant cases of dishonest responding were removed. One person’s data were deleted under these criteria because they indicated that they did not rate their mood honestly and stated that they took their mood rating “down a little” to not “seem expressionless.” Demographics from 30 of the 31 individuals were similar to retained participants in ethnicity (43% African American, 40% Caucasian), sex (67% female), and age (M_{age} = 20.90, SD_{age} = 8.28, with equal variances not assumed t (29) = -1.26, p = .22; the discarded data from one of these 31 people were mistakenly deleted).

Ultimately data from 273 people were retained for exploratory analyses. They were aged 17 to 32 (M_{age} = 18.99, SD_{age} = 1.70; 64% female; 42% African American, 33% Caucasian; see Table 1; with an α-level of .05 and power of .8016, G*Power indicated that 199 participants were required to detect a change in r^2 of .04 [Faul, Erdfelder, Buchner, & Lang, 2009]). There were 225 participants with valid data from all tasks and the questionnaires—these people were used for the a priori analyses (M_{age} = 18.96, SD_{age} = 1.63; 65% female; similar ethnicity distribution).

Materials

Difficulties in Emotion Regulation Scale (DERS)

The DERS is a widely used trait measure of emotion regulation that is comprised of six facets (Gratz & Roemer, 2004). The Nonacceptance facet measures negative secondary emotions that occur in response to negative primary emotions, the Goals facet measures difficulty carrying out goal-directed behavior during negative emotion, and the Impulse facet reflects difficulty controlling behavior in the face of negative emotion. Awareness taps into inattention and un-awareness of emotions, Strategies measures a lack of confidence in one's ability to deal with emotions once they are upset, and Clarity measures how much people know the emotions they are experiencing. The DERS overall score demonstrated convergent validity by correlating in the expected directions with high-quality questionnaires measuring participants' expectations for whether they will be able to regulate negative moods, emotional expressivity, self-harm among women and men, and intimate partner abuse among men. Test-retest reliability was good (ρ = .88, p < .01). In the present sample, Cronbach's α of the six factors ranged from .8 to .9, indicating good internal consistency; the overall DERS scale had Cronbach's α = .93 indicating excellent internal consistency. Correlations between the six factors were similar in Gratz and Roemer's study and in the present study (Table 2).

Data from this scale were deleted for one person because they failed to respond to more than 10% of items. The DERS data were examined visually for response sets—like someone answering in a repeating pattern—and checked for uniform responses with a standard deviation (SD) of zero; no participants exhibited these patterns. There were 272 remaining DERS responses that were used for main or exploratory analyses—none of these responses had missing data and all scores were within 3 SD of the mean, so missing and extreme value replacement were not necessary. After using the subscales to calculate the overall DERS score, the same procedure was used on the subscales. Across the subscales, seven values from six participants were more than 3 SD greater than the mean, so they were replaced with the value 3 SD above the mean.

Response Inhibition

The primary RI measure was the linear combination of three RI tasks. The goal was for this to be a more "clean" measure of RI in two ways. First, it is comprised of RI scores from cool tasks in order to minimize variance from emotional sources, such as differing levels of motivation or one's reaction to emotional content built into the task itself. Along with capturing RI variance, hot tasks capture emotional processing variance; the goal here is to measure cool RI as closely as possible. Second, using a linear combination of all three tasks cuts out some non-RI variance, thereby increasing the proportion of RI variance contained in the RI variable. Many tasks measure RI, yet every task generates error variance that is not associated with RI. Miyake and Friedman (2012) termed this the task-impurity problem; each task is necessarily embedded in a task context which can account for a significant proportion of the variance. One way to obtain a measure of RI with less unrelated variance is to generate a latent variable using three or more tasks that measure RI (Friedman et al., 2008). This variable is comprised of only the variance that multiple RI tasks share. Ideally this variance is mostly associated with RI because the variance unique to each task has been removed. This latent variable provides an RI metric that is less contaminated with error variance. The present study design precludes the use of a latent variable because a Confirmatory Factor Analysis with only three indicators and one factor results in a saturated model (that is, zero degrees of freedom), but a linear combination using Principal Components Analysis also yields a multiple-indicator measure of RI. This is superior to using a simple average score because each indicator can be weighted differently based on its psychometric contributions to the scale (Rencher & Christensen, 2012).

Go/No-Go Task

Criaud and Boulinguez (2013) found in a meta-analysis that the go/no-go paradigm and the stop-signal task have become the two most popular measures of RI based on quantity of published studies. They reviewed 109 fMRI go/no-go tasks and focused on three dimensions that contributed to the level of complexity of the task. First was the level of difficulty in identifying the no-go stimuli, second was the frequency of the no-go stimuli, and third was the working memory requirements of the task. They note that most of the published go/no-go tasks are complex and burdensome in at least one of these dimensions, and that they often require significant functioning of cognitive processes besides RI, for example, selective attention and sustained attention. To maximize RI measurement, the present study used a simple go/no-go design with minimal working memory and stimuli identification requirements.

The three RI computer tasks were run using Inquisit (2014). Participants responded to go stimuli by pressing the space key and tried to refrain from responding to no-go stimuli. An empty horizontal rectangle was displayed as a fixation point for 300 ms, followed by a go or no-go stimulus that was on the screen until the participant responded or until 1,000 ms had passed. Each trial ended with a 700 ms interval. The go stimulus was the empty fixation rectangle filled with green (90% of trials) and the no-go stimulus was the empty rectangle filled with blue (10% of trials). The 250 trials were presented randomly. The RI score reflects failings of RI: the proportion of no-go targets to which the participant responded (i.e., commission errors or false alarms). The plan was to keep all data from the Go/No-go regardless of poor performance, but it was warranted to discard data from one participant who clearly misunderstood the task: they responded to all no-go trials and inhibited responses to all go trials. Four Go/No-go scores that were greater than 3 SD from the mean were replaced with the actual value at 3 SD from the mean.

Stroop Color-Word Task

This task required participants to speak into a microphone the color of the ink in which stimuli were presented. Specifications for this administration are partially based on Friedman and Miyake (2008). Participants began with an 18 trial practice block of control and incongruent trials. Then, 120 trials were presented randomly and without replacement. In 60 control trials, the stimulus was a series of asterisks colored red, black, blue, green, or yellow that was comprised of the same number of asterisks as letters in the color-word (e.g. a black series of asterisks contained five asterisks). Each of the five control stimuli were presented 12 times. In 60 incongruent trials, the stimulus was one of the five previously mentioned color-words that did not match the color of the ink. Each of the 20 incongruent stimuli (such as the word "blue" in red or yellow ink) were presented three times. RI was measured using the interference score: the mean reaction time of correct incongruent trials minus the mean reaction time of correct control trials (congruent trials were not used to calculate interference scores because this score would capture the combined facilitative effect of congruent trials and detrimental effect of incongruent trials, the goal is to isolate the effect of incongruent trials). Each stimulus appeared and stayed on the screen until the participant responded; when participants responded incorrectly, the stimulus disappeared and a red X appeared briefly to indicate their mistake, and when they responded correctly the stimulus simply disappeared. Then the screen was blank for 500 ms before the next trial began.

Stroop data were deemed invalid for those who scored below chance accuracy (20%) for control trials (no data were discarded for this reason) or for those with a mean reaction time on correctly-responded-to control trials > 3 SDs from the overall mean. Long reaction times to complete the simple task of naming a color likely represent poor effort (Stroop data from six people were discarded for this reason). Stroop data from one person were deleted because the task froze and from one other person because they replied “yes” to the survey question that asked if they were colorblind. The Stroop was not administered to one participant because they were deaf and, upon learning that the task required speaking, said they would prefer to not complete the task. To limit the effect of extreme values, interference scores that were greater than 3 SD from the mean were replaced with the actual value at 3 SD from the mean (two extremely low and three extremely high interference scores replaced).

Stop-Signal Task

Participants engaged in a choice reaction time task, for example, pressing a left key in response to a left-facing arrow or a right key in response to a right-facing arrow (Verbruggen &

Logan, 2009). This task had a practice block of 32 trials followed by 3 blocks of 64 trials each; the first trial of each block and the entire practice block were not used. Participants focused on a fixation point until a left or right arrow appeared, pressing the left arrow key if a left arrow appears and the right arrow key if a right arrow appears. Twenty-five percent of trials were stop-signal trials in which a tone played shortly after the arrow appeared. This tone is the stop-signal, and upon hearing it, participants tried to inhibit their response to the stimulus by not pressing any key. The delay between the arrow appearing and the tone playing is called the stop-signal delay, and this value varied based on the participant's performance. When the participant responded when they were supposed to inhibit (a commission error), the next stop-signal trial was made easier by shortening the stop-signal delay by 50 milliseconds. Successful inhibitions resulted in the next stop-signal trial becoming more difficult by lengthening the stop-signal delay by 50 milliseconds. This adjustment procedure was used in determining each participant's stop-signal reaction time (SSRT). The SSRT is an estimate of RI and is a measure of how much time is required for an individual to inhibit an in-progress response before it is completed. An estimate of SSRT was calculated for each participant as described in Verbruggen, Logan, and Stevens (2008): (mean reaction time of all correctly-responded-to no-signal-trials) minus (mean stop-signal delay). To obtain an accurate estimate of SSRT, the stop-signal delay at which participants are able to inhibit about 50% of their responses must be known; in other words, this is the point at which the "race" between the go-process and the stop-process is tied, and this can be used to estimate the SSRT (Williams, Ponesse, Schachar, Logan, & Tannock, 1999). Accordingly, Stop-Signal Task data were deemed invalid if the probability of the participant responding to stop-signal trials was significantly different from .5 ($\alpha < .05$). Thirty-nine people's Stop-Signal data were deleted for this reason, most likely because they did not understand the task or were exhibiting poor effort. Stop-Signal data from one person were deleted because the research assistant did not turn on the speakers, and the task was not administered to one person because they were deaf. No SSRTs were greater than 3 SD from the mean.

People vary on stop-signal reaction time scores, allowing this task to measure trait-like constructs such as RI (though perhaps with state-like components as well). Individuals that have lower stop-signal reaction time scores may have more efficient RI abilities (i.e., compared to others, their stop process takes less time to complete from start to finish relative to their go process). Individuals with lower stop-signal reaction times were more able to inhibit their responses on trials in which stop-signals sounded after longer stop-signal delays.

Mood Induction

Manipulating mood in participants allows us to examine mood "in action" rather than using retrospective self-reports that rely on participants' insight and memory. The mood manipulation technique used in the present study—autobiographical recall—has been shown to effectively increase sad mood in literature reviews and meta-analyses (Martin, 1990; Westermann, Spies, Stahl, & Hesse, 1996). By using an autobiographical mood induction, participants generated their own personalized stimuli which hopefully were more powerful than standard stimuli such as music or pictures. In an attempt to recruit participants' effort to further increase the power of the manipulation, they were instructed to use autobiographical recall to make themselves sad. A concern when participants have insight into the induction is that some may report a mood change when none has occurred (i.e., demand characteristics; Martin, 1990). However, in studies where participants are provided with this insight, they often display signs of mood change that they would not "fake," including changes in eye movements and physiological measures. Additionally, mood change is also often apparent when participants do not realize that they are being observed (Martin, 1990). The purpose of the mood induction was to increase the variability of mood to allow for testing the effects of a wider range of sad mood.

Participants were randomly placed into one of the two conditions using the Qualtrics Survey Flow Randomizer feature. Research assistants were blind to condition. In the 10-minute initial induction, sad-condition participants were provided text instructions: “Please get yourself into a sad mood by reflecting on a sad event from your life for the next 10 minutes” (similar to Gunn & Finn, 2015). They were asked “What was the event?” and to “Please type in as many details as you can remember about the event. Really try to place yourself in the event.” The initial induction for neutral-condition participants was similar: “Please get yourself into a neutral mood by reflecting on what a typical day is like for you for the next 10 minutes.” They were asked “What is a typical day like for you?” and “Please type in as many details as you can remember about your typical day. Really try to place yourself into your typical day.” Participants were unable to move to the next screen until ten minutes had elapsed.

Two redux mood inductions were identical and lasted five minutes. “Please get yourself into a sad/neutral mood by reflecting for 5 minutes on the event/typical day you wrote about earlier. Here is what you wrote:”. The details typed by the participant in the initial induction were displayed below this text for five minutes. The redux mood inductions did not involve more typing.

Mood Self-Report

A continuous mood measure was used in a priori analyses in an attempt to accurately reflect the dimensionality of mood and to conduct a more powerful analysis; this was intended as a measure of valence rather than arousal. The four mood self-reports were visual analogue scales that were presented before the mood induction and before each of the three computerized RI tasks. To check that the induction lasted through the three tasks, multiple check-ins were necessary. A short single-item measure was used in order to allow for these multiple check-ins and to minimize participant fatigue. While it is possible that some validity was sacrificed in using a short measure, the baseline mood measure showed some validity by correlating with the Difficulties in Emotion Regulation Scale. Participants were instructed to "Rate your mood: lower numbers are sad mood and higher numbers are happy mood." Framing mood in this way is acceptable to scientists subscribing to the bipolar conceptualization of affect (e.g., Russell, 2017), but not to those subscribing to the bivariate conceptualization of affect (e.g., Larsen, 2017). Participants responded by dragging a slider along a 0 to 100 point scale to indicate their current mood. The sad mood variable was the mean of the three mood ratings that occurred immediately before each task (mood ratings two, three, and four). Lower scores indicate a more sad mood and higher scores indicate a less sad mood. Mood scores that were less than 3 SD from the mean were replaced with the actual value at 3 SD from the mean (two extremely low mood scores replaced for the baseline mood ratings, but all other mood ratings were within 3 SDs of the mean). These scores are naturally bounded by the scale itself, but extreme values were controlled in this way in order to remain consistent with how other variables were controlled.

Procedure

One to three people participated at once. Each participant sat alone in a room about 21.5 inches from a computer monitor. A blank white wall was behind each monitor. Sessions lasted about 50 – 60 minutes.

Participants signed in and were read a script that included letting them know that their data would be confidential and not linked to their name, and that they will "write about some of your experiences for 10 minutes" and complete three computer tasks. Participants then provided consent, completed a computerized DERS, and completed the first of four mood self-reports. Next was the initial 10-minute phase of the mood induction, followed by administration of the second mood self-report. Participants then completed the first of three counterbalanced response inhibition tasks (Haahr & Haahr, 1998). After the first RI task was the first mood induction redux, followed by the third mood self-report. Next was the second RI task then the second mood induction redux, then the fourth mood self-report. Participants then completed the final RI task, then answered the questions about the sincerity of their attempts to rate their own mood. The study concluded and the participants were debriefed. (see Figure 1 for Procedural Flow Chart).

CHAPTER III

RESULTS

Data Preparation

Data Reduction

The 225 cases with all valid data were used to determine whether reducing the three RI metrics into a single variable would be appropriate. The three RI metrics were standardized and a Principal Components Analysis was conducted on them (see Table 3 for descriptives and Table 4 for Principal Components Analysis). One component was extracted with an eigenvalue of 1.401; the next highest eigenvalue was .866. The first factor explained 46.700% of the variance. Two extremely high values of this component were replaced with the value 3 SD above the mean. All three metrics correlated with the factor at the $p < .001$ level, with Go/No-go $r = .735$, Stop Signal Task $r = .711$, and Stroop Color Word $r = .597$; that is, the extracted linear combination explains between 35.6% and 54.0% of the variance in each of the RI metrics, and though Stroop Color Word contributed significantly to the factor, it contributed less than the other two metrics. The PCA yielded a single interpretable component that correlated with each of the three RI metrics, so it was named the “RI Component” and used in the a priori regression. Higher scores on the RI component indicate *worse* response inhibition.

Analyses

The mood induction was effective. As expected, the first mood rating after the manipulation was different between groups (sad mood mean [SD] = 50.97 [23.05] and neutral group mean = 67.78 [19.74] with Levene's test indicating unequal variances, t (262) = -6.46 with equal variances not assumed, $p < .01$). Baseline mood ratings were not different between groups (sad mood mean (SD) = 71.07 (20.22) and neutral group = 69.64 (19.89) with Levene's test indicating equal variances, t (270) = .59, $p = .56$). See tables 5 and 6 for correlation matrices. Notably, the RI Component correlated negatively with the mood condition variable, indicating worse performance among those in the sad condition ($r = -.15$, $p < .05$). The RI Component correlated positively with the DERS score, indicating that people with greater emotion regulation difficulties performed slightly worse on RI tasks ($r = .16$, $p < .05$). Baseline self-reported mood did not correlate with any RI measures, but those with greater emotion regulation difficulties reported sadder moods ($r = -.46$, $p < .01$). All mood self-reports correlated negatively with five of the six DERS subscales ($p < .01$; the Aware subscale correlated only with baseline mood). The Impulse subscale correlated positively with the RI Component ($r = .19$, $p < .05$), indicating worse RI performance among those who have difficulty regulating their behavior while they are feeling negative emotions.

A Priori Analysis

The hypotheses were tested with linear multiple regression (n = 225). The mean mood rating was centered and entered into Step 1 as the predictor; the centered sum score of the DERS was entered into Step 1 as the moderator. The interaction term of the mean mood rating and DERS was entered into Step 2, and the outcome variable was the RI Component. Greater difficulties in emotion regulation predicted worse RI ($\beta = .15$, $p < .05$) but sad mood had no effect on RI ($\beta = -.03$, $p = .66$); there was no interaction ($\beta = -.03$, $p = .68$; Table 7). Neither a priori hypothesis was supported, but an unexpected main effect of DERS emerged. Running this same regression except with baseline mood as a covariate entered into a step before the other variables, DERS was similarly the only significant predictor of the RI Component (DERS $\beta = .16$, $p < .05$; other results not reported). Further, this effect is not explained by the greater sad mood that people with high DERS tend to experience.

Exploratory Analyses

Using the sample of 225 people with all-valid data, two multiple linear regression analyses were conducted to test the soundness of the assumption that continuous mood was a better metric than group membership. The RI Component was the outcome for both analyses. In the first analysis, the effect coded condition variable in Step 1 predicted the RI Component ($\beta = -.147$, $p < .05$; sad mood coded as -1, neutral mood as 1) such that those in the sad condition had worse RI. The continuous mean mood rating in Step 2 did not predict the RI Component ($\beta = -.02$, $p = .81$), nor did their interaction term in Step 3 ($\beta = .02$, $p = .76$; Table 8). In the second analysis, the continuous mean mood rating in Step 1 did not predict the RI Component ($\beta = -.07$, $p = .27$), nor did the effect coded condition variable in Step 2 ($\beta = -.14$, $p = .06$), nor did their interaction term in Step 3 ($\beta = .02$, $p = .76$; Table 9). None of the mood variables correlated with the Stroop RI metric or Go/No-go RI metric, but sad mood condition predicted worse Stop Signal Task RI ($r = -.15$, $p < .05$) and worse RI Component ($r = -.15$, $p < .05$). Neither the task response inhibition metrics nor the RI Component correlated with any of the difference scores between base mood rating and mood ratings 2 – 4 ($p > .51$).

The condition variable demonstrated predictive power in the regressions and correlations with RI variables. Considering this, four regressions were run with the condition variable in place of the continuous mood variable in Step 1, DERS as the moderator in Step 1, their interaction in Step 2, and the RI Component and each RI metric as outcomes. There were no main effects or interaction effects for the regressions with the Stroop RI and Go/No-go RI metrics as outcomes (the results of these two regressions are not reported). However, sad condition predicted worse RI on the Stop Signal Task (β = -.17, p < .05). DERS (β = .10, p = .13) and the interaction term (β = -.10, p = .11; Table 10) did not predict the RI metric (the same pattern emerged when running this regression with baseline mood as a covariate, with only sad condition predicting RI on the Stop Signal Task (β = -.17, p < .05). In a separate regression, sad condition (β = -.16, p < .05) and DERS (β = .18, p < .01) were main effects and they nearly interacted to predict the RI Component (β = -.12, p = .07; Table 11). Though the high p-value indicates high odds that this is a false positive, these three variables were modeled in Figure 2 and a simple slopes analysis was conducted. In the neutral group, DERS did not predict the RI Component (that is, the regression line's slope was not significantly different from zero; β = .07, p = .48, B = .003, Std. Error = .005). In the sad group, more difficulties in emotion regulation predicted worse performance on the RI tasks (that is, the regression line's slope was significantly different from zero; β = .30, p < .01, B = .02, Std. Error = .005). Results were similar when running this same regression with baseline mood as a covariate (sad condition β = -.16, p < .05, DERS β = .18, p < .05, interaction term β = -.12, p = .07).

The relative strength of correlations provide more evidence that group membership mattered, though only one of the below correlations was significantly different from one another. Some correlations were significant within the sad group but not within the neutral group (correlations within groups are reported in text rather than in tables). The RI Component correlated with DERS in the overall sample (r = .16, p < .05) and in the sad group (r = .30, p < .01), but not in the neutral group (r = .07, p > .05). However, this evidence is limited because the correlation from the neutral group is not significantly smaller than the correlation from the overall sample (z = .83, p > .05, all Fisher's r to z transformations are two-tailed) nor is it significantly smaller than the sad group correlation (z = 1.82, p > .05). The only subscale that correlates with the RI Component is DERS-Impulse; the RI Component had a larger correlation with the DERS-Impulse scale in the sad group (r = .32, p < .01) than in the neutral group (r = .07, p > .05; z = 1.97, p < .05). Looking into individual RI tasks, the Go/no-go RI metric correlated with DERS-Impulse only in the sad group (r = .21, p < .05; r = .08, p > .05) and the correlations were not significantly different (z = 1.08, p > .05); the Stroop RI metric correlated with two DERS subscales only in the sad group (Impulse r = .17, p < .05 and Aware r = -.18, p < .5; neutral group has p > .35 for both and neither correlation pair is significantly different, with z <.89 and p > .05 for both); and the Stop-Signal RI metric correlated with two DERS subscales only in the sad group (Impulse r = .18, p < .05 and Clarity r = .20, p < .05; neutral group has p > .78 for both and neither correlation pair is significantly different, with z < 1.69 and p > .05 for both).

Among the sad group participants, fewer difficulties in emotion regulation were associated with a *greater* decrease in mood after writing about a sad event (that is, difference score between rating one and two; r = -.18, p < .05; statistics reported only in text); this association was also present with the subscales Aware (r = -.26, p < .01) and Clarity (r = -.26, p < .01). Among the neutral group participants, the mood difference score correlated only with the subscale Goals (r = -.17, p < .05). Because participants were asked to change their mood, perhaps those with greater emotion regulation ability were more able to up-regulate their sad mood as they were instructed to do, but this is more likely a restriction-of-range artifact of measurement. Baseline mood is confounded with DERS score (r = -.46, p < .01); those with worse emotion regulation abilities had sadder moods before the mood manipulation, so those with better emotion regulation skills were able to report greater decreases in mood. Supporting the measurement artifact explanation is a regression predicting the same mood difference score with baseline mood and DERS score together in the first step (using sad group participants); higher baseline mood predicted greater mood difference (β = .40, p < .01) and DERS was not significant (β = .004, p = .97). Replacing DERS with Clarity yielded a similar result, though Aware nearly predicted mood difference (β = -.16, p = .06) along with baseline mood (β = .36, p < .01). Further, tolerance statistics were not indicative of multicollinearity for any of the regressions, and adding the baseline mood rating variable as a covariate in regressions resulted in similar results.

Sad mood and emotion regulation do not predict RI scores from individual tasks. Three regressions were conducted; they were identical to the a priori regression except that the three RI metrics were the dependent variables instead of the RI Component, and the independent variables were the mood ratings prior to the task rather than the mean mood rating. (1) The Stroop RI metric is not predicted by DERS (β = .06, p = .32) or reported mood before the Stroop task (β = .-.02, p = .78), nor is it predicted by their interaction (β = -.03, p = .63; Table 12). (2) The Stop Signal Task RI metric is not predicted by DERS (β = .05, p = .45) or reported mood before the task (β = -.11, p = .11), nor is it predicted by their interaction (β = -.04, p = .58; Table 130). (3) The Go/No-go RI metric is not predicted by DERS (β = .07, p = .28) or reported mood before the task (β = -.06, p = .35), nor is it predicted by their interaction (β = .01, p = .86; Table 14). Each of these regressions were conducted with only the neutral mood induction and sad mood induction sample, but there were no main effects in these analyses either (the results of these six regressions were not reported).

CHAPTER IV

DISCUSSION

This study explored the relative strength of two emotion-cognitive interaction models in their ability to predict cognitive effectiveness during sad mood: affect-as-information and resource allocation. The former predicts more efficient cognition during sad mood due to increased focus on detail and analysis, and the latter predicts less efficient cognition during sad mood due to sad thought content using up limited cognitive resources, thus leaving fewer resources for performance of cognitive tasks. To investigate these theories, the interplay of sad mood, emotion regulation, and response inhibition (RI) were studied. This study differs from most other studies (1) by using sample of greater than 200 participants, (2) by using a multiple-indicator composite measure of RI, and (3) by using cool tasks that measure RI without the immediate influence of emotion in the task stimuli, and thus whose variance is comprised of a larger proportion of RI performance compared to hot tasks. Participants were inducted into a neutral or sad mood by writing and reflecting on either a typical day or a sad event from their past. Then they completed three RI tasks, rating their mood before each task.

A Priori Hypotheses

Different theories predict facilitative or detrimental effects of sad mood on executive functions such as RI, so mood was hypothesized to either improve or worsen RI, and greater difficulties in emotion regulation were hypothesized to strengthen this association (i.e., moderation). Mood ratings did not predict the RI Component nor any of the RI metrics from the individual tasks, and difficulties in emotion regulation did not interact with mood ratings to predict any of these outcomes. If sad mood had improved RI scores, this would have supported an affect-as-information model; if sad mood had worsened RI scores, this would have supported a resource allocation/cognitive load model. This null result supports neither of these theories, and instead suggests that a negatively valenced mood does not impact response inhibition. Though the hypotheses were not supported, exploratory findings inform the research question.

Sad Condition Effects

A different metric of mood—simply being in the sad condition—resulted in a worse RI Component score. This extends Ellis and Ashbrook's (1988) theory that sad mood worsens performance on memory tasks; however, the present results suggest that it is not sad mood per se that impairs RI performance. Rather, being in the sad mood condition could have worsened RI performance because participants were distracted by thoughts related to the sad event they wrote about. Those in the neutral condition wrote about their typical day instead of a more arousing and valenced sad event, so perhaps the less intense topic of their writing triggered fewer distracting thoughts to consume their attention. Those in the sad condition may have exhibited worse RI due to cognitive resources being used up by distracting thoughts about the sad event they wrote about; their minds may thus have wandered away from the task at hand more frequently. If this is true then it makes sense that random placement in the sad condition hurt RI scores but self-ratings of mood did not—writing about a sad event would have caused both a sad mood and worse RI performance, but sad mood would not have caused worse RI performance. In other words, writing about a sad event could have caused a lingering distraction which in turn impaired RI performance, while the sad mood that was caused by the same writing did not in turn affect RI performance. This possibility is supportive of resource allocation/cognitive load theories. The sad condition may have triggered distracting thoughts via rumination, mind-wandering, and/or some other process, which competed for cognitive resources and worsened RI. The mind-wandering and rumination literatures offer helpful possible explanations for these effects.

Mind-Wandering

Marchetti, Koster, Klinger, and Alloy (2016) conceptualize spontaneous thought—undirected, effortless thought that is unrelated to the current environment or task—as an umbrella term that encompasses mind-wandering. Spontaneous thought, they contend, is a precursor that can lead to either adaptive outcomes like creativity or planning, or depressive and maladaptive outcomes like rumination, hopelessness, low self-esteem, and cognitive reactivity. They propose several individual differences factors that increase the likelihood of these maladaptive outcomes: trait negative affectivity, mood, and stress, all of which may reduce one's attentiveness to external stimuli. Others define mind-wandering as "a shift of attention away from a primary task toward internal information, such as memories" (Smallwood & Schooler, 2013, p. 130). These authors predict that mind-wandering occurs more frequently during simple tasks, impairs performance on demanding tasks, and competes with task performance for cognitive resources. If these positions are valid, variables such as spontaneous thought and mind-wandering would impact cognitive performance.

Mind-wandering and inhibitory control/response inhibition. Findings from the mind-wandering literature support the explanation that those in the sad condition performed worse due to distraction. The context and content regulation hypotheses inform the interplay of mind-wandering and cognitive performance (Smallwood & Schooler, 2015). The *context* regulation hypothesis incorporates these findings by holding that for cognition to be operating most effectively, thoughts unrelated to the task at hand are generated less often when the task requires continuous attention, and that unrelated thoughts harm performance when the task does require continuous attention. Mind-wandering would then harm performance less if certain contextual variables are present, namely, if the task requires only minimal monitoring or when automated performance is sufficient (Teasdale et al., 1995); likewise, mind-wandering has been found to worsen cognitive performance in demanding tasks (Smallwood & Schooler, 2015). Randall, Oswald, and Beier (2014) carried out a meta-analysis on mind-wandering, concluding that the available data supports cognitive resource allocation models: more resource-consuming mind-wandering worsened cognitive task performance while on-task thoughts improved performance, and both of these associations were stronger for complex tasks. It follows that RI task performance would be impaired during mind-wandering because RI tasks demand continuous attention, and slipping into automatic processing may make prepotent and dominant responses more difficult to inhibit, leading to more errors and a worse RI score. Researchers have shown that mind-wandering likely reduces cognitive analysis and awareness of the outside world. Smallwood, Beach, Schooler, and Handy (2008) administered a go/no-go task to participants, and considered responses to no-go targets as indicators of mind-wandering. Further, they measured participants' P300 amplitudes resulting from seeing the no-go stimulus, where the P300 amplitude acts as a metric of how much attention the person is directing toward the task. They predicted lower P300 amplitude preceding no-go trials that were errantly responded to, and this was exactly what they found. Amplitudes were lower in response to commission errors (i.e., mind-wandering), representing less cognition being directed toward the task. In summary, a biological measure showed that attention reductions during a task led to failures in response inhibition .

One way executive functions can be impaired is via perceptual decoupling, which is a shift in attention away from an external task (here, the RI tasks) and toward self-generated thoughts (the recent sad reflections). This shift results in cognition being more focused toward internal rather than external input, and with less attention paid to the external input (Smallwood & Schooler, 2015). Stated somewhat differently, Teasdale et al. (1995) gathered data supporting the position that generation of thoughts that are not related to external stimuli requires executive resources, leaving less available for executive functioning tasks; Smallwood (2010) argued for this position as well, asserting that because mind-wandering content can be consciously reported on, it consumes prefrontal resources that are used for executive functioning. McVay and Kane (2010) offer the alternative interpretation that mind-wandering does not consume executive control resources; instead it results from a failure of executive control. In this view, cognitive resources are not divided between mind-wandering and tasks; rather, mind-wandering occurs when interfering content disrupts executive control. Both views support a negative association between mind-wandering and performance, and the present results can fit into either of these views; perhaps (1) sad mind-wandering competed for executive control resources thereby reducing RI capacity, or perhaps (2) the sad memories served as interference that distracted participants, led to failures of executive functioning and response inhibition, and encouraged mind-wandering.

Mind-wandering and affect. A different pattern of findings is reflected in the *content* regulation hypothesis, which holds that the content of the mind-wandering affects how functional it is (Smallwood & Schooler, 2015). Another finding supporting the content regulation hypothesis is that negative affect and mind-wandering are related. The association between mind-wandering and emotions is complex and not yet confidently understood (Mason, Brown, Mar, & Smallwood, 2013), but evidence that is mostly correlational suggests that people tend to mind-wander more often if they are in negative or sad moods. One example of this—notable for its ability to infer some causality—is provided by Poerio, Totterdell, and Miles (2013). They conducted an experience sampling study showing that people's minds were more likely to wander shortly after they reported feeling sad (but see Killingsworth & Gilbert [2010] for an experience sampling study that found evidence of causality in the reverse direction, but with problematic hours-long gaps between time points).

A study by Seibert and Ellis (1991) supported these points; each of two experiments induced 45 participants into happy, neutral, or sad mood states, followed by a perceptual grouping memory task. Participants in Experiment 1 listed their thoughts after the task; those in Experiment 2 said their thoughts out loud during the task. In both experiments, the neutral group performed better than the happy and sad groups, and the happy and sad groups did not differ from each other. Also in both experiments, participants in the neutral group reported a lower proportion of irrelevant thoughts compared to the happy and sad groups, who did not differ from each other. Further, all participants reporting more irrelevant thoughts tended to perform worse. These results suggest that happy and sad moods lead to more irrelevant thoughts and worse memory; distracting thoughts during a sad mood may also harm RI abilities.

In sum, people in sad moods probably mind-wander more. In the present study, mood-consistent content from the past was explicitly cued with the writing task, making it more likely that participants had thoughts of the sad event they wrote about while completing the RI tasks. In other words, participants in the present study's sad group had primed themselves more specifically to mind-wander to sad content by recently writing about sad events from their past. Work by McVay and Kane (2013) suggests that personalized stimuli is likely to prime subsequent thoughts that are unrelated to the task at hand. They developed a method in which words relevant to each participant's own goals were displayed during a go/no-go task, and found that they triggered 3-4% more task-unrelated thoughts than non-personalized words. Others induced people to worry about delivering a speech (a future negatively valenced event), and found that those whose affect decreased more upon hearing about their upcoming speech experienced increased frequency of mind-wandering during a go/no-go task (Stawarczyk, Majerus, & D'Argembeau, 2013). Worrying about a future event or thinking about a future goal increases mind-wandering; the stimuli in the present study were different in that they were focused on the past rather than future goals or worries, yet similar to McVay and Kane's induction in that they were personalized, and similar to Stawarczyk and colleagues' induction in that they were sad in valence.

Notably, mind-wandering to past events has been linked to negative affect (Ruby, Smallwood, Engen, & Singer, 2013). Participants completed a simple cognitive task and periodically answered questions including whether their thoughts were on-task, whether they were thinking about the past or future, whether they were thinking about themselves or others, and their mood. Researchers found that when participants were thinking about the past or about other people, they were more likely to experience a negative mood. This effect persisted even when these thoughts were positive in valence. Also, thoughts about the future and oneself, even if negative in valence, predicted positive mood. Smallwood et al. (2002) report studies on dysphoria and thoughts unrelated to the task at hand; they found that when people are not feeling dysphoric, rumination tends to *improve* task focus, but that when people are ruminating and feeling dysphoric, they tend to have *decreased* task focus due to increased thoughts unrelated to the task. The present study asked sad condition participants to think about a sad event from the past, which decreased mood similar to Ruby and colleagues' participants and encouraged both rumination and dysphoria similar to some of Smallwood et al.'s participants. This combination of thinking about the past and feeling dysphoric seems to be especially detrimental to performance on cognitive tasks.

The present study was designed to compare the effects of sad and neutral mood, but considering the unexpected results of the condition variable but not the mood self-report variable predicting RI performance, the study could be cast in a different light: does the induction of a mental state that is conducive to mind-wandering affect RI performance more if the thought content is sad or neutral in valence? The present design unintentionally mirrored a common mind-wandering design, which involves a mind-wandering induction then completion of computerized tasks (Smallwood & Schooler, 2015). The present inductions could be thought of as creating conditions that encourage mind-wandering. One condition encouraged neutrally-valenced daily routine thoughts. The other condition encouraged self-generated sad thoughts and memories. The sad group participants were more likely to mind-wander because of the self-generated thoughts that were more powerful and attention-grabbing due to their increased valence (and probably arousal). Mind-wandering was not measured in this study so these interpretations are certainly speculative, though this possibility is reasonable and supported by the literature.

Rumination

Rumination is another mental process that, though unmeasured in this experiment, may have been triggered by the sad writing task and contributed to worse RI performance. Some think of rumination as mind-wandering with a negative valence, but Christoff, Irving, Fox, Spreng, and Andrews-Hanna (2016) distinguish the two; to them, mind-wandering thoughts jump from topic to topic, and rumination tends to focus on a theme or topic and is thus more constrained. Going beyond the commonly espoused descriptions of these cognitive constructs, the authors have developed a model that embeds mind-wandering and spontaneous thought into a broader model of thought (Christoff et al., 2016). They describe two ways thoughts can be constrained. First, a person can direct their thoughts deliberately using cognitive control. Second, a person's thoughts can be constrained automatically via affective- and sensory-salience drawing attention. Mind-wandering, then, is more deliberately constrained than a state like dreaming and less deliberately constrained than a state like creative or goal-directed thought, and less automatically constrained than a state like rumination.

Interpreting the present results using this framework, a participant would likely perform best when engaging in goal-directed thought toward the RI task. However, recently recalled sad memories would serve as affectively salient automatic constraints that pull attention toward them, encouraging rumination and thus distraction from the task at hand. Further, from a cognitive load perspective, rumination would compete for attentional resources and lead to executive control failure. Rumination, then, is another cognitive process that could have been at play in harming sad-group participants' RI capacity. Rumination could have occurred in addition to or in place of mind-wandering.

A review by Roberts, Watkins, and Wills (2015) explores whether rumination causes inhibitory deficits. They found four experimental studies that use measures with good construct validity and investigate whether rumination leads to inhibitory deficits, and three of these four studies revealed findings that support rumination impairing performance on interference (a component of inhibitory control). A recent meta-analysis of 3,066 participants across 34 studies found that rumination predicted worse executive functions (Yang, Cao, Shields, Teng, & Liu, 2016). More specifically, they found that rumination was associated with lower inhibition ability (21 studies) and set-shifting ability (11 studies), but not working memory (8 studies). Similar to the present study, Young, Erickson, and Drevets (2012) used valenced autobiographical memories to study cognition. They displayed multiple positive, neutral, and negative cue words to participants, asked them to recall a memory after each word, then had them complete a simple perceptual attention task; they performed worse on the positive and negative trials compared to neutral trials, and worse on the negative trials compared to the positive trials. This may be because the valenced autobiographical memories consumed cognitive resources and made it more difficult for participants to stay focused on the task. This sampling of rumination research suggests that, perhaps in addition to mind-wandering, rumination may have played a role in the present study's sad-group participants performing somewhat worse on response inhibition tasks.

Implications for Emotion-Cognition Interaction Theories

These results speak to the cognition-emotion interaction theories discussed above. These results are not explained by the affect-as-information theory, at least in regard to response inhibition—being in the sad mood condition was not associated with any improvements in RI efficiency. This is not evidence that sad moods do not encourage a more analytic cognitive style as posited by Schwarz and Bless (1991), though if sad moods do encourage analytic thinking, the present results suggest that this thinking style does not facilitate RI performance. The present results also suggest that—at least with RI—sad mood does not bias attention toward goal-relevant stimuli thereby conferring an advantage, as suggested by Mather and Sutherland's arousal-biased competition theory (2011). Considering the discussion above on the possible impact of mind-wandering, these results are well-explained by a resource-allocation model (Seibert & Ashbrook, 1988). The sad mood, particularly the ruminative content that was primed by the sad mood induction, may have distracted participants by consuming cognitive resources, leading to worsened RI performance. If this is the case, maybe the other theories are true but overshadowed by the distraction of rumination and/or mind-wandering explaining more variance, or maybe they are false at least for the executive function of RI. Overall, these results provide support for the cognitive-allocation model; this support does not tarnish the other theories, but it does speak against their applicability to response inhibition performance in the context of sad mood and distracting cognitions.

Impact of Emotion Regulation

Emotion regulation ability was influential in this study, adding to a small group of studies suggesting that it is worthwhile to examine emotion regulation along with RI. Participants who reported greater difficulty regulating their emotions performed worse on RI tasks. The cold tasks used by Lee, Turkel, Woods, Coffey, and Goetz (2012) did not correlate with affective lability or impulsiveness measures; due to the small sample, this finding does not preclude a true relationship. The present findings are however consistent with Lee and colleagues' hot task findings; trait affective lability (a construct related to emotion regulation) reduced performance on hot RI tasks, and similar to their findings, the DERS-RI association persisted even after controlling for current mood. Lee and colleagues further found that greater self-reported attentional impulsiveness predicted worse RI as measured by the reaction time metric of a hot go/no-go task using faces. A similar finding emerged from the present study—the Impulse subscale of the DERS correlated with RI. This subscale contains items that indicate difficulty controlling behavior while negative emotion is felt (Gratz & Roemer, 2004). This correlation disappears when using only the neutral condition participants, but it becomes stronger when using only the sad mood condition participants; reflecting the scale description, Impulse scores only affected RI performance among those in the sad condition. There is more evidence that sad group placement influenced RI scores more among those with poor emotion regulation skills: though the interaction term was not significant, the simple slopes analysis revealed that those with greater difficulties in emotion regulation had worse RI if they were in the sad condition (Figure 2). Two tentative conclusions can be drawn from this data: emotion regulation skill does not affect RI during neutral mood, and those with strong emotion regulation skills are more able to modulate the detrimental effect of sad mood on cognition.

The present study considers the state-side of RI and the trait-side of emotion regulation, but others have considered the other “sides” of these variables (e.g., Tang & Schmeichel, 2014). Joorman (2010) explains why poor cognitive control might harm emotion regulation ability. Those with worse cognitive control may have a lesser ability to push mood-congruent information out of their minds (here, the sad induction memories). Thus, mood-congruent information would use up limited working memory resources and impair performance. It could even be the case that executive functioning and self-regulation share a similar limited resource (perhaps effort and/or glucose; Kaplan & Berman, 2010). These authors discuss studies supporting both sides of this position—challenging self-regulation tasks have reduced future executive functioning performance and vice versa. The situation brought about for the present study’s sad-group participants would have placed resource-consuming demands on both of these processes, leaving fewer resources (e.g., effort or glucose) available for efficient deployment of response inhibition. Demands were placed on emotion regulation due to the sad memories and feelings of sadness, demands were placed on their executive functioning in that they had to resist the interference caused by the sad memories, and performing the response inhibition tasks was another demand. Recall that the cognitive load/resource-allocation model was most supported by the results of the present study. Considering emotion regulation ability allows us to consider some of the mechanisms that may have driven reduced RI ability in the context of the sad condition.

Links between emotion regulation and RI have been documented in the literature. Carlson and Wang (2007) tested children aged four to six using three laboratory measures of inhibitory control (Simon Says, touching of a toy that the children were asked not to touch, and disobeying instructions by peeking at a present that is being wrapped for the child). These inhibitory control tasks were combined into a single principal component, as were two laboratory measures of emotion regulation (suppressing disappointment when receiving an undesirable gift, and ability to suppress positive emotion in order to keep a secret). These two components were moderately correlated at the principal component level (r = .46), a finding that remained after controlling for age and verbal ability. Parent reports of self-control and emotion regulation also remained correlated after controlling for age and verbal ability. These two constructs are related and seem to develop in concert (Carlson & Wang, 2007). Other researchers found emotion regulation-cognitive control links in adults (Bridgett, Oddi, Laake, Murdock, & Bachmann (2012): participants who reported on a questionnaire that they had stronger tendencies to express negative affect (e.g., “It is difficult for me to hide my fear.”) performed worse on the Stroop color-word task on average.

Fitting these and the present study’s findings into Gross’s (1998) process model of emotion regulation, attentional deployment is one mechanism of emotion regulation that likely played a part in affecting RI task performance. Those exhibiting poor emotion regulation by focusing their attention in a ruminative fashion toward the sad event they wrote about would be using up cognitive resources that would have aided in their RI task performance. Further, those exhibiting skilled emotion regulation may have instead used distraction by shifting their attention to the RI task at hand rather than the sad event they wrote about, thereby improving their RI score (Suri et al., 2013). Other emotion regulation variables are interesting to consider here, such as automatic versus deliberate and effortful regulation of emotion, and emotion regulation in-the-moment as opposed to a trait measure; however the present study does not include data to address these aspects of emotion regulation.

Limitations and Future Directions

A goal of this project was to reduce some of the methodological limitations of similar studies; a sample of over 200 people was used, RI was measured using cool tasks and multiple indicators, and multiple mood self-reports and mood induction refreshers were used to ensure a mood induction that lasted long enough. These features strengthen the finding that sad mood per se does not affect response inhibition, though it could be that an established measure such as the Positive and Negative Affect Schedule may have provided a more reliable measure of current mood and yielded different results (Watson, Clark, & Tellegen, 1988). Though the study uncovered evidence that rumination and mind-wandering may harm response inhibition, note that this and other findings are post hoc and derived from many exploratory analyses. Thus, they are less likely to replicate and are more likely to represent Type I errors. This study used a fast one-item valence measure of affect and did not measure level of arousal; this had the advantage of moving participants quickly from manipulation to task so the manipulation effect had less time to fade away, but it had the disadvantage of having an incomplete picture of affect's components by excluding measurement of arousal (Kuppens et al., 2013). Other common limitations apply, such as whether this undergraduate convenience sample generalizes to other populations. These results also may not generalize to other contexts and conditions (Schaller, 2016); for example, if reduced RI scores are truly explained by distraction from emotional thoughts, then an induction that generates a sad mood but does not encourage sad thoughts may not reduce RI at all (e.g., listening to sad music or viewing sad pictures may not affect RI). Experiments aimed at finding the boundary conditions under which an effect occurs would determine whether this effect replicates, and to which situations this effect does not generalize (Greenwald, Pratkanis, Leippe, & Baumgardner, 1986).

Future research could directly investigate whether mind-wandering affects RI by parsing out the effects of mood and distracting thought. This could be done by measuring participants' thoughts during or after task completion and adding a condition that does not change mood but triggers distracting thoughts; for example, participants could be asked to write instructions on how to complete a complicated task. Similarly, probes inserted within tasks could ask participants whether their minds were wandering, and to what topic they were wandering (e.g., ruminative thought about the past). Studies like this would test the sad condition finding for replication and would help determine whether mind-wandering, rumination, and/or sad mood drives the effect on RI. Trying to measure valence and arousal separately would further inform which of these two components of affect—if either—are driving the effect on RI. A larger study using sophisticated multivariate analyses would shed more light on these questions. For example, one could use a latent variable approach with multiple executive functions, examining how mood affects them. Simultaneously accounting for multiple variables within the same model would give clues to the mechanisms through which mind-wandering, rumination, and mood might affect cognition.

Clinical Implications

These results have clinical implications in psychological assessment contexts. To measure cognitive constructs accurately, the patient should be able to perform to the best of their ability. Invalid assessment results can be produced by a number of factors, including hunger, effects of medication, fatigue, and illness. This study contributes to a literature that reveals the influence of rumination and mind-wandering on cognition. Just as examiners may consider results with caution if their patient is very fatigued during testing, the present findings support the practice of considering results cautiously if their patient is significantly distracted by rumination or mind-wandering; respecting the ability of such non-task cognitive demands to confound measurement may reduce misdiagnosis of problems such as mild cognitive impairment and dementia. Lastly, the impaired thinking ability often seen in depression—such as difficulty concentrating or making decisions—receive less focus than they deserve in treatments. In depression interventions, it would be worthwhile to target the executive functioning deficits that can co-occur with depression, including using stimulus control to eliminate distractions from work environments and teaching structured guidelines for assessing the pros and cons of choices.

The intent of this study was to explore competing theories of emotion-cognition interaction by taking a close look at response inhibition and sad mood. Affect-as-information theories would predict helpful effects of sad mood on executive functions such as RI, as sad mood is purported to trigger a more detailed and analytical processing style that can be beneficial to cognitive tasks; resource allocation models would predict a worsening of executive functions, as sad mood is purported to consume limited cognitive resources such as effort, attention, and working memory, leaving fewer resources available for efficient cognitive functioning. Results revealed that being in the sad mood condition worsened RI slightly; however, because mood self-reports did not predict RI, this was likely due to other effects of being in the sad condition. Thinking about sad memories encourages rumination and mind-wandering, which likely drove the reduction in RI ability. There was some evidence that those with poor emotion regulation tended to have even more impaired response inhibition while in a sad mood. The results of this study are most consistent with the resource allocation rather than the affect-as-information model; reflecting on sad memories seems to have a negative impact on response inhibition.

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APPENDIX A

TABLES AND FIGURES

Table 1

Demographics

	Retained Sample N (%)	Main Analysis Sample N (%)
Freshman	183 (67)	154 (68)
Sophomore	57 (21)	47 (21)
Junior	15 (6)	11 (5)
Senior	9 (3)	7 (3)
Other	9 (3)	6 (3)
Black/African American	114 (42)	92 (41)
White/Caucasian	90 (33)	75 (33)
Multiracial	27 (10)	22 (10)
Latino/Hispanic	20 (7)	19 (8)
Asian/Pacific Islander	18 (7)	14 (6)
Other	3 (1)	2 (1)
Native American/Alaskan Native	1 (<1)	1 (<1)

Table 2

Pearson Correlation Matrix of DERS Subscales with Each Other

	Nonaccept	Goals	Impulse	Aware	Strategies	Clarity
Overall DERS	.78**	.69**	.73**	.39**	.90**	.72**
Nonaccept		.48**	.47**	.11	.68**	.48**
Goals			.49**	-.07	.67**	.30**
Impulse				.07	.63**	.40**
Aware					.17**	.44**
Strategies						.55**

Note. ** $p < .01$; n = 272

Table 3

Descriptive Statistics

Variable	α	N	Min	Max	Mean (SD)	Skew	Kurtosis
DERS (all valid)	.92	225	37	127	74.63 (18.78)	.46	-.31
DERS	.93	272	37	133	76.66 (19.95)	.51	-.26
Nonacceptance	.88	272	6	27	11.83 (4.99)	1.01	.59
Goals	.88	272	5	25	13.61 (4.61)	.41	-.62
Impulse	.86	272	6	27.44	10.79 (4.49)	1.19	1.29
Awareness	.82	272	6	28	14.19 (4.77)	.38	-.33
Strategies	.85	272	8	33.58	15.99 (5.82)	.79	.14
Clarity	.77	272	5	20.41	10.20 (3.37)	.53	-.28
First mood rating		273	9.88	100	70.34 (20.03)	-.88	.18
Stroop mood rating		264	0	100	58.00 (21.42)	-.21	-.72
Go/No-go mood rating		272	0	100	57.98 (22.32)	-.23	-.77
SST mood rating		232	0	100	58.19 (22.80)	-.36	-.57
Mean mood 2 – 4		225	0	100	57.66 (21.42)	-.17	-.78
Mean sad mood 2 – 4		112	0	96	49.01 (21.17)	.25	-.50
Mean N. mood 2 – 4		113	25	100	66.24 (18.01)	-.43	-.57
RI Component		225	-2.63	3.13	0.00 (1.00)	.15	.26
Go/no-go RI		272	.00	.82	.28 (.18)	.79	.44
Stroop Control RT		264	521.19	1269.26	759.42 (146.10)	.95	.43
Stroop Incong. RT		264	608.89	1487.84	905.17 (165.62)	.79	.58
Stroop RI		264	-117.07	408.57	145.51 (84.40)	.38	1.39
Stop-Signal Task RI		232	96.86	367.01	224.76 (50.05)	.23	.51

Note. DERS = Difficulties in Emotion Regulation Scale; First Mood Rating = from all retained participants; Mean Mood Ratings = mean of mood ratings 2 – 4 for participants with all valid data; Sad and Neutral Mood Ratings = mean of mood ratings 2 – 4 for participants in the sad and neutral conditions, respectively; SST = Stop-Signal Task; RI = response inhibition metric

Table 4

Principal Components Analysis on the Three RI Metrics

Component	Eigenvalue	% Variance Explained	Cumulative % Variance Explained
1	1.40	46.70	46.70
2	.87	28.87	75.56
3	.73	24.43	100.00

Table 5

Pearson Correlation Matrix

	2	3	4	5	6	7	8	9	10	11
1. RI	.73**	.60**	.71**	-.08	-.06	-.09	-.07	-.07	-.15*	.16*
Component	(225)	(225)	(225)	(225)	(225)	(225)	(225)	(225)	(225)	(225)
2. Go/no-go RI	1	.14*	.27**	-.05	-.08	-.05	-.04	-.05	-.07	.08
	(272)	(263)	(231)	(272)	(272)	(271)	(271)	(271)	(272)	(271)
3. Stroop RI		1	.16*	-.03	-.02	-.04	.01	-.01	-.07	.07
		(264)	(226)	(264)	(264)	(264)	(264)	(264)	(264)	(264)
4. Stop-Signal RI			1	-.06	-.05	-.08	-.12	-.09	-.15*	.08
			(232)	(232)	(232)	(232)	(232)	(232)	(232)	(231)
5. Baseline mood				1	.54**	.54**	.58**	.58**	-.04	-.46**
				(273)	(273)	(272)	(272)	(272)	(273)	(272)
6. Go/no-go mood					1	.87**	.88**	.96**	.38**	-.27**
					(273)	(272)	(272)	(272)	(273)	(272)
7. Stroop mood						1	.88**	.96**	.36**	-.27**
						(272)	(272)	(272)	(272)	(271)
8. Stop-Signal mood							1	.96**	.35**	-.28**
							(272)	(272)	(272)	(271)
9. Mean mood 2 – 4								1	.38**	-.29**
								(272)	(272)	(271)
10. Mood condition									1	.10
									(273)	(272)
11. DERS										1
										(272)

Note. * $p < .05$, ** $p < .01$; task mood ratings occurred immediately before the task; mean mood is the mean of the three pre-task mood ratings; mood condition is effect-coded with sad mood at -1; higher RI scores indicate worse RI; lower mood scores indicate more sad mood

Table 6

Pearson Correlation Matrix with DERS Subscales

	Nonaccept	Goals	Impulse	Aware	Strategies	Clarity
RI Component	.11	.08	.19*	.08	.11	.13
Go/no-go RI	.05	.01	.14*	.09	.01	.08
Stroop RI	.07	.05	.12	-.05	.08	.02
Stop-Signal RI	.05	.03	.07	.11	.03	.07
Baseline mood	-.31**	-.28**	-.33**	-.20**	-.45**	-.39**
Go/no-go mood	-.19**	-.23**	-.20**	-.07	-.26**	-.18**
Stroop mood	-.19**	-.20**	-.19**	-.08	-.26**	-.22**
Stop-Signal mood	-.22**	-.21**	-.20**	-.08	-.26**	-.20**
Mean mood 2 – 4						
Full sample	-.21**	-.22**	-.20**	-.08	-.27**	-.21**
Neutral	-.37**	-.28**	-.31**	-.15	-.44**	-.37**
Sad	-.15	-.27**	-.21*	-.03	-.26**	-.13

Note. * $p < .05$, ** $p < .01$; n = 272; correlation between total DERS score and Mean mood 2 – 4 is -.46** in the neutral group and -.25** in the sad group

Table 7

A Priori Regression Predicting the RI Component with DERS and Sad Mood, n = 225

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.027					
Mean mood rating		-.001	.003	-.031	.653	.922
DERS		.008	.004	.154	.027	.922
Step 2	.028					
Interaction term		.000	.000	-.028	.675	.997

Table 8

Exploratory Regression Predicting the RI Component with the Condition Variable, then Sad Mood, n = 225

Predictor	R^2	Unstandardized Coefficient	Standard Error	β	*p*	Tolerance
Step 1	.147					
Mood condition		-.146	.066	-.147	.028	1.000
Step 2	.148					
Mean mood rating		-.001	.003	-.018	.806	.838
Step 3	.149					
Interaction term		.001	.003	.020	.765	.976

Table 9

Exploratory Regression Predicting the RI Component with Sad Mood, then the Condition Variable, n = 225

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.074					
Mean mood rating		-.003	.003	-.074	.268	1.000
Step 2	.148					
Mood condition		-.139	.072	-.140	.056	.838
Step 3	.149					
Interaction term		.001	.003	.020	.765	.976

Table 10

Exploratory Regression Predicting the Stop Signal RI Metric with DERS and Mood Condition, n = 231

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.035					
Mood condition		-8.343	3.262	-.167	.011	.990
DERS		.264	.174	.099	.131	.990
Step 2	.045					
Interaction term		-.276	.174	-.103	.115	.993

Table 11

Exploratory Regression Predicting the RI Component with DERS and Mood Condition, n = 225

Predictor	R^2	Unstandardized Coefficient	Standard Error	β	*p*	Tolerance
Step 1	.053					
Mood condition		-.162	.065	-.162	.014	.992
DERS		.009	.003	.177	.008	.992
Step 2	.067					
Interaction term		-.006	.003	-.119	.068	.995

Table 12

Exploratory Regression Predicting the Stroop RI Metric with DERS and Sad Mood, n = 264

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.071					
Pretask mood		-.071	.253	-.018	.781	.922
DERS		.270	.270	.064	.318	.922
Step 2	.078					
Interaction term		-.006	.012	-.030	.627	.995

Table 13

Exploratory Regression Predicting the Stop Signal RI Metric with DERS and Sad Mood, n = 231

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.018					
Pretask mood		-.238	.150	-.109	.113	.919
DERS		.138	.182	.052	.451	.919
Step 2	.019					
Interaction term		-.004	.007	-.036	.583	.997

Table 14

Exploratory Regression Predicting the Go/No-go RI Metric with DERS and Sad Mood, n = 271

Predictor	R^2	Unstandardized Coefficient	Standard Error	*β*	*p*	Tolerance
Step 1	.010					
Pretask mood		.000	.001	-.059	.352	.929
DERS		.001	.001	.069	.278	.929
Step 2	.010					
Interaction term		.000	.000	.011	.863	.992

Figure 1

Procedural Flowchart

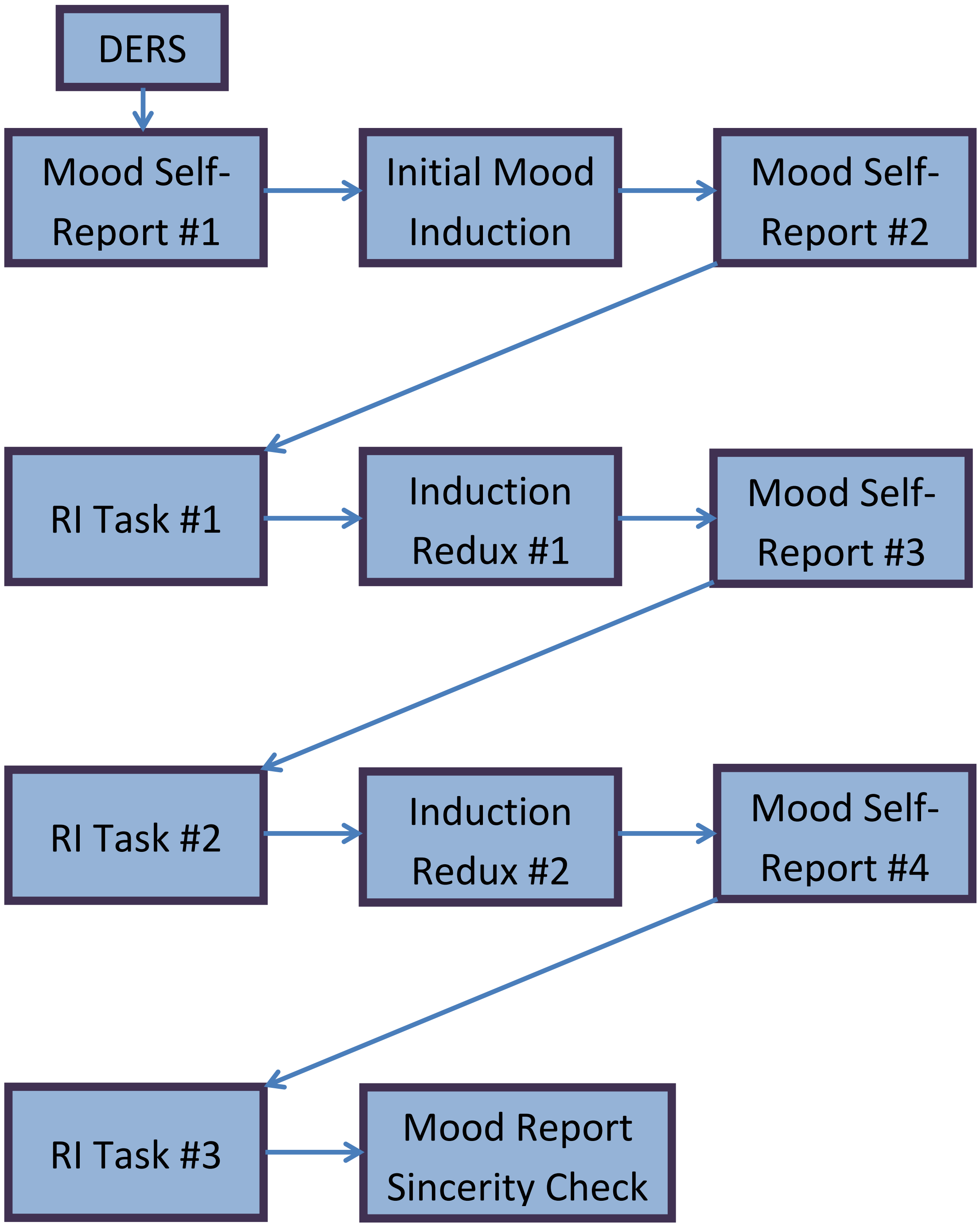
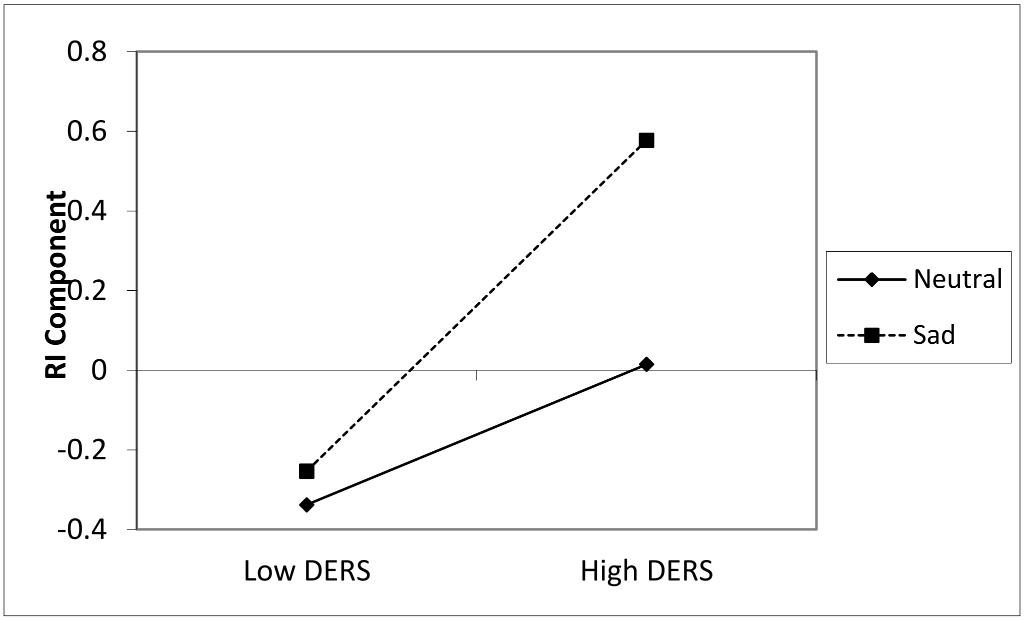


Figure 2

Simple Slopes Analysis on the Effect of DERS on the RI Component within each Condition



APPENDIX B

TASK DETAILS

Go/no-go text instructions on computer screen: Put the pointer finger of your dominant hand on the spacebar. On each trial, a green or blue rectangle will appear on the screen. Press the spacebar as quickly as possible when a GREEN rectangle appears. If a BLUE rectangle appears, DO NOT respond at all. Try to respond as quickly as possible while making as few errors as possible. There'll be no practice. The task will take about 10 minutes to complete.

Go/no-go script: When the text is first displayed, the research assistant says “read the instructions, take your time.” When the participant finishes reading, the research assistant says “don’t press anything when you see a blue rectangle,” then briefly answers any questions the participant has about the task.

Color Word Stroop instructions on computer screen: In this task you will see words and asterisks (***) presented in different colors. Your task is to say into the microphone the COLOR each word or line of asterisks is printed in while ignoring what the words actually say. Example: if you see the word RED printed in the color GREEN, say GREEN. Try to respond as quickly and accurately as you can, because you will be timed. If an incorrect response is made, a red X will appear briefly.

Color Word Stroop script: When the text is first displayed, the research assistant says “read the instructions, take your time.” When the participant finishes reading, the research assistant says “does that make sense?” Regardless of the answer, they say “say the color of the ink out loud into the mic. An X appears if you make a mistake, but do not say the color of the X” and then they wait for the participant to complete the first incongruent trial. If the participant says the correct color, the research assistant says “good” and leaves the room. If the participant says an incorrect color on the first incongruent trial, the research assistant says “say the color of the ink” and leaves the room.

Stop-Signal Task instructions on computer screen: Press the left arrow key when you see a left-arrow and the right arrow key when you see a right-arrow. Sometimes, the arrow is followed by a sound. When the sound plays, DO NOT RESPOND to the current arrow. DO NOT WAIT for the sound to play, because if you wait, the computer will wait to play the sound. Respond as FAST and ACCURATE as you can, but try to STOP yourself from pressing a key when you hear the sound. Press the 'Continue >>' button to start practice.

Stop-Signal Task script: When the text is first displayed, the research assistant says “read the instructions, take your time.” When the participant finishes reading, the research assistant says “does that make sense?” Regardless of the answer, they say “when you hear a tone, don’t respond to that arrow.”