2013-07-05

Emotion Regulation in Depression: Investigating Mechanisms Underlying Reappraisal

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EMOTION REGULATION IN DEPRESSION: INVESTIGATING MECHANISMS UNDERLYING REAPPRAISAL

By

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A DISSERTATION

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Doctor of Philosophy

Coral Gables, Florida

August 2013

UNIVERSITY OF MIAMI

A dissertation submitted in partial fulfillment of
the requirements for the degree of
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D'AVANZATO, CATHERINE M. (Ph.D., Psychology)

Emotion Regulation in Depression: Investigating Mechanisms Underlying Reappraisal. (August 2013)

Abstract of a dissertation at the University of Miami.

Dissertation supervised by Professor Jutta Joormann.
No. of pages in text. (118)

Sustained negative affect is a hallmark feature of Major Depressive Disorder (MDD), and much evidence indicates that depression is associated with difficulties regulating negative emotions. Whereas many studies have demonstrated an association between rumination and depression, few studies have examined depressed individuals' ability to utilize adaptive strategies, such as reappraisal. The present study was the first to investigate whether individuals with depression have difficulty effectively using reappraisal in response to a laboratory mood induction. Further, we examined whether interpretive biases and cognitive control deficits underlie individual differences in the ability to reappraise. Consistent with hypotheses, results demonstrated that reappraisal was less effective in reducing subjective sadness among depressed participants compared to controls. In addition, participants' self-reported dispositional use of emotion regulation strategies was associated with the degree to which reappraisal was successful in reducing their sadness. However, interpretation bias and cognitive control did not differ between the diagnostic groups and were unrelated to the effectiveness of reappraisal in our laboratory task. This study has important implications for theories and interventions of MDD.

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Chapter 1: Introduction

Background

Affecting nearly 17 percent of individuals in the United States during their lifetime, Major Depressive Disorder (MDD) causes great emotional suffering and impairment in individual functioning (Kessler et al., 2003). At the societal level, MDD results in substantial economic costs due to decreased productivity and increased use of healthcare resources (Greenberg et al., 2003; Birnbaum et al., 2010). Cognitive-Behavioral treatments (CBT) have shown widespread success in treating depressive disorders. Nevertheless, many individuals with MDD who undergo CBT do not recover, and the risk for relapse among those benefitting from these treatments remains a significant concern (Blackburn & Moore, 1997; Gloaguen, Cottraux, Cucherat, & Blackburn, 1998). Thus, research that furthers understanding of the etiology and maintenance of MDD, and provides a basis for improved theories and treatment of the disorder, is of utmost importance.

Role of Cognition and Emotion Regulation in MDD

Sustained negative mood is a central feature of depressive disorders. In fact, persistent sadness lasting most of the day, nearly every day, for at least two weeks, is one of the hallmark criteria required for a diagnosis of MDD outlined in the Diagnostic and Statistical Manual- Fourth Edition (DSM-IV-TR, American Psychiatric Association, 2000). Numerous studies have demonstrated that the onset of first episodes of depression typically follows a negative life event (Monroe & Reid, 2008). Although the majority of people who experience these events do respond initially with negative affect, they do not

go on to develop depression. In fact, whereas 60 to 80% of first onsets of depression follow a negative life event, only about 20% of people who experience negative life events will subsequently develop a depressive episode (Monroe & Harkness, 2005). These numbers clearly document the importance of gaining a better understanding of the mechanisms that underlie depression-associated difficulties in recovering from negative events and the ensuing negative affect.

Individual differences in emotion regulation may play a key role in this important symptom of MDD. Emotion regulation is defined as cognitive or behavioral strategies that are employed to modify the circumstances in which an emotion occurs, the experience of an emotional response (including intensity and duration), or how an emotion is expressed outwardly (Gross, 2002). Emotion regulation applies to both positive and negative emotions and can either involve amplifying, or alleviating, an emotional response; the primary focus in emotional disorders, however, is on strategies to alleviate negative emotions. It is important to note the distinction between emotional reactivity, or the initial generation of an emotional response to an event, and emotion regulation. People differ not only in the intensity of their initial emotional reactions, but also in their ability to exert control over these reactions. Two aspects of individual differences in emotion regulation which may help to distinguish depressed from non-depressed individuals include differences in the dispositional *use* of specific types of emotion regulation strategies, as well as in the *effectiveness* of these strategies (Aldao, Nolen-Hoeksema & Schweizer, 2010; Joormann, Yoon & Siemer, 2009).

Gross (1998, 2002) proposed a model of emotion regulation that distinguishes between different types of emotion regulation strategies. Known as the process model of emotion regulation (2002), this model distinguishes among emotion regulation strategies based upon the point in the sequence of a developing emotional response which they target. The emotion generation sequence begins with internal or external input (the situation), which capture an individual's attention and focus attention on specific aspects of the situation. Influenced by aspects of the situation attended to, appraisals, or evaluations, of the input are made by the individual, which in turn lead to an emotional response (Lazarus & Folkman, 1984; Lazarus, 1999). According to Gross's model, there are numerous points in this sequence which can be influenced by emotion regulation strategies; the primary distinction between strategies is whether they are implemented prior to or after the emotional response has been elicited. Antecedent-focused strategies are implemented early in the course of an unfolding emotional response and include strategies, such as choosing which situations to enter or avoid (situation selection), modifying characteristics of a situation (situation modification), purposefully directing attention to less upsetting aspects of a situation (attentional deployment), or even cognitive change, which involves altering appraisals in advance of a situation to lessen its emotional impact (anticipatory reappraisal). In contrast, response-focused strategies are applied after an emotional response is already underway and include actions, such as concealing emotional reactions from others (suppression), or repetitively analyzing aspects of an event and one's emotional response to it (rumination).

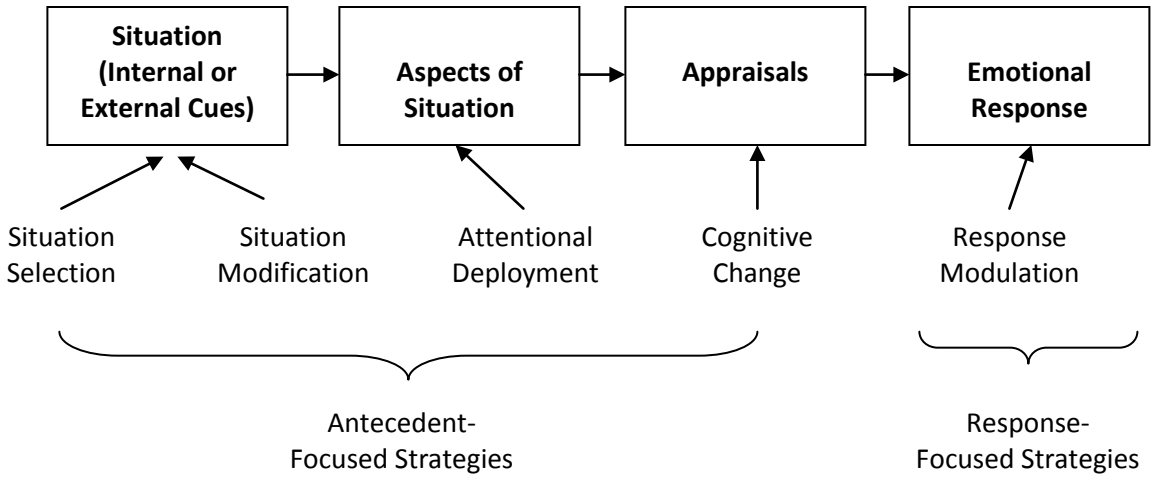


Figure 1.1. Gross's Process Model of Emotion Regulation

Antecedent- and response-focused emotion regulation strategies differ both in how effective they are in alleviating negative affect, as well as in the additional negative consequences they carry (Gross, 2002). As a result, a potential risk factor for the onset and maintenance of depression that has received much attention in recent models of MDD is the habitual use of various emotion regulation strategies. In addition, studies have compared the effectiveness of different strategies and have begun to identify individual differences associated with the effective use of these emotion regulation strategies.

An important factor which may influence the effectiveness of emotion regulation strategies is cognitive processes. Cognitive theories of emotion hold that people's appraisals, or interpretations, of an event, influence whether an emotion is experienced, as well as the type and intensity of the emotion experienced (Lazarus, 1999). Various types of appraisals are made simultaneously when evaluating an event, including ideas about responsibility for the event, the degree to which the event is controllable or

expectable, and the meaning and impact of the event. For example, a person who has recently lost a job can attribute the reason for being let go to a prejudiced boss, leading to anger, to one's own lack of ability, leading to sadness or embarrassment, or to temporary bad luck, leading to a much less intense emotional response or no emotional response at all. The process of generating appraisals is dynamic and continuous over time, with characteristics of a situation influencing the appraisals that are made by drawing attention to certain aspects of the situations over others, and appraisals in turn influencing the situation, which further influences appraisals. As a result, appraisals influence the generation of an emotional response at all points of the sequence of a developing emotional response (e.g. both in anticipation of an event or after an emotional response is already underway). According to cognitive models of depression, depression-associated cognitive biases, or systematic ways of processing information in a negatively skewed manner, may lead to automatic depression-congruent appraisals of events, in turn worsening mood and leading to a cycle of increasingly negative mood and cognition.

Importantly, appraisals not only impact the generation of an emotional response, but they also affect the implementation of emotion regulation strategies in response to a situation. Characteristics of appraisals of negative events (e.g. Negative: I am to blame for this situation; there is not much I can do to change this situation, versus Positive: I have the situation in control; There are many ways I can improve the situation) may influence which emotion regulation strategies an individual is more likely to use to respond to the situation, as well as how easy or difficult it is to implement particular strategies. Given that appraisal is continuously occurring, influenced and being shaped in turn by attention to the situation, cognitive processes may impact emotion regulation

strategies with targets at any point along the sequence of an unfolding emotional response, including both antecedent and response-focused strategies. For example, difficulty disengaging from negative aspects of a situation may affect attentional deployment, leading a person to focus attention on negative over neutral or positive aspects of a situation, which in turn affect later appraisals and emotional responding. At the same time, patterns of interpreting situations may influence the use of reappraisal in advance of an emotional response. Given the importance of cognitive processes in emotion generation and emotion regulation, cognitive biases associated with depression may lead to impairments in emotion regulation, specifically greater use of less adaptive strategies and difficulties implementing adaptive strategies. A better understanding of the role of cognitive biases in the ability to effectively implement emotion regulation strategies has the potential to inform current cognitive theories of depression.

Use and Effectiveness of Specific Emotion Regulation Strategies in MDD

A growing body of literature demonstrates that individuals with MDD use emotion regulation strategies shown to be less effective in alleviating negative mood and more likely to backfire, resulting in a range of negative consequences. It is well established, for example, that individuals with depression ruminate more frequently, which involves repetitively thinking about one's negative mood and analyzing its causes and consequences (see review by Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination prolongs sad mood, predicts a more chronic course of the disorder (Nolen-Hoeksema & Morrow, 1991), and predicts poorer outcomes in a range of areas of functioning (Lyubomirsky, Tucker, Caldwell, & Berg, 1999; Nolen-Hoeksema & Davis,

1999). Several recent studies have demonstrated that depression is also associated with a greater tendency to use expressive suppression (e.g. Moore, Zoellner, & Mollenholt, 2008), which involves attempts to conceal negative emotional responses from others (Gross, 1998). Suppression, similar to rumination, has been shown to be ineffective in reducing the subjective experience of negative emotion, often magnifying the physiological component of a negative emotional response (Gross, 1998; Campbell-Sills, Barlow, Brown & Hoffman, 2006). In addition, suppression is cognitively taxing, leading to impairment in cognitive functioning and interpersonal functioning (Richards & Gross, 1999; Egloff, Schmukle, Burns & Schwerdtfeger, 2006). Similarly, Wenzlaff and colleagues have demonstrated that depression is correlated with greater use of cognitive suppression, which involves attempts to avoid or stop negative thoughts and is thought to be less adaptive due to its tendency to lead to increases in negative thoughts (Wenzlaff, Rude & West, 2002).

In contrast, a strategy that is thought to be more adaptive is reappraisal, which involves changing a situation's meaning to alter one's emotional response to the situation (Gross, 1998; Gross & John, 2003). Reappraisal has been studied extensively in non-clinical populations and has been shown to reduce negative affect (John & Gross, 2004) without the social and cognitive costs associated with rumination and other less adaptive strategies, such as suppression (Wenzlaff, Rude & West, 2002; Richards & Gross, 2000; Butler et al., 2003). Recent studies have tied lower dispositional use of reappraisal to greater depression severity (Fresco et al., 2007; Garnefski & Kraaij, 2006a; Joormann & Gotlib, 2010). A recent study also indicated an association among less frequent use of reappraisal in daily life and prolonged stress reactivity to a laboratory stress induction,

suggesting that impaired recovery from stress may be one way in which decreased use of reappraisal is tied to depressive symptom severity (Mauss, Cook, Cheng & Gross, 2007). It is important to note that recent researchers have differentiated between anticipatory reappraisal, initiated early in the time sequence of an emotional response, from *online* reappraisal, which is put into use mid-way during an emotional response. In a series of studies, Sheppes and colleagues found evidence that online reappraisal is more difficult to implement and may be more cognitively taxing than anticipatory reappraisal (Sheppes & Meiran, 2007; Sheppes, Catran & Meiran, 2009). At the same time, online reappraisal is particularly important to examine in MDD; given the persistent negative affect characterizing this disorder, individuals with depression are likely to need to implement emotion regulation strategies late in the emotion generation sequence.

Despite increasing evidence that depressed and nondepressed individuals differ in their use of emotion regulation strategies, previous studies of emotion regulation in depression have important limitations. In a meta-analysis examining the relation among use of these strategies and symptoms of various disorders, Aldao and colleagues (2010) emphasized that a majority of previous studies have not utilized diagnosed samples; importantly, they found that studies utilizing clinical or diagnosed samples found stronger relationships between strategy use and symptom severity. In addition, the majority of studies of the role of emotion regulation in psychopathology have utilized cross-sectional designs examining the relation among self-reported frequency of strategy use and symptom measures. There are many challenges involved in measuring emotion regulation using self-report. These include demand characteristics, limitations in a person's awareness of the particular emotion regulation strategies used, and the difficulty

in accurately reporting how frequently these are used on a day to day basis. Further, these studies cannot provide information about mechanisms that may underlie depression-associated differences in the use of these strategies (Joormann & D'Avanzato, 2010). It also remains unclear why use of particular strategies is associated with symptom severity. For these reasons, emotion regulation researchers have argued for the need for more studies utilizing diagnosed samples which combine self-report and experimental methods to understand the role of emotion regulation in risk for and maintenance of emotional disorders (Campbell Sills, Barlow, Brown & Hoffman, 2006; Aldao et al., 2010).

An additional limitation of previous research is the relative lack of studies examining the role of adaptive emotion regulation strategies, such as reappraisal, in depression. Individuals with MDD, in addition to differing from healthy individuals in the types of strategies they frequently use, may also differ in the effectiveness with which they are able to implement adaptive emotion regulation strategies. Despite increasing evidence that depressed individuals less frequently use adaptive strategies, such as reappraisal, less is known about the effectiveness of reappraisal, in MDD. In fact, difficulties with the effective use of reappraisal may be one reason why less frequent use of reappraisal is reported among depressed individuals. Investigating reappraisal in depression seems critical given that it is a central component of CBT treatments, which teach individuals to attempt to override negative, automatic interpretations of events with more adaptive interpretations. Despite its prominence in current cognitive-behavioral interventions, however, the literature examining reappraisal in depression is surprisingly

lacking (Aldao et al., 2010). The present study therefore examined the effectiveness of reappraisal among individuals with MDD compared to individuals with no history of a psychological disorder.

Cognitive Biases in MDD

Further, this study investigated cognitive mechanisms underlying reappraisal to understand why depressed people may have difficulties implementing this strategy. As discussed previously, cognitive theories of depression hold that cognitive biases play a central role in perpetuating negative affect in this disorder, and they also influence emotion regulation. Specifically, depressed individuals exhibit enhanced memory for negative material, difficulty disengaging attention from negative stimuli, cognitive control deficits, and negatively skewed interpretations, biases which are thought to play a causal role in maintaining MDD (Joormann & D'Avanzato, 2010; Mathews & MacLeod, 2005). Recent longitudinal studies using never-disordered high risk samples, as well as studies of individuals with a history of MDD who are currently in remission, suggest that these biases are not merely byproducts of the disorder but may in fact play a causal role in its development and maintenance (e.g. Joormann, Talbot & Gotlib, 2007). These biases, however, have yet to be directly linked to specific mechanisms which influence risk for and maintenance of MDD, such as deficits in reappraisal. In the present study we focused on interpretation biases and individual differences in cognitive control in depression, which seem crucial to the ability to reappraise.

Interpretation Bias

Previous studies have found a greater tendency to interpret ambiguous information in a negative manner in MDD. Negative interpretive bias may lead to negative initial appraisals of events. As initial interpretations often occur quickly and automatically and may not be easily modified through conscious use of emotion regulation strategies, interpretive bias may interfere in anticipatory reappraisal, which requires the ability to generate a positive appraisal early in the sequence of a developing emotional response. Negative interpretive bias may also interfere with online reappraisal after an emotional response is underway. It has been argued that interpretation bias may involve multiple components, such as generating both an initial negative appraisal, as well as deciding on negative appraisals over positive alternatives at later stages of processing (Wisco, 2009). Interpretive bias may lead to the predominance of negative appraisals which are difficult to overcome in favor of positive alternatives at later stages in the development of an emotional response.

Initial evidence of interpretive biases came from studies demonstrating that individuals with MDD exhibit negatively biased interpretations when assessed using self-report measures (see review by Wisco, 2009). For example, in an early study, depressed individuals were found to be more likely than controls to assign threatening interpretations to ambiguous scenarios (Butler & Mathews, 1983). In addition, depressed compared to control participants in this study estimated a greater probability of negative events occurring, both to themselves and to others, as well as a greater impact of negative events, reflecting negatively skewed interpretation of the world and the self. In addition,

there is ample evidence that individuals vulnerable to depression are biased in their attributions of negative events. Typically, this has been assessed using self-report measures, such as the Cognitive Bias Questionnaire (Krantz & Hammen, 1979) and the Attributional Style Questionnaire (Peterson et al., 1982), by presenting individuals with descriptions of negative events and asking them to describe their responses to or appraisals of the events. In these studies, depressed individuals tend to be more likely to assign personal responsibility for negative events, as well as to view negative outcomes as generalizing to a wide range of situations and over time (e.g. Moore & Fresco, 2007). Importantly, in the latter study dysphoric individuals' attributions were also less realistic, determined by ratings made by objective observers comparing their attributions to experimenter-provided descriptions of the actual causes of these events.

However, several concerns about use of self-report measures to assess interpretive bias have been noted, including the possibility of response bias, which refers to a tendency to select negative responses, which may not necessarily reflect more negative interpretations (Wisco, 2009). In addition, in her review Wisco points out that it is not possible using self-report measures to distinguish between multiple processes involved in interpretation, including the generation of various possible interpretations, the selection of one interpretation among these options, and the reporting of this interpretation, particularly processes that may occur automatically. For these reasons, there has been a move toward incorporating novel experimental methods which may better distinguish between sub-processes of interpretation and control for the possibility of response bias.

Recent experimental studies have confirmed the presence of negative interpretive bias in depressed individuals, demonstrating that this bias also extends to automatic interpretations. Previous studies have found evidence of interpretive bias in MDD using tasks in which participants are presented with auditory stimuli. One task on which differences between individuals high and low in depressive symptom severity has been found involves presenting participants with acoustically blended ambiguous words which can be heard as either neutral (e.g. thumb) or negative (e.g. dumb) words differing only in one phoneme. In addition, participants are presented with unambiguous negative and neutral words. While listening to the stimuli, the magnitude of participants' eye-blink startle reflex, which previous studies have demonstrated is reliably magnified in negative and attenuated in positive contexts, is assessed as an indicator of the valence of participants' interpretations. Startle reflex to ambiguous stimuli is contrasted with that to neutral and negative stimuli. Enhanced magnitude of startle reflex to ambiguous stimuli suggests a negative interpretation bias. In one recent study, individuals with high, but not low, BDI scores exhibited blink reflex magnitudes that were significantly greater for the ambiguous versus neutral stimuli, supporting the presence of a negative interpretation bias in depression. Importantly, results held even after controlling for anxiety symptoms (Lawson, MacLeod & Hammond, 2002). Mogg, Bradbury & Bradley (2006) also found evidence of depression-related interpretive bias using a homophone task. In this task, participants listen to orally presented words, which include homophones, or word pairs which sound identical but have either a negative or neutral meaning (e.g. die/dye, weak/week). Individuals diagnosed with MDD produced a significantly higher proportion of negative to neutral interpretations relative to controls (Mogg et al., 2006).

Not only is interpretation bias associated with depression symptoms concurrently, but recent studies have demonstrated that interpretive bias predicts the future onset of symptoms of depression. One study found that college students who provided more negative solutions on the Scrambled Sentences Task, which involves unscrambling sentences that have either a negative or benign interpretation, tended to exhibit elevated depression symptom severity when assessed over a month later, even when controlling for previous levels of depression symptoms (Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). On this task, participants are asked to rearrange a series of scrambled sentences using all except one word. Sentences are identical in length, with each yielding two possible solutions, including either a negative or positive interpretation. Participants completed as many sentences as possible in 2.5 minutes. A greater proportion of negative solutions indicates negative interpretive bias. Dearing and Gotlib (2009) showed that a high risk sample of girls born to mothers with recurrent MDD demonstrated a negative bias in interpretations of stories and words compared to daughters of healthy controls, suggesting that interpretive bias is not merely a correlate of a depressive episode but may play a causal role.

The most direct evidence of a causal role of interpretation bias in the development and maintenance of depression comes from recent studies which have manipulated interpretation biases and demonstrated subsequent changes in mood. One such study which trained participants to resolve ambiguous emotional scenarios in a positive manner using visual imagery, found that training a positive visual interpretation bias resulted in improved mood assessed both following the training and in response to a later negative mood induction (Holmes, Lang & Shah, 2009).

It is important to note that some studies have failed to find support for an interpretation bias in depressed individuals. Despite obtaining evidence of interpretive bias using the homophone task, Mogg et al. (2006) did not find differences across groups high versus low in depression levels using a text comprehension task. In this task, participants view ambiguous sentences (e.g. "Carol felt emotional throughout the service") followed by continuation sentences that resolved the sentence in either a negative or benign way ("Funerals always made her cry" OR "Weddings always made her cry"). Some ambiguous sentences were also preceded by a cue word related to either the negative or benign interpretation. The dependent variable in this task is reading time of the continuation sentences. Interpretive bias is indicated when reading times of negative continuation sentences are similar in the ambiguous and negative cue conditions, both of which are faster than in the benign cue condition; similarly, for benign continuation sentences, reading times are expected to be similar in the ambiguous and negative cue conditions, with both being slower than the benign cue condition. Some authors have argued that the failure to find evidence for interpretation bias in such studies may be attributable to problems with tasks relying on reaction times (Lawson et al., 2002).

Cognitive Control

In addition to interpretation biases, depressed individuals exhibit deficits in cognitive control (Joormann & Gotlib, 2008), which involves the ability to update the contents of working memory. Working memory involves the storage, processing and integration, and retrieval of information. Importantly, working memory is capacity-

limited; therefore, the ability to control its contents by prioritizing relevant over irrelevant information is critical for adaptive functioning. Two components of cognitive control are frequently investigated: the ability to keep irrelevant information from entering working memory, and the ability to remove material from working memory that is no longer relevant (Hasher, Zacks, & May, 1999). It is well known that negative mood results in the activation of mood congruent material in working memory (Watkins, 2002). Cognitive control in healthy individuals, however, assists to limit how much negative material is activated in working memory in favor of positive material. In individuals with impaired cognitive control, too much negative material is allowed access to working memory. An inability to inhibit negative emotional material from working memory is likely to interfere with ability to effectively use strategies such as reappraisal, which require the ability to maintain focus on alternative positive appraisals of a situation, to repair negative mood. In addition, impaired cognitive control may lead to increased use of less adaptive strategies, such as rumination and suppression.

Deficits in inhibition of negative emotional material have been observed in depression utilizing various tasks assessing these components of cognitive control (Joormann & Gotlib, 1998; Goeleven, DeRaedt, Baert, & Koster, 2006). The Negative Affective Priming Task (NAP; Joormann, 2004) is one paradigm which has been used to assess difficulties inhibiting emotional material. This task is a modified version of the negative priming task which consists of viewing pairs of trials, including a prime trial followed by a test trial. In both the prime and test trials, two adjectives are presented (one target and one distractor), and participants are asked to ignore the distractor (white letters on dark background) and respond to the target (dark letters on white background).

In the negative priming condition, distractors in the prime trial are the same valence as targets in the test trial; in contrast, in the control condition prime trial distractors and test trial targets are not related to one another. At the end of both the prime and test trial, participants are asked to respond to the target and ignore the distractor. The response given by participants can vary and typically involves judging whether the target is negative or positive, or self-referent or non self-referent. Mean response time to control trials is subtracted from that to test trials. If effective inhibition of negative material has occurred, participants should be slower to respond to test trial targets matched in valence to prime trial distractors, a phenomenon termed negative priming. Joormannn (2004) showed that dysphoric compared to non-dysphoric individuals exhibited impaired inhibition of negative emotional material indicated by reduced negative priming to negative test trial targets that were preceded by negative prime trial distractors; this group difference was not found for positive test targets preceded by positive distractors. Similar results were obtained, regardless of whether participants were asked to evaluate valence or self-reference. In an additional study, formerly depressed individuals not in a current episode failed to show negative priming using the NAP, suggesting that difficulties inhibiting negative material may constitute a vulnerability to future episodes of depression (Joormann, 2004).

Several studies have demonstrated impaired inhibition associated with MDD using a modified emotional Sternberg Task (Joormann & Gotlib, 2008). In this task, participants learn two lists of words and are later cued by a colored frame to remember one list and discard from memory the other list. Participants respond to the probe trial, in which a word from either the relevant or irrelevant list, or a novel word, is presented,

pressing Yes only if the word was in the relevant list and No if the word was novel or irrelevant. Response times to novel probes are compared to irrelevant probes. In previous studies, dysphoric or depressed individuals have been found to exhibit longer response latencies to irrelevant negative words relative to novel words, indicating ineffective inhibition of negative material (e.g. Joormann & Gotlib, 2008; Joormann & Gotlib, 2010).

Another category of tasks assessing inhibition are Directed Forgetting tasks. Directed forgetting tasks were developed to assess whether inhibition deficits may account for enhanced memory for negative material that has been commonly observed in individuals with depression. The tasks involve instructing participants to remember items, and later requiring them to "forget" already encoded items, explaining that this information will not be tested later. After a delay, free-recall or recognition of to-be-forgotten items and relevant items are tested. Power, Dalgleish, Claudio, Tata, and Kentish (2000) exhibited evidence for impaired inhibition in depression in a series of studies using a directed forgetting task in which participants were asked to evaluate features of positive and negative words and told they will need to remember the words. Midway into the study, participants are told that the previously presented words were practice trials and to forget these words, focusing on the remaining words presented; in fact, they are later given a memory task for to-be-remembered and to-be-forgotten words. In a study in which participants evaluated degree of self-reference of the adjectives presented, non-dysphoric students recalled more to-be-forgotten positive words, whereas dysphoric students lacked this positive bias. In a further study using a diagnosed sample, the MDD group showed significantly greater recall of negative to-be-forgotten words,

whereas the positive bias was replicated in the control group. In a variation on this task utilized by Hertel and Gerstle (2003), participants were cued using positive or negative adjectives to either suppress or recall target nouns. Recall of words was later tested and was found to be higher for words assigned to be suppressed in the dysphoric group, particularly for negative to-be-suppressed words; further, recall bias was related to reported rumination and intrusive thoughts.

Several recent studies have demonstrated that individuals with difficulties in cognitive control in fact report more frequent use of rumination (Hertel & Gerstle, 2003; Whitmer & Banich, 2007), even after controlling for depressive symptoms (Joormann, 2006; Joormann & Gotlib, 2008 and 2010). Moreover, depressed individuals exhibiting inhibition deficits have also been found to report greater use of other maladaptive strategies, such as expressive suppression (Joormann & Gotlib, 2010). However, there is a lack of studies examining whether cognitive control may be related to difficulties effectively using other, more adaptive, emotion regulation strategies, such as reappraisal. One recent study, however, found that difficulty inhibiting negative adjectives is associated with more frequent self-reported use of reappraisal in daily life (Joormann & Gotlib, 2010), providing support for a relation between cognitive control difficulties and reappraisal. It is possible that past difficulties reappraising effectively might be one reason why individuals with depression attempt reappraisal less frequently, but experimental studies are needed to test this hypothesis.

Despite a lack of experimental studies examining the effectiveness of reappraisal in depression and its relation to cognitive variables, promising support for a link between

deficits in reappraisal and impaired inhibition comes from studies examining the neural correlates of reappraisal, and differences in brain function between depressed and nondepressed individuals. Neuroimaging studies, which typically investigate patterns of brain activation during instructed reappraisal in response to emotional stimuli, have demonstrated that an interaction between the dorsolateral prefrontal and cingulate cortex, regions involved in cognitive control, with the amygdala and insula, which play a role in emotional reactivity, underlies reappraisal (Ocshner & Gross, 2008). Past neuroimaging studies have demonstrated a pattern corresponding to effective use of reappraisal of negative stimuli in which the prefrontal and cingulate cortex exert top-down control over the subcortical regions; specifically, greater activation in the prefrontal cortex corresponding with decreases in amygdala activation is observed in healthy individuals upon instruction to reappraise. Additionally, this pattern of brain activation has been found to correspond with self-reported decrease in the experience of negative emotions. Interestingly, recent studies demonstrated deficits in prefrontal-cortical modulation of the amygdala in Major Depressive Disorder, suggesting potential deficits in effective reappraisal (Siegle et al., 2007, Johnstone et al., 2007). In the latter study, these deficits were seen even though participants were directly instructed to reappraise. Direct evidence of a potential influence of cognitive control in reappraisal comes from a recent study which demonstrated that a brief intervention training individuals with MDD to boost cognitive control, specifically working memory and selective attention, lead to decreased amygdala activation to negative stimuli during an emotional task and boosted prefrontal cortex activity during the most difficult trials of a cognitive task (Siegle, Ghinassi & Thase, 2007). Further, the cognitive control training resulted in decreased

rumination and symptoms of depression. These results are promising, but there is a need for more studies comparing individuals with MDD to controls which specifically instruct participants to reappraise, and which link individual differences in the effectiveness of reappraisal to behavioral measures assessing specific aspects of cognitive control.

Integrating Cognitive Biases, Reappraisal, and Sustained Negative Mood in Depression

Despite substantial evidence of cognitive biases in MDD, there is little research explicitly linking these biases to the persistent negative mood that characterizes this disorder. In the present study, it was proposed that cognitive biases and cognitive control deficits interfere with the use of adaptive emotion regulation strategies, such as reappraisal, in turn contributing to depression.

Critical to reappraisal is the ability to 1) entertain alternative interpretations of events and 2) retain more adaptive interpretations. Interpretation in daily life often occurs quickly and automatically, and individuals who initially gravitate toward negative appraisals may thus struggle with reappraisal. In addition, individual differences in the ability to retain more adaptive interpretations over automatic ones are likely to affect reappraisal difficulty. Interpretation biases thus affect not only individuals' initial appraisals of negative events, but also the ability to reappraise after an emotional response has developed. Cognitive control is likely to exert its influence in the emotion regulation sequence directly on reappraisal of an event once an emotional response has been elicited. Deficits in cognitive control in depression may result in greater accessibility of negative material, making it more difficult to maintain focus on adaptive interpretations required for reappraisal.

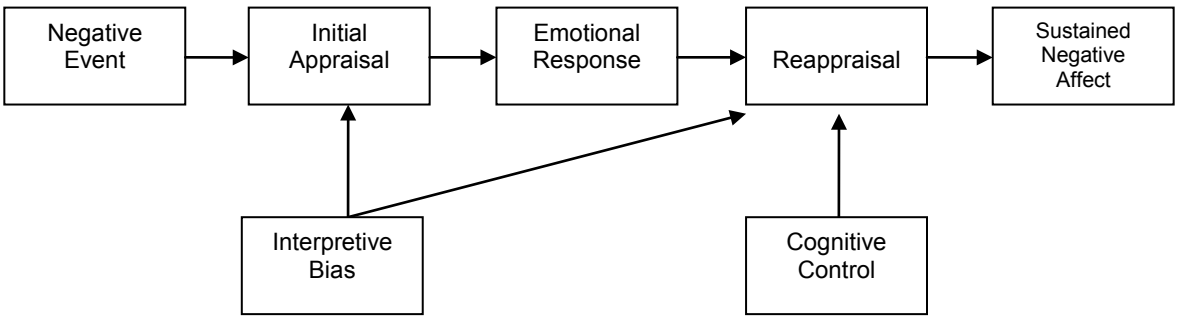


Figure 1.2. Association among Cognitive Biases, Reappraisal Deficits and Sustained Negative Mood

Whereas studies on interpretive biases and cognitive control deficits in MDD are abundant, studies that more directly examine how these processes are related to difficulty alleviating sadness in MDD are needed. Therefore, the aim of this study was to examine interpretation bias, cognitive control, and reappraisal ability within the same study to determine whether difficulties reappraising in a sad mood may underlie the association between negative interpretation bias and depression. Results from previous studies suggest an association between decreased reappraisal use and MDD, as well as decreased use of reappraisal and deficits in cognitive control (Joormann & Gotlib, 2010). Further, preliminary findings indicate differences in the neural correlates of reappraisal between MDDs and controls, suggesting difficulties in MDD (Johnstone et al., 2007). The present study extended these findings by comparing the effectiveness of reappraisal between participants with MDD and a control group with no history of an Axis 1 disorder, assessing both subjective experience and physiological indicators of negative affect. Finally, the present study assess participants' performance on tasks assessing cognitive control and interpretive bias to understand the role of specific cognitive processes required for effective reappraisal which may be disrupted in MDD.

Measurement of Emotion Regulation

The effectiveness of emotion regulation has been assessed using a combination of methods, including self-report measures and, more recently, psychophysiological and neural activity assessments. Studies employing self-report measures typically examine self-reported affect in response to a negative mood induction and contrast affect ratings prior to versus after implementing an emotion regulation strategy. A decrease in negative affect ratings from prior to following use of an emotion regulation strategy indicates effective emotion regulation. There are problems relying solely on self-report, however, given limits of people's ability to accurately report their emotions and demand characteristics. For this reason, recent studies have supplemented affect ratings with biological measures. Numerous studies have demonstrated that emotional responses are marked by changes in physiological responding. Specifically, increased sympathetic activation, indicated by increased heart-rate, is associated with the experience of stress and negative emotions, including sadness. In response to a negative mood induction or stressor, heart rate increases, reaches a peak, and gradually declines as negative affect decreases throughout recovery. Heart rate thus can be utilized to indicate changes in negative affect associated with initiation of an emotion regulation strategy in response to an unpleasant event. Several studies have documented increased heart rate in response to a stressful task. Kibler and Ma (2004) conducted a meta-analysis to examine whether increased heart-rate reactivity to stressors may be a potential mechanism through which depression is linked to cardiovascular disease; a moderate effect size was found for the relation between level of depressive symptoms and heart rate reactivity to a laboratory stressor. Additionally, increased heart-rate has been demonstrated in other studies

examining physiological response to sadness. In a series of studies, increased heart-rate characterized participants' response to sadness, as well as anger and fear, elicited by the Directed Facial Task, which involves providing detailed verbal instructions guiding participants to construct facial configurations corresponding to specific emotions (e.g. Levenson, Ekman & Friesen, 1990; Levenson, Ekman, Heider & Friesen, 1992).

Some researchers have advocated for the need to distinguish between initial physiological reactivity to stressors and the course of physiological response throughout a recovery period, arguing that it is prolonged sympathetic activation that best differentiates vulnerable from healthy individuals (e.g. Salomon et al., 2009). Salomon and colleagues found that, while depressed and non-depressed individuals did not differ in cardiovascular reactivity to a stressful speech task, depressed individuals exhibited delayed recovery to the task relative to controls. One ambulatory study of physiological response to daily stressors demonstrated that prolonged heart-rate response during recovery better distinguished between negative and positive affect; specifically, whereas both negative and positive emotional responses were marked by initial increases in heart-rate reactivity, prolonged elevation in heart-rate uniquely characterized negative affect (Brosschot & Thayer, 2003). The authors interpreted this finding to reflect that negative affect is a sign of difficulties in coping with, and rumination in response to, a negative event and is thus more likely to be accompanied by prolonged activation. Indeed, an association between rumination and prolonged cardiovascular response to stress has been found in recent studies (Gerin et al., 2006; Glynn et al., 2002). In contrast, use of strategies considered more adaptive, such as reappraisal and distraction, have been found in prior studies to facilitate faster cardiovascular recovery to negative events (e.g.

Williams et al., 2009). In a study examining the impacts of induced distraction versus a no-distraction recovery period following an anger recall task on cardiovascular recovery, distraction was associated with a faster decline in heart-rate toward baseline levels (Neumann et al., 2004). Importantly, participants in the distraction compared to no-distraction condition reported ruminating less during the recovery period, suggesting that decreased rumination may underlie the beneficial effects of distraction on physiological recovery.

Another physiological indicator commonly used in studies of emotion regulation and recovery from stressful events is heart rate variability (HRV). Heart-rate variability refers to the beat-to-beat variation in the spacing of heart-beats. Respiratory sinus arrhythmia (RSA) is a commonly used measure of HRV within the high-frequency band of respiration (HF-HRV). RSA reflects the influence of the parasympathetic nervous system on regular fluctuations in heart-rate tied to respiration, specifically in slowing heart-rate and autonomic arousal during expiration, and in removing its brake during inspiration to allow heart-rate to increase (Berntson et al., 1997). Parasympathetic influence on heart-rate is achieved via activity of the vagal nerve, which projects from the brainstem to the heart. Numerous studies have demonstrated associations among low resting levels of HRV and both physical and mental health problems (see review by Rottenberg, 2007), and, conversely, among high levels of HRV and adaptive psychological functioning, including healthier social relationships and resilience to stress (Eisenberg et al., 1995; Fabes and Eisenberg, 1997).

HRV is particularly relevant to MDD, defined by deficits in emotion regulation, because of its theorized role as a biological mechanism underlying stress regulation. The Polyvagal Theory (Porges, 1995) outlines the association among the evolution of the autonomic nervous system and that of systems involved in attention, emotion and social behavior unique to humans, such as facial gestures and speech. Specifically, it emphasizes a branch of the vagus nerve in mammals originating in the nucleus ambiguous of the brainstem which, in addition to influencing heart rate variability, projects to several organs involved in emotional experience, communication, and social behavior, including the heart, lungs, facial muscles, and larynx, among others. The vagus nerve is believed to play a critical role in the body's response to stress by decreasing parasympathetic influence on heart-rate during times of stress, seen in decreased HRV during stress, which facilitates hypothalamic-pituitary-adrenal (HPA) axis activity known as the fight-flight response. Baseline HRV levels in healthy individuals when not exposed to stress, in contrast, are elevated, reflecting the parasympathetic system's inhibition of the HPA axis, via the vagal nerve's input to the heart, for the purpose of conserving energy. According to Polyvagal Theory, the autonomic nervous system plays a primary role in emotion expression, experience and responding via the vagus nerve, and emotion should be reflected by changes in HRV.

Prior studies have supported that decreased RSA occurring during response to and recovery from stress and negative affect may reflect difficulties with emotion regulation. Rottenberg, Wilhelm, Gross and Gotlib (2003), for example, found that an increase in HRV accompanied by a later decrease in heart-rate was seen during crying in response to a sad film in non-depressed individuals, whereas this change was not exhibited by

depressed individuals. This finding was interpreted to reflect deficits in physiological mechanisms of emotion regulation in MDD. In parallel to research illustrating that use of rumination may lead to increased and prolonged heart-rate reactivity to stress, previous studies have demonstrated that emotion regulation strategies may serve as mechanism through which disruptions in RSA in response to stress occur in some individuals. Key, Campbell, Bacon & Gerin (2008) examined the relation of state and trait rumination in response to a laboratory stress task involving a speech about a past upsetting event, finding that individuals high in trait-rumination exhibited prolonged decreased HF- HRV to the stressor. Unexpectedly, state rumination was linked to delayed recovery in HF-HRV only among individuals low in trait-rumination. Lyonfields, Borkovec and Thayer (1995) examined the impact on HRV of viewing aversive imagery related to worries, as well as worrying about topics of concern, among individuals diagnosed with generalized anxiety disorder compared to a control group. Individuals with GAD exhibited lower baseline levels of HRV relative controls, which did not change, but remained depressed, throughout the aversive imagery and worrying tasks. Interestingly, aversive imagery and worrying led to reductions in HRV from baseline in healthy controls.

Hypotheses

The hypotheses for this study were as follows:

1. It was hypothesized that individuals with MDD, compared to controls, exhibit difficulties reappraising in response to a sad film, indicated by prolonged subjective experience of negative affect and prolonged physiological recovery following initiation of reappraisal.

a. Subjective experience of emotion: Participants with MDD, when compared to controls, were expected to show a slower decline toward baseline levels of negative affect from the pre-regulation to the regulation (reappraisal) and recovery periods.

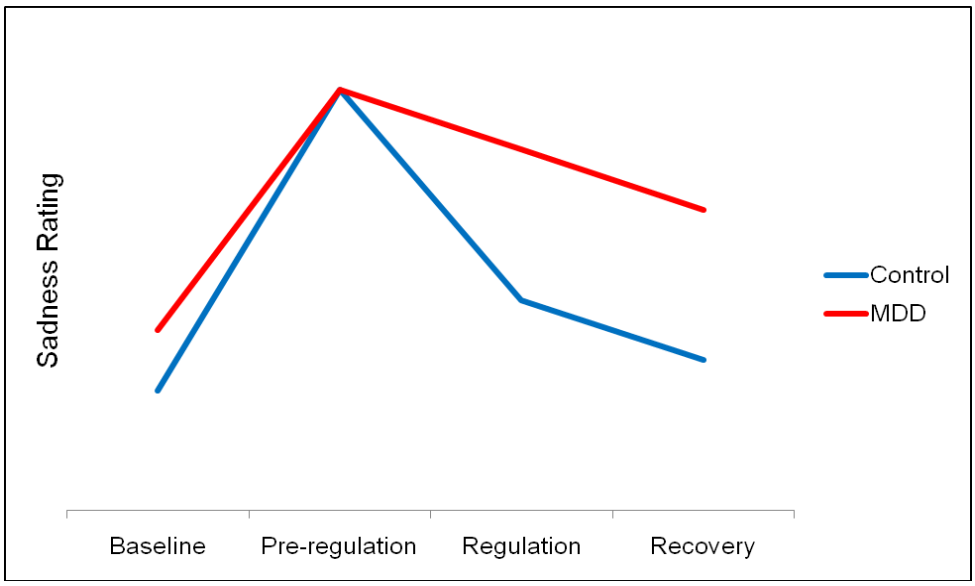


Figure 1.3. Hypothesized Change in Sadness Ratings Throughout Reappraisal Task Phases. Note: Pre-regulation denotes the first portion of the sad film prior to emotion regulation. *Regulation* denotes the second period of the film during which participants are instructed to reappraise. *Recovery* refers to the five minute period following the end of the sad film.

b. Physiological response. Participants with MDD, compared to controls, were expected to exhibit a delayed return to baseline in heart-rate and RSA throughout the reappraisal and recovery periods. Specifically, MDD, compared to control, participants were expected to demonstrate prolonged elevation in heart-rate, and prolonged decreased RSA, throughout the reappraisal and recovery periods compared to controls.

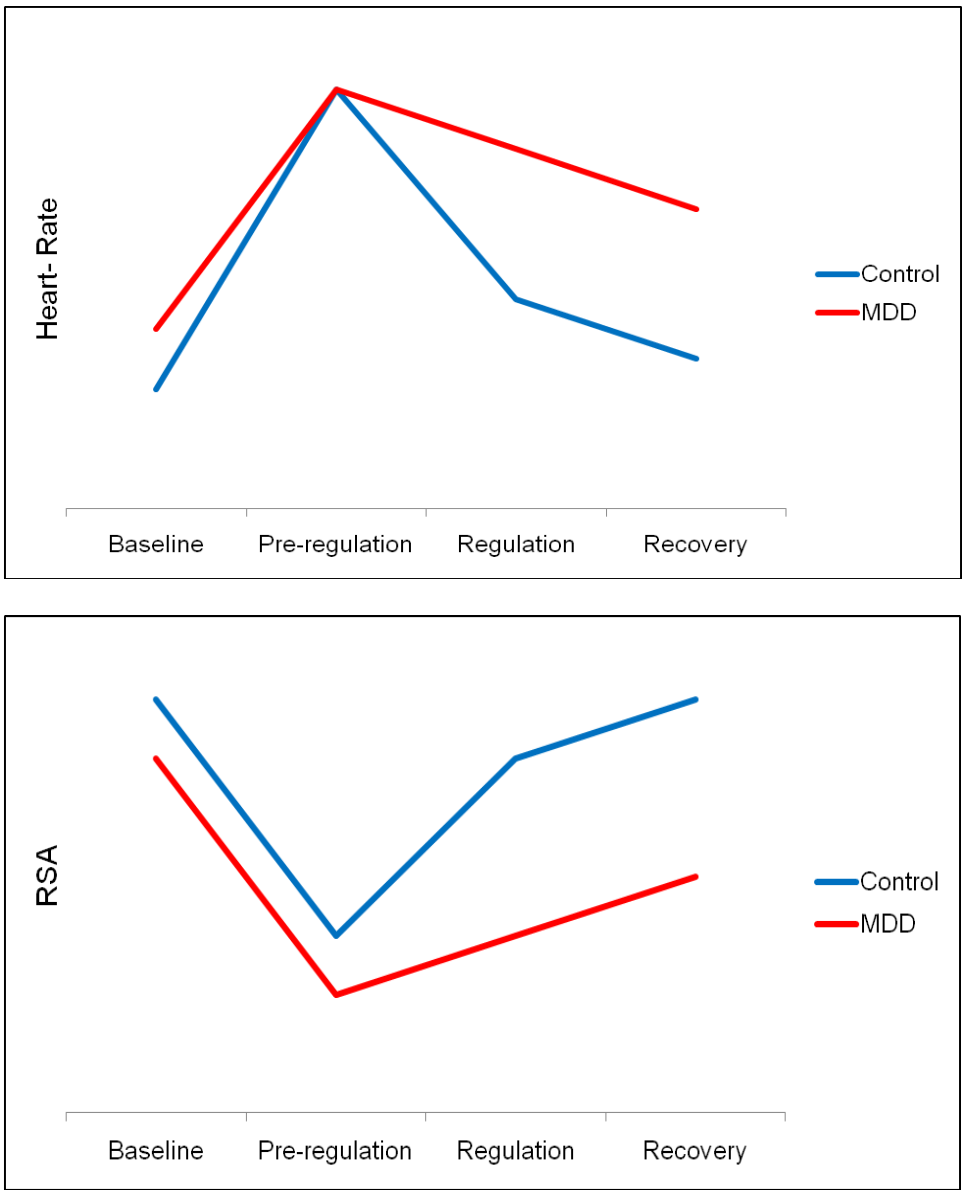


Figure 1.4. Hypothesized Change in Physiological Indices Throughout Reappraisal Task Phases.

2. It was hypothesized that the MDD group, compared to control participants, exhibit impaired cognitive control and negative interpretive bias.

a. Cognitive Control: It was hypothesized that individuals with MDD, compared to controls, exhibit deficits in inhibition of negative emotional stimuli, indicated by longer response latencies on the Sternberg task to negative words from the irrelevant list relative to novel negative words.

b. Interpretation Bias: Individuals in the depressed group were hypothesized to exhibit a negative interpretive bias, obtaining a greater proportion of negative solutions on the homophone task relative to controls.

3. Further, it was hypothesized that both deficits in cognitive control and negative interpretation bias are associated with decreased effectiveness of reappraisal.

a. Subjective experience of emotion. Diminished ability to inhibit emotional material, indicated by longer response latency to negative irrelevant compared to novel words, was expected to predict less effective reappraisal, indicated by sustained negative affect to the film during the regulation (reappraisal) and recovery periods. Negative interpretive bias, indicated by a greater proportion of negative solutions on the homophone task, was also expected to be associated with sustained negative affect during the regulation and recovery period of the reappraisal task.

b. Physiological response. We hypothesized that difficulties inhibiting negative emotional stimuli, as well as negative interpretive bias, are associated with

delayed return to baseline in heart-rate and RSA, during reappraisal of a sad film and the subsequent recovery period.

4. Decreased inhibition of negative emotional material and negative interpretive bias were expected to mediate the relation between diagnosis (MDD versus Control) and the effectiveness of reappraisal in response to a sad film.

5. It was hypothesized that dispositional use of emotion regulation strategies is associated with the effectiveness of reappraisal to the sad film. Specifically, more frequent dispositional use of rumination and suppression, and less frequent use of reappraisal, was expected to be associated with decreased effectiveness of reappraisal in response to the film.

Chapter 2: Methods

Participants

The sample was comprised of 67 individuals between the ages of 21 and 55 recruited from the community through newspaper and online advertisements. Participants who met Diagnostic and Statistical Manual of Mental Disorders, 4th ed. (DSM-IV-TR, American Psychiatric Association, 2000) diagnostic criteria for current MDD based on the Structured Clinical Interview for the DSM-IV-TR (SCID; First, Spitzer, Gibbons & Williams, 2002) were be eligible for the depressed group, whereas participants who have no current Axis I disorder or any history of past Axis I disorder were eligible for the control group. Exclusion criteria included psychotic symptoms, diagnosis of Substance Use or Dependence within the past six months, and diagnosis of Bipolar Disorder. To be included in the study, it was required for participants to be fluent in English, have no learning disabilities, reading or visual processing difficulties, including color blindness, and have no history of serious head trauma, each of which could interfere with the ability to complete the study tasks. Participants with comorbid Axis 1 disorders were not excluded from the MDD group. However, for each participant we assessed whether Major Depressive Disorder was the primary diagnosis. Primary diagnosis was established on the basis of Clinician Severity Ratings (CSR; DiNardo et al., 1983), a measure of the degree of intensity of symptoms, impairment and distress associated with a specific disorder. For each symptom cluster assessed using the SCID, participants were assigned a CSR by the SCID interviewer; individuals for whom CSR is highest for MDD relative to other symptom clusters were considered to have a primary

MDD diagnosis. Further exclusion criteria for the control group included history of psychiatric or substance abuse treatment or hospitalization, as well as history of any Axis I disorder. Participants initially completed a brief telephone interview consisting of items from the SCID, items assessing demographic variables, and items assessing other inclusion and exclusion criteria to determine eligibility for participation. Those participants determined to be eligible based on the phonescreen were next invited to the laboratory to complete the SCID, during which eligibility was verified. The flowchart in figure 2.1 displays the number of participants retained at each stage in the recruitment process. A total of 34 controls and 33 participants with MDD took part in the study.

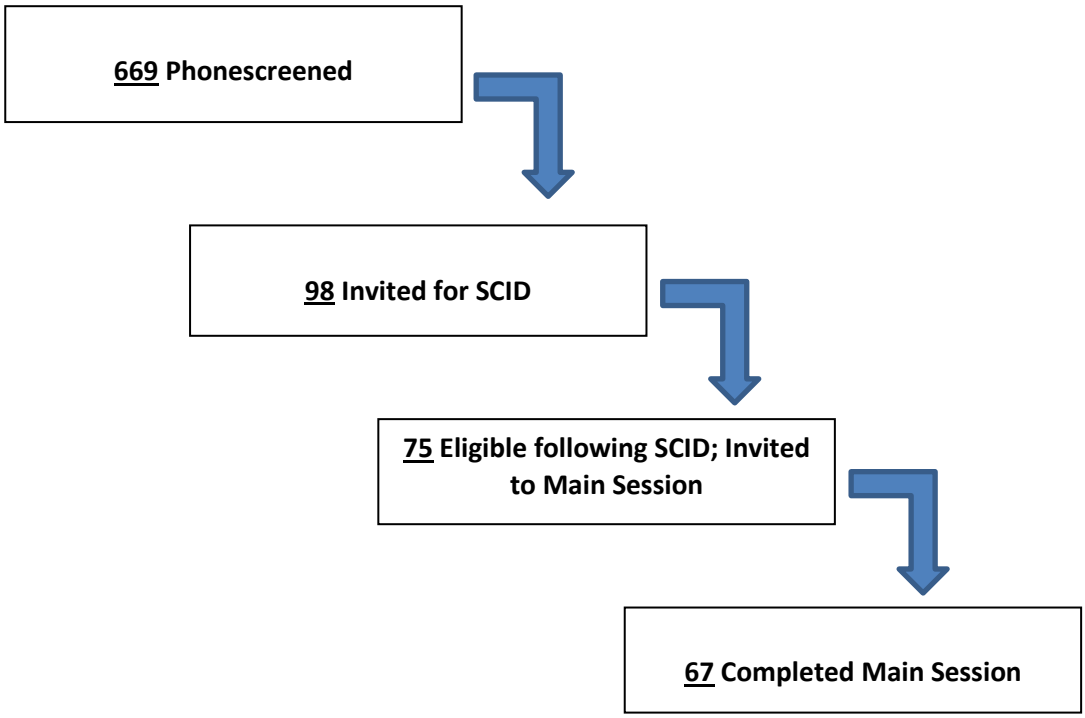


Figure 2.1. Flowchart of Participant Recruitment.

Measures

Structured Clinical Interview for the DSM-IV-TR (SCID; First, Spitzer, Gibbons & Williams, 2002). The SCID is a semi-structured interview which assesses for current and lifetime diagnoses of anxiety, mood, psychotic, alcohol and substance use, and eating disorders based on the Diagnostic and Statistical Manual of Mental Disorders, 4th ed. (DSM-IV-TR, American Psychiatric Association, 2000) criteria and which has shown good reliability (Williams et al., 1992). As part of conducting the SCID, interviewers also assess for current and past psychiatric treatment, as well as features of the course of MDD, such as recurrent versus single episode, and whether the current major depressive episode was preceded by an acute life stressor.

Clinician Severity Rating (CSR; DiNardo, O'Brien, Barlow, Waddell & Blanchard, 1983; Brown, DiNardo, Lehman & Campbell, 2001). The CSR is a measure of the severity of symptoms, impairment in functioning and distress associated with a particular diagnostic category assessed by the SCID. For each diagnostic category assessed in the SCID, the SCID interviewer rates impairment and distress on a 0 to 8 scale with 8 indicating the maximum degree of impairment and/ or distress. CSR ratings of 4 to 8 are considered clinically significant, with ratings of 1-3 indicating sub-threshold symptoms and 0 indicating the absence of any symptoms. Reliability of CSR ratings has been demonstrated to range from k=.65 to k=.84 (Brown et al., 2001).

Demographics. Participants completed a questionnaire assessing demographic characteristics, including age, gender, race and ethnicity, education background, income, occupation, marital status, and children.

Health Questionnaire. Participants were asked to provide information regarding current medical conditions (particularly diabetes, heart disease, hypertension, and health conditions affecting the central nervous system), current medication use (selective serotonin reuptake inhibitors, tricyclic antidepressants, antipsychotic drugs, antihistamines, and beta-blockers), caffeine consumption, recent exercise, and sleep, which have been shown in prior studies to affect RSA levels (see review by Rottenberg, 2007).

Beck Depression Inventory, Second Edition (BDI-II; Beck & Steer, 1993; Beck, Steer, & Garbin, 1988). The BDI-II is a 21-item self-report measure which assesses severity of depression symptoms. Each item is rated on a 0 to 3 scale. A total score, ranging from 0 to 63, is computed by summing individual item scores, with higher scores indicating elevated depression symptom severity. Internal consistency for the BDI-II has been found to range between .73 to .92, with a mean of .86 (Beck, Steer & Garbin 1988). In addition, the BDI has well-documented validity and has been found to converge with clinician ratings of depression, with correlations from .62 to .66 (Foa, Riggs, Dancu & Rothbaum, 1993).

Cognitive Emotion Regulation Questionnaire-Short (CERQ-Short; Garnefski & Kraaij, 2006b). The CERQ assesses the frequency of use of a range of cognitive emotion regulation strategies or patterns of responding to negative emotions and events, including self-blame, acceptance, rumination, catastrophizing, positive refocusing or distraction, positive reappraisal, and putting into perspective. It contains 16 items which are each rated on a scale from 1(*Almost Never*) to 5(*Almost Always*). Item responses are summed

to form 8 subscales: Self-blame, Rumination or Focus on Thought, Catastrophizing, Putting into Perspective, Positive Refocusing, Positive Reappraisal, Acceptance, and Refocus on Planning, with higher subscale scores indicating more frequent use of a particular cognitive emotion regulation strategy. The CERQ has demonstrated adequate reliability (.75 to .86 for adults in the general population, and .72 to .85 in a psychiatric sample) (Garnefski, Kraaij, & Spinhoven, 2002).

Emotion Regulation Questionnaire (ERQ; Gross & John, 2003). The ERQ is a self-report measure assessing dispositional use of reappraisal and expressive suppression. Participants rate each item on a 7-point Likert scale, with responses ranging from 1 (strongly disagree) to 7 (strongly agree). The ERQ consists of 10 items, including 6 reappraisal items and 4 suppression items. Responses are summed to compute the reappraisal and suppression subscale scores. The ERQ has demonstrated high internal consistency, ranging from .75 to .82 for the reappraisal subscale and .68 to .76 for the suppression subscale. Three month test-retest reliability was found to be .70 for both the reappraisal and suppression subscales in a sample of college students (Gross & John, 2003).

Response Styles Questionnaire (RSQ;Nolen-Hoeksema & Morrow, 1991). The RSQ is a widely used self-report measure of the tendency to ruminate, or to perseverate about one's negative mood state and its causes, in response to negative events and negative mood. It consists of 25 items, each rated on a four-point Likert scale ranging from 1(*Almost never*) to 4(*Almost always*). Individual items are summed to calculate a total score ranging from 25 to 100, with higher scores indicating more frequent use of

rumination. Test-retest reliability for the RSQ has been found to be moderate to high (Nolen-Hoeksema, Parker & Larson, 1994). The RSQ has demonstrated high internal consistency of over .80 (Nolen-Hoeksema & Morrow, 1991). Studies have also demonstrated that self-reported use of rumination on the RSQ correlates with rumination in response to depressed mood following a negative event (e.g. Nolen-Hoeksema et al., 1991).

State-Trait Anxiety Inventory-Trait (STAI-T; STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI-T is a measure of the general tendency to experience anxiety day-to-day. It consists of 20 items rated on a scale from 1(*Almost never*) to 4(*Almost always*), with 9 reverse-scored items. The STAI-T has shown excellent internal consistency (α =.90) and test-retest reliability, ranging from .73 to .86 (Spielberger, 1983).

White Bear Suppression Inventory (WBSI;Wegner & Zanakos, 1994). The WBSI is a measure of how frequently individuals engage in thought suppression, or attempts to avoid or stop unpleasant thoughts. The WBSI contains 15 items rated on a scale from 1(*Strongly Disagree*) to 5(*Strongly Agree*). The WBSI has high internal consistency, ranging from .87 to .89 and test-retest reliability ranging from .69 for a period varying from 3 weeks to 3 months to .92 over a one week period in an undergraduate sample (Wegner & Zanakos, 1994).

Cognitive Control Task. Cognitive control was assessed using the modified Sternberg Task (Joormann & Gotlib, 2008). In this computerized task, participants complete 120 trials across three blocks. Before beginning the task, participants

completed five practice trials. Each trial consisted of a learning display, cue display, and probe display. In the learning display, participants were presented with two lists of three words simultaneously: one list in blue and one in red, drawn from a mixture of negative and positive lists. Next, the cue display appeared, consisting of either a red or blue frame; the color of the frame indicated that the previously presented list of the same color was the relevant list. Participants were instructed to forget the words in the irrelevant list and that it would interfere with their performance if they did not try to forget the words. Finally, the probe appeared, consisting of one word printed in black within the colored frame; this word was drawn from either the relevant list, the irrelevant list, or it was a novel word not presented in either list. In response to the probe, participants respond Yes only if the word was in the relevant list, or No if it was either in the irrelevant list or a new word. Participants' response latencies to negative words in the irrelevant list were compared to those of novel negative words. Longer response times to words in the irrelevant list compared to novel words indicate a greater intrusion effect. Greater intrusion effects indicate difficulties with cognitive control, specifically the ability to remove material from working memory that was previously but is no longer relevant.

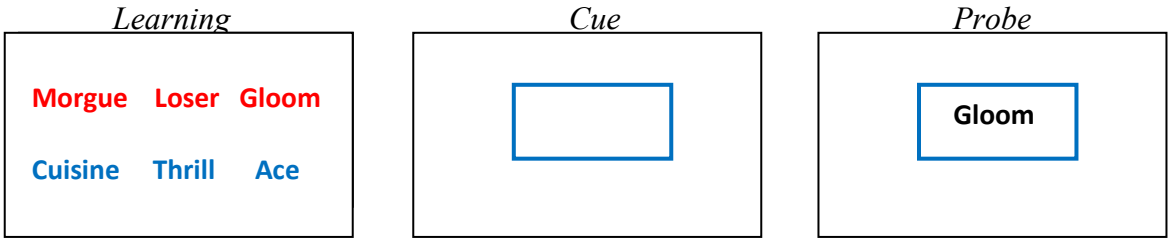


Figure 2.2. Sternberg Task.

Interpretation Bias Measure. This task was modeled after a task utilized by Mogg, Bradbury & Bradley (2006) in their study of the association of interpretive bias with MDD. In this task, participants are verbally presented with 28 emotionally ambiguous homophones, or words containing multiple meanings. Specifically, each homophone has either a positive or negative meaning (e.g. die/dye, weak/week). This task has been successfully used in previous studies (e.g. Mogg et al., 2006) to identify interpretive bias in individuals with MDD, with depressed individuals more likely to select negative word meanings.

Reappraisal Task. Following the procedure of Sheppes and Meiran (2008), this task assessed participants' ability to reappraise mid-way during a film segment lasting approximately 4 minutes (*The Champ*, Lovell & Zeffirelli, 1979), which has each been consistently effective in previous studies in inducing sadness (e.g. Gross & Levenson, 1995). Before the film, participants were given detailed verbal instructions training them on how to watch the film. Specifically, they were given instructions on each of two segments. The first segment, which occurred during the beginning of the film, was a pre-regulation (control) period during which they watched the film naturally, allowing emotions to arise without attempting to block the film or regulate emotion in any way. The second segment was the regulation (reappraisal) period, which occurred mid-way into the film during which all participants were instructed to begin to reappraise. Participants were told that at some point into the film, a subtitle would appear indicating to view the remainder of the film in one of two ways: either to continue watching the film without regulation, or to reappraise. In fact, all participants received the subtitle

instructing them to reappraise; the uncertainty maintained by the instructions was intended to ensure that they did not engage in anticipatory reappraisal or modify their emotions in any way during the pre-regulation period. The reappraisal subtitle appeared 204 seconds into the film and instructed participants to *Try your best to adopt an emotionless attitude, as if you were a scientist who examines the film objectively*, after which participants reappraised for the remainder of the film, an additional 60 seconds. This structure allowed for within-subjects comparisons from pre to post-reappraisal on both the mood ratings and physiological data, accounting for individual differences in the initial emotional reactivity to the film. Participants first completed a four minute baseline period consisting of viewing a neutral nature film clip. After receiving instructions on how to view the film, presented in a detailed script which was read on the computer screen, participants' comprehension of the instructions was verified (see Appendix A for the instructions script). The experimenter asked participants to state in their own words how they planned to respond if the subtitle appears indicating to begin reappraisal and clarified any questions or misunderstanding before moving on. Following the film, participants underwent a 5 minute recovery period and completed another mood rating. At the end of the session, participants' comprehension of and adherence to the instructions was assessed to ensure that they refrained from using regulation strategies during the pre-regulation period, and that they in fact were reappraising when instructed to do so, as opposed to using other regulation strategies (see Appendix B: Reappraisal

Adherence Measure). This procedure has been effective in previous studies examining physiological and cognitive aspects of online reappraisal (Sheppes & Meiran 2007; Sheppes, Catran & Meiran, 2009).

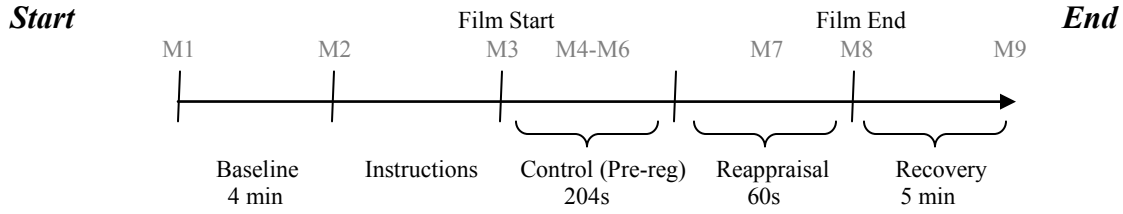
Measures of Emotional Reactivity to Film and Reappraisal Effectiveness. Dependent measures of reappraisal ability consisted of both self-reported affect, as well as physiological measures. Participants were asked to complete affect ratings before, each minute during the film, immediately following the film and following the recovery period (see Figure 2.3). In addition, physiological measures were obtained continuously beginning with the baseline period prior to the task, throughout the task, and during the recovery period following the task. A comparison of affect and physiological indices from baseline to the pre-regulation period indicated emotional reactivity to the film. In contrast, change in affect and physiological measures from the pre-regulation to regulation, and from the regulation to recovery periods served as an indicator of the effectiveness of reappraisal.

Affect Ratings. Negative affect was assessed at several points throughout the study by asking participants to rate to what extent they were experiencing each of seven emotions at that instant (Sad, Tense, Happy, Depressed, Anxious, Irritable, Angry) on a nine-point Likert scale, ranging from 1 (Not at all) to 9 (Extremely). In addition, sadness ratings on the same nine-point scale were taken during the film presented in the reappraisal task directly on the computer by overlaying these items onto the film.

Heart Rate and Respiratory Sinus Arrhythmia. Biopac System MP150 technology was used to record Electrocardiograph (ECG) and Respiration Frequency

(RF). Physiological data was collected continuously beginning with the start of the baseline period prior to the Reappraisal Task, throughout the Reappraisal Task, and during the recovery period following the task. Three ECG electrodes (TSD201) were attached to the right collarbone and both left and right upper rib cage. Respiration frequency was measured using a respiration strain-gauge respiration transducer belt (TSD101B) worn around the chest above the rib-cage and below the bust. Data was collected using BIOPAC bioamplifiers. The ECG and RF signals were sampled at 1,000 Hz, digitized with a 16-bit analog-to-digital converter, and processed using AcqKnowledge and MindWare software. High-Frequency Respiratory Sinus Arrhythmia (HF-RSA), a measure of heart rate variability in the high frequency band of respiration between .14 and .4 Hz, was utilized as a marker of parasympathetic influence via the vagal nerve. HF-RSA was calculated using MindWare HRV 2.16 software using the following procedure. Beat-to-beat interval series were obtained from the ECG and converted into time series of instantaneous beat-to-beat intervals with a resolution of 4 Hz. Spectral analysis, a technique for distinguishing between sources of HRV, was used to determine the power spectral density in the frequency band between .14 and .4 Hz. This value was then log-transformed to provide an index of HF-RSA. Prior to calculating HF-HRV, R-wave markers in the ECG signal were visually inspected for artifacts. The MAD/MED artifact detection algorithm in MindWare software (Mindware Heart Rate Variability Application, version 2.51; Mindware Technologies Ltd.) was utilized to correct artifacts. Current guidelines for calculating HF-HRV were followed (Task Force of the European Society of Pacing and Electrophysiology, 1996). RSA and heart- rate

values were calculated for 1 minute segments throughout the four minute baseline period, 204 second pre-regulation period (while participants are viewing the film prior to reappraisal), 60 second regulation period (remainder of film after reappraisal instruction appears), and 5 minute recovery period.



Key:
M = Mood Rating.

Figure 2.3. Reappraisal Task Procedure.

Reappraisal Adherence Measure. Following the reappraisal task, participants completed a questionnaire comprised of 23 items assessing state rumination, distraction, suppression, and reappraisal, during a) the pre-regulation period and b) the regulation period. These items were modeled after widely used trait assessments of these strategies, including the RSQ, ERQ, and WBSI). In addition, this measure included an item assessing the degree to which participants felt they were able to take the perspective of the main character in the film. Responses to these items were utilized to verify that participants were engaging in reappraisal, as opposed to other regulation strategies, such as rumination, distraction, or suppression, during the regulation period. At the same time, this measure was used to verify that participants were not using emotion regulation strategies during the pre-regulation period. In addition, items assessed the degree of difficulty in adhering to the instructions during the reappraisal task, and degree to which

participants were able to adhere to the instructions. Two open-ended items eliciting specific examples of participant's thoughts and strategies during a) the pre-regulation period and b) presentation of the reappraisal subtitle were also included.

Procedure

Table 2.1

Overview of Study Design

Timepoint	Prescreening (20-30 min)	Session 1 (3 hrs)	Session 2 (See Figure 2.3) (2 hrs)
Measures	Phone screen for initial inclusion/exclusion criteria	1. Diagnostic Interview (SCID) 2. Cognitive Control, Interpretive Bias Tasks	1. Reappraisal Task: Physiological Measures, Affect Ratings collected 2. Reappraisal Adherence Check 3. Questionnaires

Session 1 Overview. The University of Miami's Institutional Review Board (IRB) approved all study procedures. Trained undergraduate research assistants conducted telephone screens with participants to assess inclusion and exclusion criteria. Participants meeting these criteria were next invited to the laboratory for Session 1. During Session 1, participants, after providing consent, completed the SCID to confirm diagnosis, as well as inclusion and exclusion criteria. All SCID interviews were conducted by trained individuals at or above the graduate level with extensive experience in administering the SCID and with individuals with depression. Individuals who met criteria were asked to complete the cognitive control and interpretive bias measures at the end of Session 1. The order of the cognitive tasks was counterbalanced. The cognitive control task was expected to last approximately 30 minutes, with the interpretive bias task lasting 20

minutes. After completing the first cognitive task, participants completed the second cognitive task. Finally, participants completed questionnaires, including the BDI-II, CES-D, and STAI-T. Participants were thanked, compensated $15 per hour for their participation, and given the opportunity to have questions answered. After providing consent, they were scheduled for a time to come back into the laboratory to complete Session 2.

Session Start

Session End

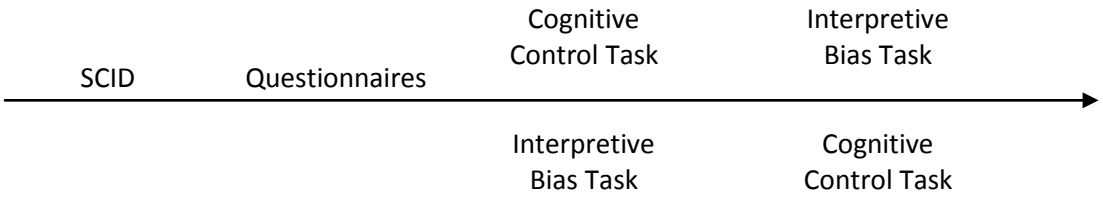


Figure 2.4. Session 1 Procedure.

Session 2 Overview. First, participants were informed that they were participating in a study on cognitive processes in coping and signed a consent form describing the procedure of the study. Participants were then attached to electrodes, and recording of psychophysiological data began. Next, they underwent a 4 minute baseline period during which a neutral nature video was presented to offset negative emotion associated with coming into the laboratory. After completing affect ratings, participants received instructions presented on the computer on the reappraisal task. Next, they completed the reappraisal task (see figure 2.3). Affect ratings were taken at several points during the Reappraisal Task (see Figure 2.3). Following the reappraisal task, participants completed a recovery period lasting approximately 5 minutes in which they viewed a second nature

film clip. Next, they completed the Reappraisal Adherence self-report form. Next, psychophysiological data recording was stopped and equipment disconnected. Participants then completed the remaining questionnaires, including the BDI, ERQ, CERQ, RSQ, and WBSI. At the end of the session, they were thanked, given the opportunity to ask questions, and compensated $15 per hour for their time.

Statistical Analysis

Preliminary analyses. First, the data was inspected for corrected problems with outliers, normality, and intercorrelations among all variables. There was minimal missing data, given that all participants invited to the lab following the SCID (Session 1) completed the study tasks within a single session. Guidelines outlined in the manuals for each measure were followed for handling missing items. T-tests were conducted to assess for group differences in demographic variables (gender, ethnicity, and age), and health variables (antidepressant use, exercise, and medical conditions such as cardiovascular disease known to impact RSA) which may serve as potential confounds in analyses of diagnostic group differences in the effectiveness of reappraisal. Correlations with outcome variables were examined for any variables in which groups were found to differ. Demographic or health variables found to be significantly different across MDD and Control groups and which were correlated with outcome variables were controlled for in subsequent analyses (except for variables on which groups were expected to differ, such as BDI score, RSQ and ERQ scores). Specifically, these variables were entered as factors in ANOVA analyses and incorporated as predictors into the first step of the regression analyses.

For example, it was expected that gender may moderate physiological response and negative affect in response to the film, based on previous studies finding gender differences in emotional reactivity to films (Gross and Levenson, 1995). Therefore, if MDD and Control groups were found to differ in gender composition, we planned to enter gender as a factor in the ANOVA and regression analyses.

Hypothesis 1. It was hypothesized that individuals with MDD, compared to controls, exhibit difficulties reappraising in response to a sad film, indicated by prolonged subjective experience of negative affect and prolonged physiological recovery. To test this hypothesis, I focused on the following periods: a) The pre-regulation period, consisting of the first 204 seconds of the film b) The regulation period, which began immediately following the instruction to begin reappraisal and continued for 60 seconds until the end of the film and c) The recovery period, consisting of the 5 minutes following the end of the film. Sadness ratings taken immediately before the pre-regulation period (See Figure 2. 3, M2), each minute throughout the pre-regulation period (M4-6) and regulation period (M7), after the film (M8), and at the end of the recovery period (M9), were be used to analyze the effectiveness of reappraisal, indicated by the impact of reappraisal on changes in negative affect. To analyze the impact of reappraisal on physiological response, mean heart-rate and RSA was calculated within the following periods: 4 minute baseline, 204 second pre-regulation period, 60 second regulation period, and 5 minute recovery period. Mean HR and RSA were compared from the pre-regulation to regulation period, as well as from the regulation to recovery period.

To compare the effectiveness of reappraisal in decreasing self-reported negative affect across MDD and control groups, I first conducted a mixed model ANOVA to examine the effect of timepoint (M2: Baseline, M6: Pre-regulation, M8: Regulation, M9: Recovery) as the within-subjects factor, and diagnostic group (CTL, MDD) as the between-subjects factor, on negative affect rating. An interaction between affect rating timepoint and diagnostic category was expected, such that CTLs were expected to show a sharper decrease in reported negative affect from pre-regulation to reappraisal, and from reappraisal to recovery than MDDs. Next, I examined the impact of reappraisal on physiological responding to the sad film. First, a mixed model ANOVA was conducted with timepoint as the within-subjects factor (baseline, pre-regulation, reappraisal, recovery), and diagnosis as the between-subjects factor, on participants' HR. Similarly, a mixed model ANOVA was utilized to examine the impact of timepoint and diagnosis on participant's RSA level. Once again, an interaction effect between timepoint and group on mean HR and RSA levels was hypothesized. CTL relative to MDD participants were expected to exhibit a greater decrease in HR from pre-regulation to regulation, and from regulation to recovery. With regards to RSA, CTL relative to MDD participants were expected to exhibit a greater increase in RSA from the pre-regulation to regulation, and from the regulation to recovery periods. Follow-up t-tests were used to decompose significant interaction effects between group and timepoint on negative affect, HR, and RSA.

Hypothesis 2. It was hypothesized that MDD, relative to CTL, participants exhibit decreased cognitive control, indicated by longer response times to negative

irrelevant than novel words. To assess this hypothesis, I conducted a three-way ANOVA (Group [MDD, Control] X Probe Valence [Positive, Negative] X Condition [Irrelevant, Novel]) on participants' response latencies. A three-way Group X Probe X Valence interaction was expected. Given that MDD and Control groups were expected to differ only for negative stimuli, two separate follow-up ANOVAs were conducted for positive and negative stimuli. A significant Group X Probe interaction was expected for Negative stimuli. Follow-up t-tests were utilized to assess the hypothesis that the MDD compared to CTL group is slower to respond to negative irrelevant probes, but that the groups do not differ in response times to novel negative probes. Lastly, I calculated intrusion effects by subtracting response latencies to novel probes from response times to irrelevant probes of the same valence (for an example see Joormann & Gotlib, 2008); t-tests were used to evaluate whether there are significant group differences in intrusion effects, with differences expected only for negative probes.

In addition, MDD, but not CTL, participants were expected to exhibit negative interpretive bias. First, following Mogg et al. (2006), a homophone bias score was computed by calculating the percentage of all homophones spelled correctly (corresponding to either the negative or neutral word) which corresponded to the negative meaning. Mean homophone bias scores were computed for the MDD and CTL groups, and a t-test was used to determine whether depressed individuals exhibit significantly greater homophone bias scores.

Hypothesis 3. I anticipated that individuals exhibiting reduced cognitive control and greater negative interpretation biases demonstrate less effective reappraisal in response to the sad film, indicated by prolonged negative affect and prolonged physiological response to the film.

To test this hypothesis, a series of difference scores was computed, first focusing on negative affect ratings. The sadness rating at the end of the baseline period (M2) was subtracted from that at the end of the pre-regulation period (M6) to indicate initial reactivity to the film (d1). The sadness rating taken at the end of the pre-regulation period (M6) was subtracted from the sadness rating following the regulation period (M8) to indicate change in negative affect caused by initiation of reappraisal during the remainder of the film (d2). Secondly, the sadness rating taken at the end of the regulation period and film (M8) was subtracted from that obtained at the end of the recovery period (M9) to indicate the impact of reappraisal on recovery in negative affect (d3). I conducted a Hierarchical Multiple Regression analysis with d1 as the predictor in the first step. Intrusion effects (cognitive control) and homophone bias scores (interpretation bias) were entered as predictors in the second step. Given that diagnostic group difference in reappraisal effectiveness were expected, diagnostic category was entered as a predictor in the second step along with the cognitive variables. The interaction terms between diagnosis and each cognitive task variable were entered in the third step. D2 was the dependent variable. This procedure was repeated in a second regression analysis using identical predictors, but with d3 as the dependent variable.

Four hierarchical regressions were conducted to examine the association among cognitive biases with the effectiveness of reappraisal, indicated by less prolonged physiological response to the film following the instruction to begin reappraisal and during the recovery period. The following difference scores were computed for HR: mean baseline HR subtracted from mean pre-regulation HR (d4), mean pre-regulation HR subtracted from mean regulation HR (d5), and mean regulation HR subtracted from mean recovery HR (d6). RSA difference scores were computed following the same procedure (d7-9). For the first regression on HR, initial HR reactivity (d4) was entered in the first step, with intrusion effects and proportion of negative homophone solutions entered as predictors in the second step. Given that diagnostic group difference in reappraisal effectiveness were expected, diagnostic category was entered as a predictor in the second step along with the cognitive variables. The interaction terms between diagnosis and each cognitive task variable were entered in the third step. Change in HR from the pre-regulation period to the regulation period (d5) was the dependent variable. The same predictors were entered in a second regression on change in HR from the reappraisal to recovery period (d6) as the dependent variable. A third regression on change in mean RSA from the pre-regulation to regulation period (d8) was conducted, once again with initial RSA reactivity (d7) entered in the first step, and intrusion effects and proportion of negative homophones in the second step. Given that diagnostic group difference in reappraisal effectiveness were expected, diagnostic category was entered as a predictor in the second step along with the cognitive variables. The interaction terms between diagnosis and each cognitive task variable were entered in the third step. Change in RSA

from the pre-regulation period to the regulation period (d8) was the dependent variable. The fourth regression on change in mean RSA from regulation to recovery (d9) was run, once again with predictors initial RSA reactivity to the film (d7) in the first step, intrusion effectives, proportion of negative homophones, and diagnosis in the second step, and the interaction terms between diagnosis and each cognitive task variable in the third step.

Hypothesis 4. It was further anticipated that cognitive control and interpretation bias partially mediate the relation between diagnosis and reappraisal ability. The procedure planned to tests this hypothesis was the Sobel Test (Baron & Kenny, 1986). This procedure involves first establishing that 1) diagnosis significantly predicts reappraisal ability 2) cognitive control and interpretation bias predict reappraisal ability and 3) diagnosis predicts cognitive control and interpretation bias. Next, the effect of diagnosis on reappraisal ability controlling for the effect of diagnosis on cognitive control and interpretation bias is examined, which was expected to decrease significantly in comparison to the magnitude of the effect in step 1, indicating mediation.

Hypothesis 5. Finally, it was hypothesized that self-reported dispositional use of emotion regulation strategies is associated with the effectiveness of reappraisal in response to the sad film. Correlations were conducted to assess the relation between dispositional use of emotion regulation strategies and the effectiveness of reappraisal. Specifically, it was expected that more frequent use of rumination (RSQ) and suppression (ERQ, WBSI), and less frequent use of reappraisal (ERQ, CERQ), is correlated with decreased reappraisal effectiveness to the sad film, indicated by a smaller change score from pre to post reappraisal in self-reported negative affect, heart-rate, and RSA levels.

Power Analyses

Projected sample size of 80 participants each was based on the following power analyses drawn from previous studies of these constructs. Joormann and Gotlib (2008) comparing MDD participants to controls on intrusion effects on the modified Sternberg Task, found an effect size of d=.78, based on which 88 participants are needed to have sufficient power (.95). Mathews and Mackintosh (2000) utilizing an interpretive bias task found an effect size of 1.96 using recognition ratings to negative targets, requiring 16 participants (8 per group). A recent study (Mauss et al., 2007) found that group differences in dispositional reappraisal predicted emotional responding to an anger induction (η^2=.13), based on which 90 participants are needed.

Chapter 3: Results

I. Demographic and Health Characteristics

Demographic Characteristics. Table 3.1 displays demographic characteristics of each diagnostic group and the overall sample. Independent samples t-tests and chi-square tests were run to examine differences in demographic characteristics between the MDD and CTL groups (see Table 3.2). MDD and CTL groups did not differ in gender, $\chi^2(1, n = 66) = 0.62$, $p > .05$, or ethnic composition, $\chi^2(5, n = 61) = 4.85$, $p > .05$. 28.4 % of the overall sample were Caucasian, 19.4% Hispanic, 26.9% African American, 1.5% Asian, 3.0% American Indian, and 11.9% identified as other or multiethnic. Further, CTL and MDD groups did not differ in Shipley vocabulary scores, $t(59) = 0.01$, $p > .05$, nor years of education, $t(58) = 0.11$, $p > .05$. MDD participants on average were significantly older than CTL participants, $t(61) = 3.15$, $p < .01$.

For any variables in which significant differences between groups were found (i.e. age), correlations with each of our primary outcome measures of reappraisal effectiveness were next examined (Table 3.3). These correlations were run in order to determine which variables to control for in our main analyses of diagnostic group differences in reappraisal effectiveness. Primary reappraisal outcome measures included self-reported sadness levels, HR, and RSA. We were interested in the *change in* each of these variables from the pre-regulation period (i.e. letting sadness arise naturally to the film prior to reappraising) to a) the reappraisal period (i.e. reframing the film following the subtitle to reappraise) and b) the recovery period (i.e. watching a distracting nature film).

We therefore conducted partial correlations (Table 3.3) in which we controlled for baseline levels of each reappraisal measure. For example, the correlation between age and mean HR during the reappraisal period was examined, controlling for mean HR during the baseline period. We controlled for baseline levels given that we are primarily interested in how the diagnostic groups differ in sadness and physiological indices after reappraising, above and beyond any group differences found at baseline. Table 3.3 shows that age was not significantly correlated with change in affect ratings, HR or RSA during the reappraisal or recovery periods.

As expected, MDD participants had significantly higher BDI scores than CTLs, t (62) = 8.37, $p < .001$. MDD participants also reported greater rumination, t (61) = 7.89, $p < .001$, expressive suppression, t (64) = 2.01, $p \leq .05$, and cognitive suppression compared to CTLs, t (62) = 5.60, $p < .001$, but did not differ from CTLs in the frequency of reappraisal use, t (64) = 1.17, $p > .05$.

Health Characteristics Relevant to Reappraisal Effectiveness Measures. Following the same procedure as with the demographic variables above, we next conducted independent samples t-tests and chi-square tests to examine diagnostic group differences in health variables known to be related to HR and RSA, such as sleep, exercise, and various medications which have been shown in past studies to affect HR and RSA. The purpose for these analyses was to ensure that any differences found between the MDD and CTL groups in the psychophysiological indices of reappraisal effectiveness are not merely driven by health and lifestyle variables that the groups also differ in (see Table 3.1).

No diagnostic group differences were found in the percentage of participants reporting asthma, allergies, high blood pressure, heart disease, high cholesterol, or other health conditions, including diabetes. In addition, MDD and CTL groups did not differ in the proportion of participants currently taking allergy medication, asthma medication, blood pressure medication, hormonal contraceptives, or other medications. Groups did not significantly differ in use of antipsychotic or anxiolytic medications, but as expected differed in antidepressant use. No group differences were found in number of missed work days, doctor visits, body mass index, caffeine consumption, proportion of smokers, and average weekly use of alcohol.

The CTL group reported greater hours of sleep and days feeling rested throughout the past week, as well as greater hours sleep the night prior to the session. In addition, CTLs reported greater hours of strenuous exercise than MDD participants and were higher in self-perceived health. Table 3.2 displays correlations between each of these variables and change in sadness ratings, HR and RSA during the reappraisal and recovery periods. Significant correlations were found between the three sleep variables and RSA in response to the reappraisal task, as well as number of days rested and change in sadness in response to reappraisal. In addition, hours of strenuous exercise was found to be correlated with HR and RSA during the reappraisal task. Thus, number of days rested and hours of strenuous exercise were entered as covariates in the following analyses.

Table 3.1

Demographic Characteristics of each Diagnostic Group

	CTL (*N*=34) *M*(*SD*)	MDD(*N*=33) *M*(*SD*)	Total Sample *M*(*SD*)
Age**	34.1 (10.5)	43.5 (13.0)	38.7 (12.5)
% Women	52.9	62.5	56.7
% Caucasian	36.3	28.6	32.8
Education Years	12.4 (6.6)	12.5 (5.1)	12.4 (5.9)
Shipley Total Score	29.1 (4.4)	29.1 (7.5)	29.1 (5.9)
BDI Total Score***	6.3 (8.2)	27.2 (11.5)	16.4 (14.4)
RSQ Rumination***	36.8 (13.1)	63.4 (13.7)	50.7 (18.9)
ERQ Suppression*	13.5 (5.8)	16.2 (5.2)	14.8 (5.6)
ERQ Reappraisal	29.1 (9.2)	26.5 (9.2)	27.7 (9.2)
WBSI Suppression***	36.6 (13.1)	54.8 (11.7)	45.7 (15.8)

Note. *N*=67. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 3.2

Diagnostic Group Differences in Health and Lifestyle Variables

	CTL	MDD	χ^2	*df*	*p*
Health Conditions	M *(SD)*	M *(SD)*			
Asthma	2 (3.1%)	3 (4.7%)			1.00^{+}
Allergies	3 (4.7%)	6 (9.4%)	0.96	1	0.48
Hypertension	4 (6.3%)	7 (10.9%)	0.78	1	0.38
High Cholesterol	2 (3.1%)	5 (7.8%)			0.43^{+}
Heart Disease	0 (0%)	0 (0%)			
Other	5 (7.8%)	7 (10.9%)	0.27	1	0.60
Proportion Smokers	7.0 (10.9%)	9 (14.1%)	0.19	1	0.67
Medication	**# Subjects (% of Diagnostic Group)**	**# Subjects (% of Diagnostic Group)**			
Asthma	1 (1.6%)	1 (1.6%)			1.00^{+}
Allergy	3 (4.7%)	1 (1.6%)			0.35^{+}
Hypertension	2 (3.1%)	5 (7.8%)			0.43^{+}
Birth Control	3 (4.7%)	3 (4.7%)			1.00^{+}
Antidepressants*	0 (0%)	5 (7.8%)			0.05^{+}
Anxiolytics	0 (0%)	2 (3.1%)			0.49^{+}
Antipsychotics	0 (0%)	0 (0%)			
	CTL	**MDD**	***t***	***df***	***p***
Other Health and Lifestyle	M (*SD*)	M(*SD*)			
Missed Work Days Yearly	1.2 (2.6)	2.9 (5.2)	1.6	59	0.12
Doctor Visits Yearly	0.8 (1.2)	1.3 (1.8)	1.3	61	0.21
Perceived Health Rating* **	4.0 (0.8)	3.2 (0.8)	3.8	58	0.00
Cups Caffeine Weekly	1.0 (1.2)	1.6 (1.6)	1.7	62	0.10
Cups Caffeine Past Day	0.5 (0.7)	0.4 (0.7)	0.4	62	0.72
Alcohol Drinks Weekly	2.4 (3.3)	1.2 (2.3)	1.6	60	0.12
Hours Sleep Weekly**	7.1 (1.4)	5.8 (1.9)	2.9	59	0.01
Days Rested Weekly**	4.6 (1.8)	3.3(1.8)	2.8	61	0.01
Hours Last Sleep**	7.0 (1.9)	5.6 (1.9)	2.9	59	0.01
Hours Exercise Weekly*	2.0 (1.3)	1.1 (1.6)	2.5	61	0.02
Body Mass Index	25.4 (5.9)	26.5 (7.8)	0.6	62	0.55

Note. *N*=67. *$p < .05$,**$p \leq .01$, *** p<.001. $^{+}$Fisher's exact test was used in chi-square analyses with cells with expected counts less than 5.

Table 3.3

Correlations between Demographic and Health Variables Differing between Diagnostic Groups with Reappraisal Effectiveness Measures

	Reappraisal			Recovery		
	Affect	HR	RSA	Affect	HR	RSA
Age	.15	-.13	-.02	-.19	-.05	.16
Hours Sleep Weekly	.05	.03	.22	-.04	.04	-.32*
Days Rested Weekly	-.05	-.10	.34*	-.16	.03	-.47**
Hours Last Sleep	-.06	.05	.28	.05	.10	-.32*
Hours Exercise Weekly	-.10	.29	-.05	.14	.09	-.20
Perceived Health Rating	-.15	.21	.09	.18	-.17	-.11

Note. *N*=67. Values represent partial correlations controlling for baseline levels. HR = Heart rate, RSA = Respiratory Sinus Arrhythmia. *$p < .05$,**$p \leq .01$, *** p<.001

II. Diagnostic Group Differences in Reappraisal Effectiveness

Reappraisal Adherence Check. Before conducting analyses to determine whether the MDD group exhibited less effective reappraisal to the film task, it was necessary to do a manipulation check to assess how closely participants followed the instructions in the reappraisal task (i.e. first to watch the film and let sadness arise naturally during pre-regulation period without using any ER strategies, versus to switch to viewing the film like a scientist during the reappraisal period denoted by the subtitle). To assess whether participants followed the reappraisal task instructions, participants' responses on the reappraisal adherence measure were examined. Once again, participants filled out two different copies of the same form, one asking about their use of ER during the pre-regulation period, and the other assessing their ER strategy use during the reappraisal period. A total pre-regulation reappraisal score was calculated by summing the items assessing reappraisal on the pre-regulation form. A total reappraisal score was calculated by repeating this procedure using responses on the reappraisal period form. If

participants complied with the instructions not to regulate in any way during pre-regulation and to reappraise during the reappraisal period, we would expect significantly higher reappraisal scores on the reappraisal period form than the pre-regulation period form. Results of a mixed-model ANOVA examining the impact of diagnosis (CTL, MDD) and film period (pre-regulation, reappraisal) on change in reappraisal scores across the two film periods indicated that participants increased significantly in their self-reported use of reappraisal from the pre-regulation (M = 19.1, SD = 8.9) to reappraisal periods (M = 28.4, SD = 8.2), F (1,63) = 62.3, $p < .001$, thus the reappraisal manipulation was effective. Importantly, the interaction between diagnosis and timepoint was not significant, F (1,63) = 1.7, $p > .05$, thus diagnostic groups did not differ in their adherence to the reappraisal instructions and any group differences in the effectiveness of reappraisal (i.e. how much the groups decreased in sadness levels from pre to post reappraisal, increased in RSA, etc.) cannot be attributed to differences in adherence. Similarly, the main effect of diagnosis was not significant, F (1,63) = 0.2, $p > .05$; thus, one diagnostic group did not report higher levels of reappraisal overall throughout the film task than another group.

Diagnostic Group Differences in Reappraisal Effectiveness: Sadness Ratings. We hypothesized that depressed participants would exhibit less effective reappraisal, as reflected by the magnitude of change in sadness ratings from pre to post reappraisal. Specifically, it was expected that the MDD, compared to CTL, group, would show a smaller decrease in sadness ratings a) from pre to post reappraisal and b) from immediately after reappraisal to the end of the nature film recovery period. A mixed-

model ANOVA was conducted to compare the MDD and CTL groups in the effectiveness of reappraisal in reducing negative affect. We examined the effects of film task period (baseline, pre-regulation, reappraisal, recovery) and diagnostic status (MDD, CTL) on sadness ratings. As expected, results showed a significant main effect of film task period (i.e. 1) baseline, 2) pre-regulation, 3) reappraisal 4) recovery). Figure 3.1 displays the change in affect ratings within the MDD and CTL groups throughout the different film task periods. Thus, all participants, regardless of diagnostic group, showed a significant change in sadness ratings throughout the course of the film task, F (4,220) = 4.8, $p \leq .001$. In addition, results showed a significant main effect of diagnosis, F (1,55) = 18.8, $p < .001$. MDD participants reported higher sadness ratings than CTLs overall throughout the film task, collapsing across the four periods of the film task. However, consistent with our hypothesis, a significant film period by diagnosis interaction was found, F (4,220) = 2.9, $p < .05$, indicating that MDD and CTL participants differed in their pattern of change in sadness ratings throughout the film task.

In order to contrast sadness levels at particular film periods, follow-up within-subjects t-tests were next conducted separately within the MDD versus CTL groups. Independent samples t-tests were run to compare sadness levels between MDD versus CTL groups at each specific film task period. We began by examining the degree to which participants increased in sadness levels from the baseline period prior to viewing the film to the end of the pre-regulation period. This contrast indicates how effective the sad film was in inducing sadness (i.e. sadness reactivity) prior to reappraising. Both the MDD, $t(32) = 4.8$, $p<.001$, and CTL groups, $t(31) = 10.3$, $p<.001$, showed significant

increases in sadness from the baseline to pre-regulation periods. Further, the MDD and CTL groups did not differ from one another in sadness levels at the end of the pre-regulation period, $t(64) = 1.4$, $p>.05$. These results demonstrate that the sad film was an effective mood induction for both groups, since at the end of the pre-regulation period the MDD and CTL groups reported similar levels of sadness.

We next examined the degree to which participants showed the hypothesized decrease in sadness levels (i.e. how effective reappraisal was) throughout the reappraisal period of the film. Both the MDD, $t(30) = 2.3$, $p<.05$, and CTL, $t(32) = 7.4$, $p<.001$, groups decreased significantly in sadness from the pre-regulation to the reappraisal period. Thus, at least to some degree reappraisal was effective in ameliorating sadness for both the MDD and CTL groups. However, results of independent samples t-tests comparing the MDD and CTL groups in sadness levels at the end of the reappraisal period provided some evidence for reduced effectiveness of reappraisal in depression. The MDD compared to CTL group remained significantly more elevated in sadness levels following reappraisal, $t(63) = 4.0$, $p<.001$.

Finally, we examined the degree to which participants continued to decrease even more in their sadness levels throughout the nature film recovery period immediately following the sad film task. Both the MDD, $t(30) = 5.6$, $p<.001$, and CTL groups, $t(33) = 6.3$, $p<.001$, also continued to decrease significantly in sadness from post-reappraisal to post-recovery. However, the MDD group still remained higher in sadness at the end of the recovery period than the CTL group, $t(63) = 4.7$, $p<.001$.

It is important to note that we found a difference between the MDD and CTL group in sadness ratings during the brief period of time between the end of the sad film and the beginning of the recovery period nature film. Specifically, a non-significant trend was found for depressed participants to increase or remain the same in sadness between the sadness rating, $t(30) = 1.6$, $p = .11$ (see Figure 3.1 below, Reappraisal) taken verbally at the end of the sad film and the next sadness rating taken approximately one minute later after the sad film had ended but prior to the nature film beginning (Reappraisal 2). During this time point the CTL group in contrast continued to decrease significantly in sadness, $t(32) = 3.6$, $p \leq .001$. This finding indicates that the CTL group may have showed better recovery in mood following reappraisal during this unstructured time prior to viewing the distracting nature film.

Diagnostic Group Differences in Reappraisal Effectiveness: HR. We next tested the hypothesis that participants with MDD exhibit less effective reappraisal compared to CTLs, as indicated by their change in heart-rate throughout the film task. Table 3.4 displays zero-order correlations among the different indices of reappraisal effectiveness. We had hypothesized that all participants would increase in heart-rate during the pre-regulation period and would decrease in heart-rate during the reappraisal and recovery periods, returning to baseline levels. Therefore, the more effective reappraisal is, the larger the decrease in HR should be. MDD participants were expected to show less of a decrease in HR than CTLs after reappraising. We conducted a mixed-model ANOVA on HR with film period (mean HR at 1) baseline, 2) pre-regulation, 3) regulation, and 4) recovery) and diagnosis as factors.

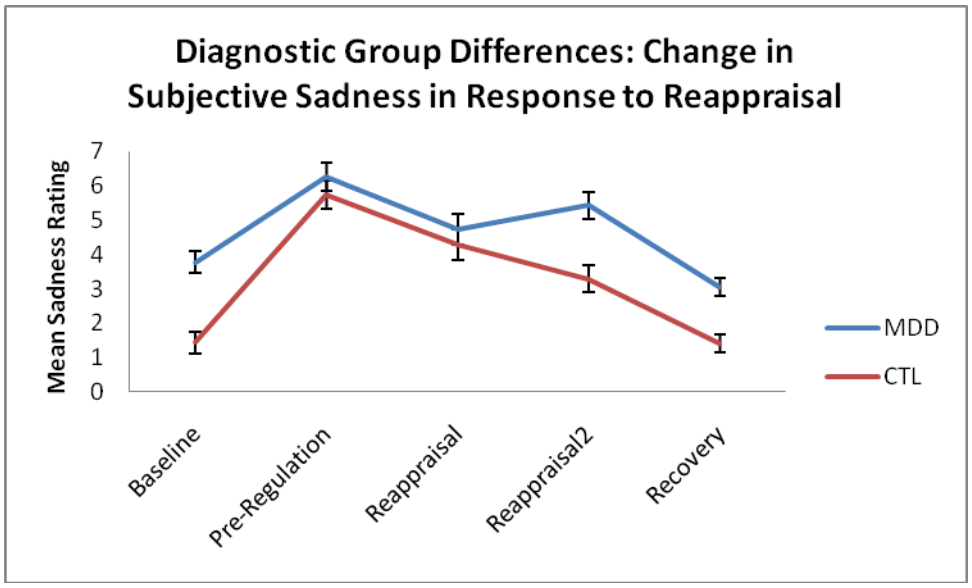


Figure 3.1. Change in subjective sadness ratings throughout the reappraisal task in the MDD versus CTL group. Reappraisal represents the fourth verbally reported sadness rating taken during the film at the end of the reappraisal period. Reappraisal 2 represents the pencil and paper sadness rating taken one minute after the end of the film. Whereas the CTL group showed a significant continued decrease in sadness from the first to second reappraisal ratings, the MDD group showed a non-significant increase in sadness during the time between the first and second reappraisal ratings.

ANOVA results indicated that the main effect of film period on heart-rate was not significant, however, F (3,147) = 0.4, $p > .05$, indicating that participants' HR did not change significantly throughout the course of the reappraisal task (see Figure 3.2). There was no significant effect of diagnosis on heart-rate, F (1,49) = 0.04, $p > .05$, thus the MDD and CTL groups did not differ in HR overall throughout the film task, collapsing across the four film periods. Contrary to hypotheses, the interaction between diagnosis and timepoint was also not significant, F (3,147) = 0.03, $p > .05$; thus, results did not indicate a differential impact of reappraisal on HR for MDD versus CTL groups. To summarize, we did not find evidence of reduced reappraisal effectiveness, as indicated by change in HR.

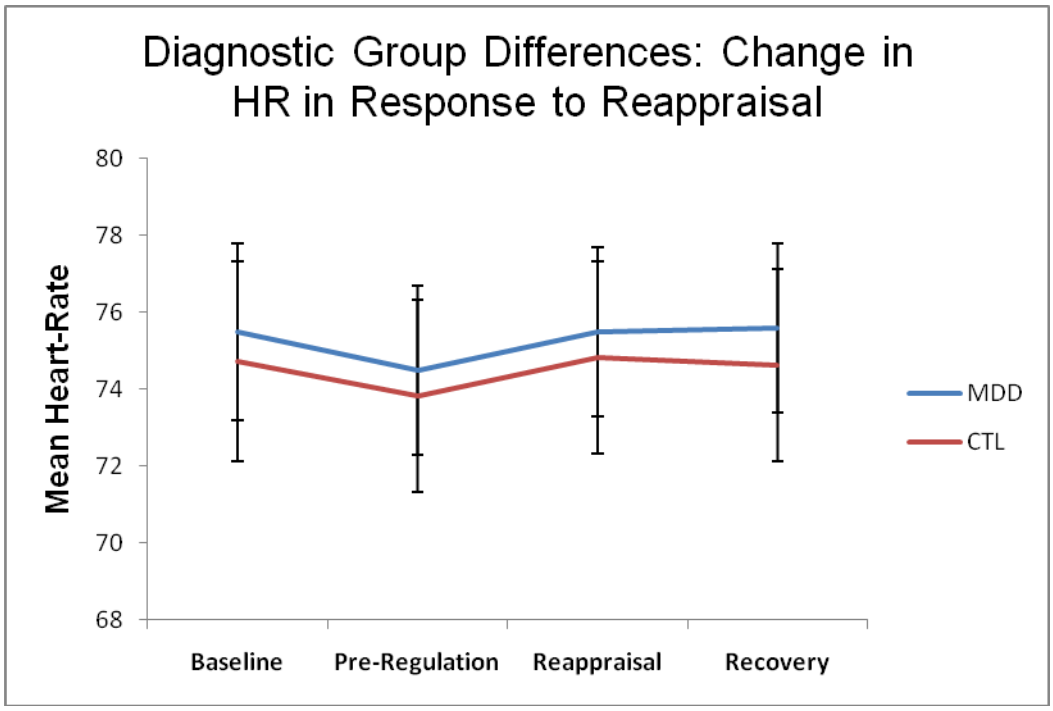


Figure 3.2. Change in HR throughout the reappraisal task in the MDD versus CTL group. Baseline represents mean HR throughout the duration of the baseline period. Pre-regulation represents participants' mean HR during the duration of the pre-regulation, natural viewing, period of the film prior. Reappraisal represents mean HR throughout the final minute of the film when participants were reappraising. Recovery represents mean HR throughout the duration of the relaxing nature video recovery period following the sad film.

Diagnostic Group Differences in Reappraisal Effectiveness: RSA. We next tested the hypothesis that participants with MDD exhibit less effective reappraisal compared to CTLs, as indicated by their change in RSA throughout the film task. We hypothesized that all participants would decrease in RSA during the pre-regulation period and would increase in RSA during the reappraisal and recovery periods, returning to baseline levels. Therefore, the more effective reappraisal is, the larger the increase in RSA should be. MDD participants were expected to show less of an increase in RSA than CTLs after reappraising. A third mixed-model ANOVA was conducted on RSA levels with film task

period (mean RSA levels during the 1) baseline, 2) pre-regulation, 3) reappraisal, and 4) recovery period) and diagnosis as factors. ANOVA results indicate that the effect of timepoint on RSA levels was not significant, F (3,135) = 0.5, p > .05 (see Figure 3.3). Therefore, participants' RSA levels did not change significantly throughout the course of the reappraisal task. Overall when collapsing across diagnostic group, participants tended to decrease as expected in RSA while viewing the sad film, later increasing in RSA during recovery; however, this change was not significant. In addition, diagnostic groups did not differ overall in their RSA levels throughout the task, collapsing across the four film task periods, F (1,45) = 0.8, p >.05. The interaction between diagnosis and timepoint was also not significant, F (3,135) = 0.5, p > .05. Thus, contrary to hypotheses, there was not a differential impact of reappraisal on RSA levels for CTL versus MDD groups. To summarize, we did not find evidence of reduced reappraisal effectiveness, as indicated by change in RSA.

Table 3.4

Correlations between Different Indices of Reappraisal Effectiveness

		Reappraisal			Recovery		
		Sadness	**HR**	**RSA**	**Sadness**	**HR**	**RSA**
REAP	**Sadness**		.09	-.11	.50***	-.07	-.16
	HR			-.44***	-.07	.98***	-.42***
	RSA				-.05	-.42***	.93***
RECV	**Sadness**					-.16	.04
	HR						-.46***
	RSA						

Note. *N*=67. Reap = reappraisal; Recv = recovery. Values represent correlations between mean levels of each measure (e.g. sadness, HR, RSA) throughout the a) reappraisal and b) recovery periods of the film task. $^{+}$p<.10, *p<.05, **p<.01, ***p<.001

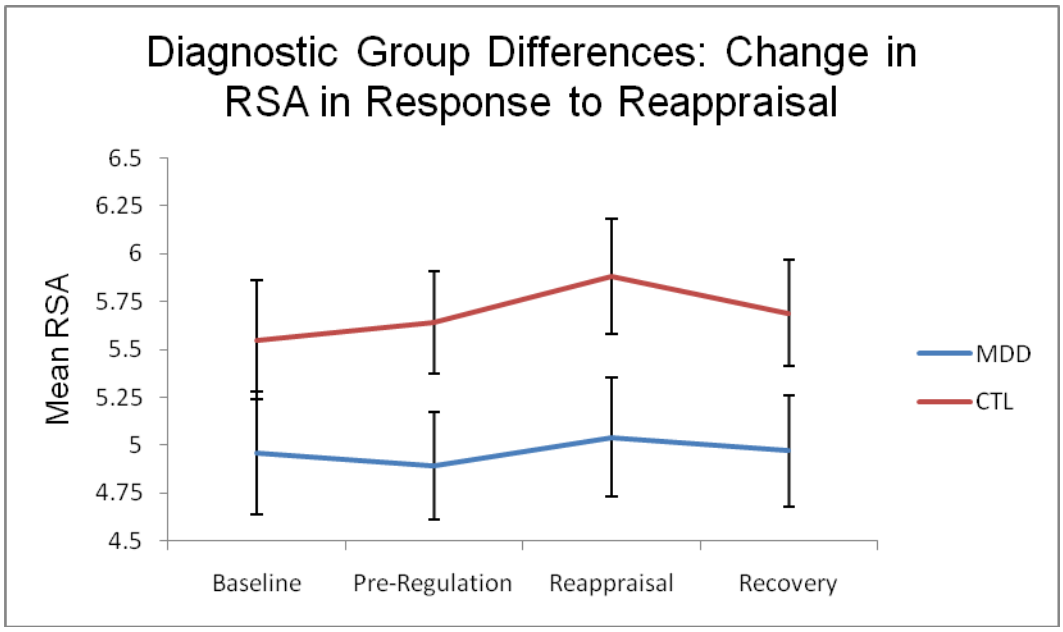


Figure 3.3. Change in RSA throughout the reappraisal task in the MDD versus CTL group. Baseline represents mean RSA throughout the duration of the baseline period. Pre-regulation represents participants' mean RSA during the duration of the pre-regulation, natural viewing, period of the film prior. Reappraisal represents mean RSA throughout the final minute of the film when participants were reappraising. Recovery represents mean RSA throughout the duration of the relaxing nature video recovery period following the sad film.

III. Diagnostic Group Differences in Cognitive Processes

Cognitive Control. A three-way mixed-model ANOVA was conducted on response times to evaluate diagnostic group differences in the ability to discard no-longer-relevant negative words from working memory on the Sternberg task. Prior to conducting the analyses of cognitive control, response time outliers, defined as trials with response times faster than 200 milliseconds and slower than 3000 milliseconds, were eliminated. Thus individual participant means were computed across trials with valid response times, consistent with prior studies utilizing the Sternberg Task (Joormann & Gotlib, 2008). Diagnosis, valence (positive, negative) and condition (irrelevant, novel) were the

independent variables. A diagnosis by valence by condition interaction was hypothesized, with MDD participants expected to respond more slowly to negative irrelevant compared to negative novel words than CTLs, but not to differ from CTLs for positive words. Table 3.5 displays mean reaction times on the Sternberg Task. As expected, results indicated a significant main effect of condition type, with participants overall responding more slowly to irrelevant probes than novel probes, F (1,52) = 168.7, $p < .001$. Also as expected, there was no significant main effect of valence, F (1,52) = 0.2, $p > .05$. The main effect of diagnosis was not significant, indicating that MDD and CTL participants did not differ overall, when collapsing across condition and valence trial types, in response times on the Sternberg Task, F (1,52) = 0.1, $p > .05$. Contrary to our hypothesis, the three-way diagnosis by valence by condition interaction was not significant, F (1,52) = 0.02, $p > .05$. A significant interaction of condition and valence was found, F (1,52) = 4.1, $p \leq .05$. Follow-up paired samples t-tests showed that participants were slower to respond to novel negative probes when the positive list was relevant than they were to respond to novel positive probes when the negative list was relevant, t(61) = 3.5, $p \leq .001$. However, participants did not differ in response times in trials where the probe was negative and irrelevant compared to trials where the probe was positive and irrelevant, t(53) = 0.9, $p > .05$.

We also calculated mean intrusion effects, or the difference in response times between irrelevant and novel probes of the same valence. Independent samples t-tests showed that MDD and CTL groups did not differ significantly in mean intrusion effects for negative probes, t(56) = 0.6, $p > .05$, nor did they differ in intrusion effects for

positive probes, $t(54) = 0.8$, $p > .05$. In sum, no evidence was found that MDD participants, in comparison to CTLs, exhibit reduced ability to inhibit no-longer-relevant emotional stimuli.

Table 3.5

Mean Reaction Times on Sternberg Task by Diagnostic Category and Trial Type

Trial Type	CTL	MDD
Positive Cue Novel Negative Probe	1212.56 (310.36)	1276.40 (339.96)
Positive Cue Irrelevant Negative Probe	1653.32 (399.69)	1666.04 (412.38)
Negative Cue Novel Positive Probe	1163.02 (286.58)	1218.75 (338.46)
Negative Cue Irrelevant Positive Probe	1696.52 (440.76)	1690.42 (446.97)

Note. Values represent mean reaction times. Values in parentheses are standard deviations.

Interpretive Bias. To test the hypothesis that MDD compared to CTL participants exhibit greater negative interpretation bias, an independent samples t-test was conducted comparing the mean proportion of negative to all (negative and neutral) correctly spelled solutions on the homophone task between groups. The mean proportion of negative homophones for MDD participants was 0.59 ($SD = 0.18$), whereas that for CTLs was 0.64 ($SD = 0.12$). Contrary to our hypothesis, no significant difference between MDD and CTL groups was found in the proportion of negative homophone solutions, $t(61) = 1.32$, $p<.05$. In sum, we did not find evidence that depressed participants exhibit greater negative interpretive bias compared to CTLs.

IV. Relation between Cognitive Processes and Reappraisal Effectiveness

Affect Ratings. We hypothesized that greater negative interpretive bias (i.e. higher proportion of negative homophone solutions) and greater cognitive control deficits (i.e. greater intrusion effects) are associated with reduced effectiveness of reappraisal during our film task. First, we examined whether these cognitive variables are related to the effectiveness of reappraisal in reducing negative affect from pre to post reappraisal (i.e. how much sadness levels decreased back in the direction of baseline levels from before compared to after reappraising). We expected that greater negative cognitive biases on each of these tasks (i.e. greater proportion of negative homophones, greater intrusion effects) would be related to less of a decrease in sadness ratings from pre to post reappraisal. Two hierarchical regression analyses were conducted to examine the relationship between the cognitive variables and change in sadness ratings. For each regression, in the first step we entered initial sadness reactivity, d1 (how much participants increased in sadness levels from the baseline period prior to the start of the sad film to the pre-regulation period when watching the film naturally). This was done because we wanted to examine specifically how the cognitive variables relate to the effects of *emotion regulation*, after accounting for any relation between the cognitive variables and people's initial change in sadness ratings while letting sadness arise naturally during the pre-regulation period (i.e. sadness *reactivity*). Our main cognitive variables, proportion of negative homophone solutions and intrusion effects, were next entered in the second step. These variables were each centered by subtracting the total sample mean from each participant's score in order to reduce collinearity. Given that we

had found diagnostic group differences in analyses of reappraisal effectiveness, diagnostic category was also included as a factor in the second step in order to determine whether the relation between the cognitive variables and reappraisal effectiveness differs depending on diagnosis. In the third step, we entered the interaction between diagnosis and proportion of negative solutions, as well as the interaction between diagnosis and intrusion effects.

In the first regression, we examined the relationship between the cognitive variables and the change in sadness levels from the pre-regulation period to the reappraisal period. Therefore, the dependent variable in this analysis was sadness level at the end of the reappraisal period minus mean sadness level at the end of the pre-regulation period, (d2). Results showed that, inconsistent with our hypothesis, interpretive bias and cognitive control deficits were not significant predictors of reappraisal effectiveness, as indicated by the impact of reappraisal on sadness ratings (see Table 3.7). Thus, neither interpretive bias nor cognitive control deficits were related to how much participants decreased in sadness during the reappraisal period. A marginally significant effect of diagnosis was found, with control participants tending to show a greater decrease in sadness levels back in the direction of baseline levels from pre to post reappraisal. However, interactions between diagnosis and each of the cognitive task variables were not significant. Therefore, depressed and control participants did not differ in the relation between the cognitive variables and the effectiveness of reappraisal in reducing subjective sadness levels.

In the second regression analysis, we examined the association between the cognitive variables and the change in sadness levels from the reappraisal period to the recovery period. The dependent variable was participants' sadness level at the end of the recovery period minus their sadness level at the end of the reappraisal period (d3). This analysis allowed us to examine the continued impact of reappraisal on sadness throughout the recovery period. Once again, interpretive bias and cognitive control deficits were not related to how much participants continued to decrease in sadness level during the recovery period. The effect of diagnosis, and the interactions between diagnosis and each of the cognitive task variables, were not significant. Therefore, participants' diagnosis was not related to how much their sadness levels decreased back toward baseline levels throughout the recovery period. In addition, the relation between cognitive variables and the effectiveness of reappraisal during the recovery period (i.e. how much participants decreased in sadness levels during the recovery period) did not differ depending on diagnosis.

It should be noted that participants' initial sadness reactivity to watching the sad film (i.e. how much they increased in sadness between the baseline period to the pre-regulation period when they were allowing sadness to arise naturally) was significantly related to our main affect rating outcome variables. The greater the increase in participants' sadness level while they were watching the film naturally during the pre-regulation period, the smaller the decrease back toward baseline levels in their sadness. This was the case both when looking at the decrease in sadness during the reappraisal period, and at the continued decrease in sadness during the recovery period.

HR. We also hypothesized that greater negative interpretive bias and greater cognitive control deficits are associated with reduced effectiveness of reappraisal, as indicated by the change in HR, during our film task. Thus, we next examined whether these cognitive variables are related to the effectiveness of reappraisal in changing HR (i.e. how much HR increased back in the direction of baseline HR levels from pre to post reappraisal). We therefore expected that greater negative cognitive biases would be related to less of an increase in HR (i.e. less of a return to baseline HR levels) from pre to post reappraisal. Two hierarchical regression analyses were run to examine the relationship between the cognitive tasks and change in HR. Once again, in each analysis, HR reactivity (change in HR from baseline to pre-regulation, d4) was entered in the first step. Our main cognitive variables, proportion of negative solutions and negative intrusion effects, were once again centered and entered in the second step. Once again, diagnostic status was entered along with the cognitive variables in the second step. In the third step interaction terms between diagnosis and proportion of negative homophone solutions, and diagnosis and intrusion effects, were entered.

In the first regression, we examined the relationship between the cognitive variables and the change in HR from the pre-regulation to the reappraisal period. Therefore, the dependent variable in this analysis was mean HR throughout the reappraisal period minus mean HR during the pre-regulation period (d5). Complete results of the regression analyses are presented in Table 3.9. Contrary to hypotheses, however, neither interpretive bias nor cognitive control deficits were found to be significant predictors of change in HR during the reappraisal period. Diagnosis was not a

significant predictor of the degree to which HR increased back toward baseline levels during the reappraisal period. Further, neither the interaction between diagnosis and homophone bias score, nor the interaction between diagnosis and intrusion effects, were significant. Therefore, MDD versus CTL participants did not differ in the nature of the relation between the cognitive variables and the degree to which HR changed during the reappraisal period.

In the second regression analysis, we examined the association between the cognitive variables and the change in HR from the reappraisal period to the recovery period (d6). The dependent variable was participants' mean HR during the recovery period minus their mean HR level during the reappraisal period (d6). This analysis allowed us to examine the continued impact of reappraisal on HR throughout the recovery period. Once again, interpretive bias and cognitive control deficits were not related to HR change during the recovery period. In addition, diagnosis was not a significant predictor of the degree to which HR increased back toward baseline levels during the recovery period. A marginally significant interaction effect between diagnostic group and proportion of negative homophone solutions on the degree to which HR changed during the recovery period was found. To further examine this interaction, follow-up simple slope analyses were conducted for the MDD and CTL groups (Holmbeck, 2002). These analyses demonstrated that proportion of negative homophone solutions was a significant predictor of change in HR throughout the recovery period in the MDD, but not the CTL, group. As seen in Figure 3.4, within the MDD group, a marginally significant relationship was found between higher proportion of negative

homophone solutions and less change in HR throughout the recovery period, β = -.31, *SE* =2.55, $t(53) = 1.94$, $p = .06$. Within the CTL group, however, proportion of negative homophone solutions was not significantly related to change in HR during the recovery period, $\beta = .13$, $SE = 4.18$, $t(52) = .49$, $p > .05$. The interaction between diagnostic group and intrusion effects was not significant. Therefore, diagnostic groups did not differ in the relation between cognitive control deficits and the degree to which HR changed during the recovery period.

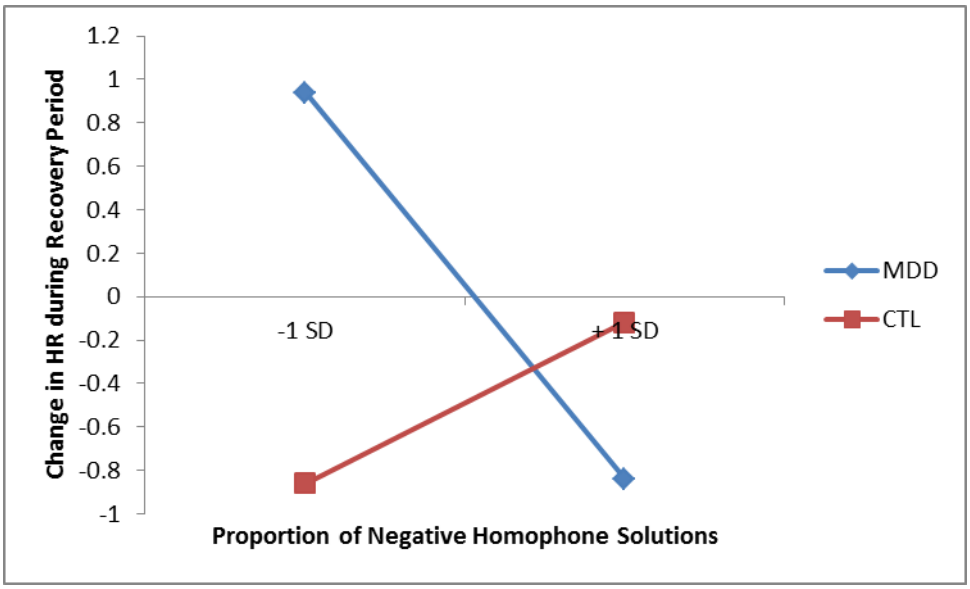


Figure 3.4. Regression lines for relations between proportion of negative homophone solutions and change in HR during the recovery period by diagnostic group (MDD versus CTL) (a 2–way interaction).

It is interesting to note that participants' initial heart-rate reactivity to watching the sad film (i.e. the decrease in HR between the baseline period to the pre-regulation period when participants were allowing sadness to arise naturally) was significantly related to our main HR outcome variables. The greater the drop in participants' HR

while they were watching the film naturally during the pre-regulation period, the smaller the increase back toward baseline levels in their HR during reappraisal.

RSA. We also hypothesized that greater negative interpretive bias (i.e. higher proportion of negative homophone solutions) and greater cognitive control deficits (i.e. greater intrusion effects) are associated with reduced effectiveness of reappraisal, as indicated by change in RSA, during our film task. Thus, we next examined whether these cognitive variables are related to the effectiveness of reappraisal in increasing RSA (i.e. how much RSA increased from the pre-regulation to a) the end of the reappraisal period and b) the end of the recovery period). We therefore expected to see that greater cognitive biases on each of these tasks would be related to less of an increase back in the direction of baseline levels in RSA from pre to post reappraisal. Two regression analyses were run to examine the relationship between the cognitive tasks and change in RSA (see Table 3.11 for complete regression results). In each analysis, RSA reactivity (change in RSA from baseline to pre-regulation, d7) was entered in the first step. Our main cognitive variables, proportion of negative solutions and negative intrusion effects, were once again centered and entered in the second step. Once again, diagnostic status was entered along with the cognitive variables in the second step. In the third step interaction terms between diagnosis and proportion of negative homophone solutions, and diagnosis and intrusion effects, were entered.

In the first regression, examined the relationship between the cognitive variables and change in RSA from the pre-regulation period to the reappraisal period. Therefore, the dependent variable in this analysis was mean RSA during the reappraisal period

minus mean RSA during the pre-regulation period (d8). Contrary to hypotheses, after accounting for RSA reactivity, neither interpretive bias nor cognitive control deficits were a significant predictor of change in RSA in response to reappraisal. Diagnostic status was not significantly related to the degree to which reappraisal changed during the reappraisal period. Further, neither the interaction between diagnosis and interpretive bias, nor the interaction between diagnosis and cognitive control deficits, was significant. Therefore, depressed and non-depressed participants did not differ in the relation between the cognitive variables with the degree of RSA change during the reappraisal period.

In the second analysis we examined the association between the cognitive variables and the change in RSA from the reappraisal period to the recovery period (d9). The dependent variable was participants' mean RSA level during recovery minus their mean RSA level during reappraisal. Neither of the cognitive task measures significantly predicted change in RSA throughout the recovery period. The effect of diagnosis was not significant, therefore diagnosis was not associated with the degree of change in RSA during the recovery period. Finally, neither the interaction between diagnosis and interpretive bias, nor the interaction between diagnosis and cognitive control deficits, was significant. Thus, depressed participants did not differ from non-depressed participants in the relation between cognitive biases with the degree to which RSA changed during the recovery period.

To summarize, results did not support the hypothesis that greater negative interpretation bias, nor difficulties inhibiting irrelevant negative stimuli, are related to the effectiveness of reappraisal. This was the case regardless of whether the effectiveness of

reappraisal was assessed by the impact on sadness ratings, HR, or RSA. Further, depressed and non-depressed participants generally did not differ in the relation between cognitive biases with effectiveness of reappraisal.

Table 3.6

Correlations between Cognitive Measures and Change in Affect Ratings from Pre to Post Reappraisal

	Sadness Reactivity	Sadness reappraisal	Sadness Recovery	Proportion Negative Homophones	Intrusion Effects
Sadness reactivity		-.63***	-.44***	.10	-.04
Sadness reappraisal				.07	-.03
Sadness recovery				-.20+	.04

Note. $N = 57$. $^{+}p<.10$, *p<.05, **p<.01, ***p<.001

Table 3.7

Hierarchical Regression Analyses Predicting Change in Affect Ratings from Pre-Regulation to Reappraisal

Variable		*b*	*SE (B)*	*β*	R^2	R^2 *Change*
Pre-Regulation to Reappraisal (d2)						
S1	Sadness Reactivity (d1)	-.38	.08	-.55***	.40***	
S2	Prop Neg Homphn	.87	2.86	.07		.07
	Intrusion Effects	-.00	.00	-.16		
	Diagnostic Group	.88	.47	.22+		
S3	Diagnosis*Homphn	1.87	3.36	.12		.01
	Diagnosis*Intrusion	.00	.00	.10		
Reappraisal to Recovery (d3)						
S1	Sadness Reactivity (d1)	-.38	.10	-.52***	.18**	
S2	Prop Neg Homphn	-3.00	3.38	-.22		.09
	Intrusion Effects	.00	.00	.26		
	Diagnostic Group	-1.06	.55	-.25+		
S3	Diagnosis*Homphn	.94	3.97	.06		.03
	Diagnosis*Intrusion	.00	.00	-.28		

Note. $N = 57$. S = Step. Sadness reactivity entered in Step 1. Proportion of negative homophone solutions, intrusion effects, and diagnostic group entered in Step 2. Interaction effects between diagnosis and proportion of negative homophone solutions, and between diagnosis and intrusion effects, entered in Step 3. $^{+}p<.10$, *p<.05, **p<.01, ***p<.001

Table 3.8

Correlations between Cognitive Measures and Change in HR from Pre to Post Reappraisal

	HR Reactivity	HR reappraisal	HR Recovery	Proportion Negative Homophones	Intrusion Effects
HR reactivity		-.59***	-.23+	.21+	.13
HR reappraisal				-.06	-.10
HR recovery				-.21+	.05

Note. $N = 49$. +p<.10, *p<.05, **p<.01, ***p<.001

Table 3.9

Hierarchical Regression Analyses Predicting Change in Heart-rate in Response to Reappraisal

Variable		*b*	*SE (B)*	*β*	R^2	R^2 *Change*
Pre-Regulation to Reappraisal (d5)						
S1	HR Reactivity (d4)	-.48	.11	-.59***	.33	
S2	Prop Neg Homphn	-1.87	5.05	-.09		.01
	Intrusion Effects	-.00	.00	-.12		
	Diagnostic Group	-.34	.78	-.05		
S3	Diagnosis*Homphn	4.49	5.88	.19		.01
	Diagnosis*Intrusion	.00	.00	.08		
Reappraisal to Recovery (d6)						
S1	HR Reactivity (d4)	-.14	.09	-.23	.05	
S2	Prop Neg Homphn	4.32	4.34	.28		.05
	Intrusion Effects	.00	.00	.27		
	Diagnostic Group	.44	.67	.09		
S3	Diagnosis*Homphn	-9.51	5.06	-.53+		.09
	Diagnosis*Intrusion	-.00	.00	-.16		

Note. $N = 49$. HR reactivity (change in HR from baseline to pre-regulation period) entered in Step 1. Proportion of negative homophone solutions, intrusion effects, and diagnostic group entered in Step 2. Interaction effects between diagnosis and proportion of negative homophone solutions, and between diagnosis and intrusion effects, entered in Step 3.
+p<.10, *p<.05, **p<.01, ***p<.001

Table 3.10

Correlations between Cognitive Measures and Change in RSA from Pre to Post Reappraisal

	RSA Reactivity	RSA reappraisal	RSA Recovery	Proportion Negative Homophones	Intrusion Effects
RSA reactivity		-.19	-.28*	.01	-.37**
RSA reappraisal				-.15	.05
RSA recovery				.16	.17

Note. $N = 48$. +p<.10, *p<.05, **p<.01, ***p<.001

Table 3.11

Hierarchical Regression Analyses Predicting Change in RSA in Response to Reappraisal

Variable		*b*	*SE (B)*	*β*	R^2	R^2 *Change*
Pre-Regulation to Reappraisal (d8)						
S1	HR Reactivity (d7)	-.23	.15	-.28	.04	
S2	Prop Neg Homphn	.84	1.24	.21		.04
	Intrusion Effects	.00	.00	.09		
	Diagnostic Group	-.14	.20	-.11		
S3	Diagnosis*Homphn	-1.98	1.47	-.41		.05
	Diagnosis*Intrusion	.00	.00	-.11		
Reappraisal to Recovery (d9)						
S1	HR Reactivity (d7)	-.11	.12	-.16	$.08^{+}$	
S2	Prop Neg Homphn	-.64	1.03	-.18		.05
	Intrusion Effects	.00	.00	-.12		
	Diagnostic Group	.14	.16	.13		
S3	Diagnosis*Homphn	1.53	1.22	.37		.07
	Diagnosis*Intrusion	.00	.00	.23		

Note. $N = 48$. RSA reactivity (change in RSA from baseline to pre-regulation period) entered in Step 1. Proportion of negative homophone solutions, intrusion effects, and diagnostic group entered in Step 2. Interaction effects between diagnosis and proportion of negative homophone solutions, and between diagnosis and intrusion effects, entered in Step 3.
$^{+}$p<.10, *p<.05, **p<.01, ***p<.001

V. Relation between Daily ER Strategy Use and Reappraisal Effectiveness in the Laboratory

In order to test the hypothesis that self-reported daily use of ER strategies is associated with the effectiveness of reappraisal in response to our laboratory task, partial correlations were conducted between self-reported rumination (RSQ), expressive suppression (ERQ), cognitive suppression (WBSI) and reappraisal (ERQ and CERQ) with each measure of reappraisal effectiveness (sadness ratings, HR, RSA) in response to our laboratory reappraisal task (see Tables 3.12 - 3.13). Given that depressed and control participants were found to differ in the effectiveness of reappraisal in reducing sadness ratings, correlations were run separately across diagnostic groups. In all correlation analyses, we controlled for initial reactivity in reappraisal effectiveness variables given that reactivity in these variables was previously found to be related to the degree of change during the reappraisal and recovery periods (i.e. change from the baseline to pre-regulation period in either sadness, HR or RSA).

Results confirmed that the daily use of ER strategies is significantly related to the effectiveness of reappraisal in reducing self-reported sadness. In the CTL group, the degree to which participants reported they use rumination day to day was found to be related to the degree to which their sadness levels decreased in response to reappraisal. CTLs who reported a greater tendency to ruminate day to day showed less of a decrease in sadness ratings during the reappraisal task. Interestingly, among the CTL group, greater habitual rumination was also related to poorer recovery in heart-rate during reappraisal in our laboratory task. That is, CTLs who ruminate more frequently remained lower in HR after reappraising the sad film, indicating less of an increase in HR back

toward baseline levels. Within the CTL group, there was a trend for participants higher in habitual use of reappraisal to exhibit enhanced reappraisal effectiveness on our laboratory film task, as indicated by affect ratings. CTLs who reappraise more frequently in day to day life reported lower sadness levels throughout the reappraisal and recovery periods. Unexpectedly, CTLs who reported more frequent cognitive suppression on the WBSI exhibited higher RSA levels at the end of the recovery period.

In general, the strength of correlations between daily ER and the laboratory measures of reappraisal effectiveness were less strong among participants with MDD than correlations within the CTL group. Nevertheless, similar to CTLs, depressed participants who reported more frequent day to day use of reappraisal exhibited a trend toward enhanced effectiveness of reappraisal on our laboratory task. Depressed participants who reappraise more often day to day had a tendency to report lower sadness levels following reappraisal, although this correlation was not statistically significant.

VI. Relation between Comorbidity and Reappraisal Effectiveness

Finally, we examined whether the presence of comorbid anxiety disorders influences the effectiveness of reappraisal among participants in the MDD group. These analyses focused on subjective sadness ratings, given that differences between MDD and CTL participants were seen in subjective sadness ratings, but not the physiological indices. Table 3.14 displays the prevalence of specific comorbid anxiety disorders within the MDD group. Mixed model ANOVAs were repeated following the same procedure as previously described (see Chapter 3, section II), now including as a factor whether the

participant currently met diagnostic criteria for each of the anxiety disorders. Separate ANOVAs were run for each anxiety disorder. Results of the ANOVAs are displayed in Table 3.15 below. The presence of each of the comorbid anxiety disorders examined was not related to the effectiveness of reappraisal.

Table 3.12

Correlations between Habitual ER Strategy Use and Effectiveness of Reappraisal in the Laboratory: MDD Group

		ERQ Reap	ERQ Suppress	RSQ Total	RSQ Brood	RSQ Reflect	WBSI Total	CERQ Perspect	CERQ Reap
Reappraisal	Sadness Rating	-.23	.14	.07	.14	-.15	.02	.15	-.22
	HR	-.20	-.05	.02	-.06	-.16	.14	.00	-.20
	RSA	.21	.17	-.34	-.21	-.16	-.37+	-.15	.31
Recovery	Sadness Rating	.01	.06	-.03	-.04	.05	.10	.10	.22
	HR	-.24	.03	.17	.23	.09	-.20	.08	.46**
	RSA	-.10	-.18	.26	.20	.12	.28	.27	-.24

Note. N=67. Values are partial correlations controlling for initial reactivity in each measure in response to the sad film. ERQ = Emotion Regulation Questionnaire, Reap = Reappraisal, Suppress = Expressive Suppression, RSQ = Response Styles Questionnaire, Brood = Brooding, Reflect = Reflection, WBSI = White Bear Suppression Inventory, CERQ = Cognitive Emotion Regulation Questionnaire, Perspect = Putting into Perspective. $^{+}p < .10$, $*p < .05$,$**p < .01$

Table 3.13

Correlations between Habitual ER Strategy Use and Effectiveness of Reappraisal in the Laboratory: CTL Group

		ERQ Reap	ERQ Suppress	RSQ Total	RSQ Brood	RSQ Reflect	WBSI Total	CERQ Perspect	CERQ Reap
Reappraisal	Sadness Rating	-.24	.22	.48**	.34+	.50**	.22	.09	.19
	HR	.18	.11	-.28	-.27	-.02	.07	.27	.08
	RSA	.09	-.16	-.25	-.09	-.26	-.00	.07	.00
Recovery	Sadness Rating	-.25	.25	.45*	.42*	.26	.27	-.11	.10
	HR	.20	-.06	-.46*	-.50*	-.23	-.36+	.38+	.24
	RSA	.04	.22	.01	.12	-.03	.46*	-.22	.02

Note. N=67. Values are partial correlations controlling for initial reactivity in each measure in response to the sad film. ERQ = Emotion Regulation Questionnaire, Reap = Reappraisal, Suppress = Expressive Suppression, RSQ = Response Styles Questionnaire, Brood = Brooding, Reflect = Reflection, WBSI = White Bear Suppression Inventory, CERQ = Cognitive Emotion Regulation Questionnaire, Perspect = Putting into Perspective. $^{+}p < .10$, $*p < .05$,$**p < .01$

Table 3.14

Frequency of Comorbid Anxiety Disorders in the MDD Group

Specific Phobia *N* (%)	Social Phobia *N* (%)	GAD *N* (%)	Panic Disorder *N* (%)	AWOPD *N* (%)	PTSD *N* (%)	OCD *N* (%)
9 (27.3%)	14 (42.4%)	5 (15.2%)	5 (15.2%)	1 (3.0%)	3 (9.1%)	0 (0.0%)

Note. N = 33 depressed participants

Table 3.15

Analysis of Variance Results for Effectiveness of Reappraisal in Reducing Subjective Sadness Ratings by Comorbid Anxiety Diagnoses

Source	*df*		*F*	*p*
Panic Disorder				
Group	1		.10	.76
Error (group)	28	(5.6)		
Timepoint	3		10.6	.00**
Timepoint X Group	3		.09	.97
Error (timepoint)	84	(3.2)		
Social Phobia				
Group	1		1.66	.21
Error (group)	28	(5.3)		
Timepoint	1		20.5	.00**
Timepoint X Group	1		1.15	.33
Error (timepoint)	84	(3.1)		
Specific Phobia				
Group	1		2.43	.13
Error (group)	28	(5.2)		
Timepoint	1		19.7	.00**
Timepoint X Group	1		.50	.68
Error (timepoint)	84	(3.2)		
PTSD				
Group	1		.13	.72
Error (group)	25	(4.7)		
Timepoint	1		12.4	.00**
Timepoint X Group	1		1.81	.15
Error (timepoint)	75	(3.1)		
GAD				
Group	1		.37	.55
Error (group)	27	(2.0)		
Timepoint	1		14.4	.00**
Timepoint X Group	1		1.61	.19
Error (timepoint)	81	(3.2)		

Note. $N = 33$, Values enclosed in parentheses are mean square errors. $*p < .05$, $** p < .01$

Chapter 4: Discussion

Previous studies have demonstrated that MDD is characterized by deficits in emotion regulation, including a tendency to use strategies which prolong depressed mood over more adaptive strategies, such as reappraisal. Depressed individuals also exhibit cognitive biases, including negatively skewed interpretations and reduced ability to disengage from and inhibit negative information from working memory, which are held to play a role in their persistent negative mood. To date, few studies have simultaneously examined cognitive processes and adaptive emotion regulation strategies within the same study, and existing studies have tended to over-rely on self-report measures of emotion regulation. The present study was the first study to compare depressed and healthy individuals in the effectiveness of reappraisal in reducing sadness during a laboratory task, and to examine whether biased interpretation and deficits inhibiting negative emotional material are related to reappraisal effectiveness.

Diagnostic group differences in reappraisal effectiveness

Results provided support for the hypothesis that reappraisal was less effective in reducing negative affect for the MDD group than for CTLs. This finding is consistent with prior studies which found irregularities in neural mechanisms underlying reappraisal in depressed individuals (e.g. Johnston et al. 2007; Siegle et al. 2007), indicating potential deficits in reappraisal. These studies found that when reappraising emotion eliciting images, healthy individuals show increased activation in prefrontal cortical areas followed by subsequent decreased amygdala activity; however, depressed individuals

were characterized by weaker prefrontal-amygdala connectivity and sustained amygdala responding during reappraisal coinciding with prolonged self-reported negative affect. Taken together, these findings suggest that even when depressed individuals are instructed to and try hard to reappraise, reappraisal has less of an impact on their mood than it does for healthy individuals, which may be due to dysfunction in neural mechanisms supporting reappraisal. In fact, recent studies demonstrated the efficacy of interventions to boost executive control ability among depressed individuals, showing improved effectiveness of reappraisal in reducing subjective negative affect which was associated with normalization in these neural mechanisms during reappraisal (e.g. Siegle et al., 2007). It is encouraging that the MDD group, in addition to CTLs, did show a significant impact of reappraisal in reducing negative affect ratings, even though it was less effective than for CTLs. This suggests that, at least to some degree, depressed individuals have the ability to benefit from reappraisal, and it would be important in future studies to clarify the precise mechanisms influencing these diagnostic group differences in the effectiveness of reappraisal.

One possible alternative explanation is that depressed and healthy individuals may differ in how well they adhere to instructions to reappraise, or in what they are actually doing when attempting to reappraise. However, on our measure of adherence to the reappraisal task instructions, we did not find significant diagnostic group differences in self-reported use of reappraisal. All participants, regardless of diagnosis, reported that they increased in reappraisal to a comparable degree in response to the instructions. All participants also decreased in rumination while reappraising. It is important to note,

however, that diagnostic group differences were found in rumination and cognitive suppression throughout the reappraisal task. Whereas CTLs decreased significantly in rumination during the reappraisal period, MDD participants remained more elevated in rumination than CTLs did, suggesting that depressed individuals had some difficulty stopping rumination, even at the same time they were reappraising just as much as CTLs. Both CTLs and MDD participants increased in cognitive suppression during reappraisal. This is not too surprising given that boundaries between different emotion regulation strategies are probably less clear cut to participants, and it may be natural to engage in some cognitive suppression when attempting to reframe negative events from a detached and neutral perspective. Our training was brief and did not include extensive instructions to participants describing to them to avoid suppression, for example. However, MDD participants reported higher levels of cognitive suppression than did CTLs. Given that both cognitive suppression and rumination have been shown to backfire, increasing negative affect (Gross, 1998; Campbell-Sills, Barlow, Brown & Hoffman, 2006; Wenzlaff et al., 2002), this may be one additional factor in why depressed individuals remained more elevated than CTLs in negative affect after reappraising.

Contrary to hypotheses, neither diagnostic group showed significant changes in HR or RSA throughout the reappraisal task. As no interaction was found between diagnostic status and change throughout different timepoints of the task, no conclusions about group differences in the effectiveness of reappraisal can be drawn from the HR and RSA data. These findings are in contrast with several previous studies which found that negative affect is characterized by increased sympathetic activation, and that prolonged

increased sympathetic activation as well as decreased RSA during emotion regulation characterizes individuals who are vulnerable to psychopathology (Key et al. 2008; Levenson et al. 1990, 1992; Lyonfields et al. 1995; Rottenberg et al., 2003). Our findings are also inconsistent with a growing numbers of recent studies using similar paradigms as the present study which demonstrated that reappraisal is characterized by significant physiological responses. One such study demonstrated that individuals high in neuroticism exhibited decreased RSA relative to individuals low in neuroticism during reappraisal of aversive images (DeSimplicio et al., 2012). Shiota and Levenson (2012) found increased heart-rate among men and women during viewing of unpleasant films, and change in heart-rate during reappraisal depended on the particular type of reappraisal that participants were assigned to implement while viewing the films. Decreased heart-rate was observed during both types of reappraisal among men. Among women, however, positive reappraisal, involving finding positive meaning in the films, was associated with decreased heart-rate, whereas distancing, involving maintaining an objective and unemotional stance in viewing the film, was associated with increased heart-rate. Kim and Hamann (2012) found that, while reappraisal to down-regulate negative emotions while viewing negative pictures was characterized by decreased corrugator activity (i.e. frowning) relative to a no-regulation control condition, these two conditions did not differ in sympathetic activation as assessed by skin conductance responses. Clearly, results across studies examining physiological correlates of reappraisal are not uniform and further research is needed to understand physiological

correlates of different ER strategies, as well as moderating variables of physiological response, such as gender and psychopathology.

Group Differences in Cognitive Tasks and Relation to Reappraisal Effectiveness

In contrast with prior studies, depressed participants were not found to exhibit greater negative interpretation bias relative to CTLs on the homophone task (Lawson et al., 2002; Mogg et al., 2006; Rude et al., 2002). Although one previous study showed negative interpretation bias in depressed individuals utilizing the homophone task, the literature on interpretation bias in depression is somewhat more mixed than that in anxiety disorders, and more studies are needed to determine if depression is in fact characterized by negative interpretation bias. It has been argued that one reason for the mixed results in the literature regarding interpretive bias in depression is that interpretive bias is present only under particular conditions (Wisco, 2009). Studies using interpretive bias measures in which stimuli were made more self-relevant to depressed individuals, for example, were more likely to find evidence of depression related interpretive bias.

Inconsistent with our hypotheses, we did not find evidence for greater deficits in depression in inhibiting no-longer relevant material from working memory. This finding is also inconsistent with prior studies which found inhibition deficits in depressed individuals specific to negative stimuli (e.g. Cohen et al. 2012; Joormann & Gotlib, 2008), and which found associations between such deficits and reduced use of reappraisal (Cohen et al. 2012; Joormann & Gotlib, 2010). We elected to use the Sternberg Task because it was shown to detect deficits in prior studies of depression and because it assesses inhibition of emotional material (Joormann & Gotlib, 2008; 2010), however it is

important to note that the number of studies utilizing the emotional Sternberg task is still small, thus it is possible that results from these prior studies do not replicate consistently.

As we did not find expected diagnostic group differences in either the interpretive bias measure or the cognitive control measure, limited conclusions can be drawn about the role of these cognitive processes in the reduced effectiveness of reappraisal which is seen in depression. The failure to find associations between interpretive bias and cognitive control with the effectiveness of reappraisal may be due to limitations in our measures of cognitive biases.

Alternatively, it is possible that other particular types of cognitive biases which we did not examine in this study play more of a central role in depression and in difficulties reappraising. Interpretive bias and cognitive control are not uniform processes, but instead are comprised of several subcomponents (Wisco, 2009; Hasher et al. 1999). For example, biases in interpretation may occur at several different stages, ranging from initial generation of several possible alternative interpretations to weighing of different alternatives and, finally, to selection of an interpretation. Similarly, there are multiple aspects of cognitive control; for example, recent studies have differentiated between inhibition at earlier stages of processing (i.e. on tasks assessing the ability to initially attend selectively to positive or neutral rather than neutral material, and to prevent negative material from initially entering working memory) to later stages of processing (i.e. tasks such as the emotional Sternberg Task which assess ability to remove negative material which has already been stored in working memory) (Hasher et al., 1999). Prior studies have found differences between different subcomponents and

their relation both to depression symptoms and self-reported use of emotion regulation strategies (Zetsche et al., 2011; De Lissnyder et al. 2010). There are also recent studies linking other types of cognitive processes, such as attention and memory, to emotion regulation in depression (Bebko et al., 2011). Bebko and colleagues found that effective reappraisal was characterized by averting one's gaze from negative images and looking towards emotional aspects of the images. However, Urry et al. (2010), in a test of whether attentional deployment mediates reappraisal, found that reappraisal was effective in regulating affect even when gaze was held constant, leading them to suggest that deliberate appraisal processes are more central to the ability to reappraise. This underscores the importance of examining multiple cognitive processes within the same study and utilizing multiple measures.

Relation between Self-report Measures and Laboratory Reappraisal Effectiveness Measures

Interestingly, we found that participants who reported greater use of reappraisal, and less use of rumination, in their day to day lives demonstrated greater effectiveness of reappraisal in reducing negative affect ratings. One criticism of self-report measures of daily emotion regulation strategy use is that people may be inaccurate in describing their use of these strategies, and self-report responses may not correspond to characteristics of people's actual day to day strategy use. This finding therefore lends support to the validity of self-report measures of emotion regulation, including the ERQ and RSQ, in capturing meaningful aspects of people's application of ER strategies. It is possible that one reason for this association is that individuals who report using reappraisal less frequently are less likely to attempt reappraisal due to prior experiences in which it was

not effective for them. Alternatively, more practice using reappraisal on a regular basis may contribute to greater effectiveness of reappraisal over time, and this may be a central mechanism through which cognitive therapy reduces depression symptoms. The same biases in attention and memory, and difficulties disengaging from negative material, which play a role in difficulties stopping rumination may also play a role in difficulties with reappraisal.

We unexpectedly found that, while the MDD compared to CTL group reported more frequent habitual use of reappraisal, this difference was not significant. This finding was surprising given that the majority of existing studies have demonstrated less frequent reappraisal to be associated with depression (e.g. Garnefski & Kraaij, 2006a, 2009; Gross & John, 2003: Joormann & Gotlib, 2010). In many studies of the habitual use of various emotion regulation strategies in psychopathology, however, use of adaptive strategies such as reappraisal was found to be related less consistently to psychopathology than use of maladaptive strategies, such as rumination and suppression (Aldao et al., 2010; Aldao & Nolen-Hoeksema, 2010). This finding prompted recent studies to identify moderators of the association between reappraisal use and symptoms of psychopathology (e.g. Aldao et al. 2012). One such moderator may be individual differences in the effectiveness of reappraisal.

Limitations and Future Directions

The study design possessed many strengths, most notably that it extended prior studies relying entirely on self-report by using a laboratory task that allowed us to observe individual differences in the implementation and effects of reappraisal. The

selection of a widely used sad film clip provided a standardized means to induce sadness and assess the effects of reappraisal that was comparably effective for both diagnostic groups. In addition, the use of a film clip mood induction offered the ability to simulate situations of loss that are most relevant to depressed individuals. The use of a diagnosed community sample ensured that results are more generalizable to clinical populations, an important advantage given that a majority of previous studies examined undiagnosed samples. Finally, very few studies have examined both cognitive biases and the application of emotion regulation strategies within the same study, particularly studies focusing on adaptive strategies.

Despite these strengths, some limitations should be noted. While the use of a film clip allowed for a standardized and controlled mood induction, differences in reappraising contents of a film clip versus more self-relevant autobiographical events might be expected. Autobiographical events should elicit more intense emotion, and use of more self-relevant autobiographical content might result in an even more pronounced difference between depressed and non-depressed people because reappraisal would be more difficult under these circumstances. In fact, a recent study demonstrated that reappraisal is more cognitively taxing even among healthy individuals when emotion is higher in intensity (Sheppes et al., 2011).

There were limitations in the ability to draw conclusions about reappraisal effectiveness from the physiological measures, given these indices did not change significantly in response to the induction. It may be advantageous to use a more demanding task, such as a stress task, which might result in a more reliable change in

physiological indices. However, use of a sad film clip allowed us to focus specifically on sadness, which is most directly relevant to depression. It may not be accurate to assume that regulation of anxiety or other emotions generalizes to regulation of sadness.

The cognitive tasks in this study possess some limitations which may have played a role in our lack of findings of diagnostic group differences on these variables. The stimuli used in the homophone task may have limited self-relevance to participants, as the task does not specifically guide them to draw connections between the words and their own lives or self-perception. Given interpretation bias has been shown to be found more reliably when content has greater self-relevance, this may be an important limitation of our task (Wisco, 2009). In addition, external validity of the homophone task is a limitation. Whether individuals hear ambiguous words as negative or neutral may not necessarily correspond to the way in which they interpret more complex, personally meaningful situations and stimuli that they experience day to day. Relatively less research on interpretive bias, particularly which utilizes implicit measures, has been conducted than other cognitive biases in depression, and there is a need to develop new measures which address these limitations. As noted previously, both the homophone task and Sternberg task each assessed only one subcomponent of a particular cognitive process, and it would be preferable to assess multiple components of each process.

It is not too surprising that participants reported increased suppression at the same time that they were reappraising. In attempting to maintain a distanced perspective on the film, participants may have naturally tried to block thoughts and feelings about the emotional aspects of the film. Similarly, while both MDD and CTL participants reported

low levels of rumination during the reappraisal period, MDD participants reported more elevated rumination during this period than CTLs, suggesting some difficulties stopping rumination. Even though there is evidence that different strategies such as reappraisal, distraction and suppression are distinct, including distinct neural correlates (e.g. Goldin et al. 2008; McRae et al 2009), participants are probably unable to completely distinguish between when they are using reappraisal versus another ER strategy. In fact, there may be some overlap across strategies. For example, one recent eye-tracking study found that both reappraisal and suppression were associated with greater looking away from negative pictures to some degree, although suppression was associated with even more looking away and reappraisal was also associated with more looking toward emotional contents of the images (Bebko et al., 2011). Similarly, Eftekhari et al. (2009), who classified participants on the basis of their frequency of both suppression and reappraisal use, found that people classified as high on both strategies represented the most common pattern of ER. Although people high in reappraisal and low in suppression reported the lowest symptom levels, people high in use of both strategies also reported effective ER and lower symptom levels. Similarly, participants are likely not able to fully control which strategy they are using at a given time; these are common challenges in studies of ER. As can be expected, while the majority of participants demonstrated good adherence to the instructions, there was some variability in adherence. Despite ensuring that participants comprehended the instructions prior to the task, a minority of participants reported some difficulties adhering to the reappraisal instructions during the task, showing minimal increase in reappraisal during the regulation period. When repeating

the analyses and excluding these participants, similar results were found overall, but even greater differences between the MDD and CTL groups were seen in the change in affect ratings in response to reappraisal. Use of other strategies, such as suppression and rumination, and difficulties adhering to reappraisal, may have affected physiological and emotional responses to the task for some participants.

Finally, one recent study of reappraisal which also utilized film clips found that it is the combination of depressive symptoms and experience of a recent stressful life event which is associated with reduced reappraisal effectiveness (Troy et al. 2010). In future studies it would be interesting to assess participants' life stress, which may be an important moderator of the relation between depression and reappraisal effectiveness. While we found evidence of reduced effectiveness of reappraisal in relieving negative mood without accounting for the presence of a major recent life stressor, even more pronounced deficits in reappraisal effectiveness may be seen in depressed individuals in the context of a highly stressful life event or significant ongoing stress.

Summary

This study demonstrated that depression is characterized by reduced effectiveness of reappraisal, an adaptive emotion regulation strategy, in alleviating sad mood relative to individuals without depression. Moreover, lower effectiveness of reappraisal in reducing negative affect was found to be associated with less frequent habitual use of reappraisal, and more frequent rumination, in participants' day to day lives. These findings are important because this is one of the few studies to date to demonstrate deficits in the application of an adaptive ER strategy in depression. The majority of studies to date have

focused on the role of strategies, such as rumination and suppression, which have been found to be less effective in alleviating sad mood. Our results suggest that, even when depressed individuals are explicitly instructed and try hard to reappraise, reappraisal alleviates sad mood to a lesser degree than it does in healthy individuals. Given the relation found between decreased day to day use of reappraisal and reduced reappraisal effectiveness in response to the laboratory task, it is possible that prior difficulty with reappraisal is a reason why some individuals may attempt this adaptive strategy less often; however, given this finding is correlational further studies are needed. The results suggest that reduced effectiveness of adaptive strategies, such as reappraisal, may be an important factor in the maintenance of depression, and point to the need for interventions to boost the effectiveness of reappraisal. Unexpectedly, we did not find diagnostic group differences in cognitive control of negative material or in interpretive bias, nor were these cognitive processes related to the effectiveness of reappraisal or to habitual use of reappraisal. However, given that the diagnostic groups did not differ in their self-reported adherence to the reappraisal instructions, this suggests that the groups are not differing in what they are doing when reappraising, but instead in the consequences of reappraisal. This suggests that automatic cognitive processes and neurobiological mechanisms which individuals may not aware of or easily able to control are likely playing an important role in the effectiveness of reappraisal. There is a need for more studies which build on the present study by examining both reappraisal and multiple

cognitive and neurobiological variables within the same study in order to identify correlates of reduced reappraisal effectiveness, which will guide the development of improved interventions.

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Appendix A: Reappraisal Task Instructions

You are about to watch a short scene from a movie clip. Please watch the film carefully. In addition, if any emotions arise while watching the film, please allow yourself to naturally experience them, rather than trying to block your emotions. For example, if the film makes you feel angry, happy, sad, afraid or any other emotion, just try to naturally allow feeling the emotion without blocking yourself. We recommend two ways of doing that- You can either try to adapt the main character's point of view, or you can try and find personal relevance in what the main character is saying.

Also, at some point during the film a subtitle will appear in the lower part of the screen. This subtitle can represent either one of two things, though in fact only one subtitle will appear. One possible subtitle will ask you to continue watching the film in the same way you did before. In this case you should continue watching the film carefully, and continue allowing any emotions you experience to arise. A second possibility is that another subtitle will appear asking you to "Try your best to adopt an emotionless attitude, as if you were a scientist who examines the film objectively". In this case it is important that, from that moment onward, you will try to detach yourself emotionally and personally from the events. You are supposed to continue paying close attention to the movie, **continue listening to what is being said**, **but to change the meaning of what is being said**. It is crucial that you search for facts, stay objective, and don't look for personal or emotional meaning in the contents. For example, if you are watching a certain person, you shouldn't think about whether you like him, but rather- this is a man who is somewhat tall, who is wearing such and such clothes, and is going to this place, etc…

Do you understand? Do you think you could give me another example or explain to me in your own words how you are going to follow this instruction, so that **if** it appears, you will be able to follow it immediately?

Once again, this subtitle is only one of two possibilities. In any case, once a subtitle appears, it will not change during the film. The subtitle will occasionally flash in order to remind you the importance in trying to follow it **continuously and throughout the film**.

To summarize, you should watch the film carefully, while allowing yourself to experience any emotions if those arise. If you see a subtitle which asks you to continue your watching, nothing changes. If you see a subtitle which asks you to take a neutral approach to viewing the film, it is important you will follow it from that moment onward, and continuously. Do you have any questions?

Appendix B: Reappraisal Adherence Measure- Pre-Regulation Period

We would like to ask you some questions about your experience while watching the film, including your thought processes and any strategies you may have tried to control your emotions. Please read each of the following items and indicate how much each statement describes what you **actually** did during Part One of the film when you were asked to allow your emotions to arise naturally. Remember, focus ONLY on the first part of the film while you were asked to watch the film naturally, allowing your emotions to arise.

1----------2----------3----------4----------5----------6----------7
strongly disagree — neutral — strongly agree

---

1. I changed what I was thinking about in order to feel better. ____
2. I tried to keep my emotions to myself. ____
3. I was careful not to express my emotions. ____
4. I thought about the film in a way that helped me to stay calm. ____
5. I controlled my emotions by not expressing them. ____
6. I controlled my emotions by changing the way I thought about the situation shown in the film. ____
7. I watched the film like a scientist, observing it objectively with an emotionless attitude. ____
8. While watching the film, I tried to distract myself with other things. ____
9. I tried to focus on the more pleasant parts of the film. ____
10. I thought about pleasant things that had nothing to do with the situation in the film. ____
11. I tried hard to keep upsetting thoughts about the situation in the film out of my mind. ____
12. I tried to reason about why the objective situation isn't so bad. ____
13. I thought about the situation from a different perspective to feel better. ____
14. I thought about how I was feeling.
15. I tried to analyze and understand why I was feeling the way I did. ____
16. I thought about unpleasant memories and times in the past. ____
17. I thought about past shortcomings, failings, faults, mistakes that the film reminded me of. ____

18. I got caught up in thinking about unpleasant parts of the film. ____
19. I found myself preoccupied with my thoughts and feelings about the film. ____
20. I tried to erase unpleasant thoughts and images from my mind. ____
21. I tried to avoid certain thoughts about the film. ____
22. I wished I could stop thinking about certain things. ____
23. I put myself in the shoes of the character in the film and found I could relate to the character. ____

Appendix C: Reappraisal Adherence Measure: Regulation Period

We would like to ask you some questions about your experience while watching the film, including your thought processes and any strategies you may have tried to control your emotions. Please read each of the following items and indicate how much each statement describes what you **actually** did during the second part of the film, following the point at which the subtitle appeared, when you were asked to view the film objectively, like a scientist. Remember, focus ONLY on the last minute of the film, when the subtitle appeared, indicating to watch the film like a scientist.

1----------2----------3----------4----------5----------6----------7
strongly disagree — neutral — strongly agree

---

1. I changed what I was thinking about in order to feel better. ____
2. I tried to keep my emotions to myself. ____
3. I was careful not to express my emotions. ____
4. I thought about the film in a way that helped me to stay calm. ____
5. I controlled my emotions by not expressing them. ____
6. I controlled my emotions by changing the way I thought about the situation shown in the film. ____
7. I watched the film like a scientist, observing it objectively with an emotionless attitude. ____
8. While watching the film, I tried to distract myself with other things. ____
9. I tried to focus on the more pleasant parts of the film. ____
10. I thought about pleasant things that had nothing to do with the situation in the film. ____
11. I tried hard to keep upsetting thoughts about the situation in the film out of my mind. ____
12. I tried to reason about why the objective situation isn't so bad. ____
13. I thought about the situation from a different perspective to feel better. ____
14. I thought about how I was feeling.
15. I tried to analyze and understand why I was feeling the way I did. ____
16. I thought about unpleasant memories and times in the past. ____
17. I thought about past shortcomings, failings, faults, mistakes that the film reminded me of. ____

18. I got caught up in thinking about unpleasant parts of the film. ____
19. I found myself preoccupied with my thoughts and feelings about the film. ____
20. I tried to erase unpleasant thoughts and images from my mind. ____
21. I tried to avoid certain thoughts about the film. ____
22. I wished I could stop thinking about certain things. ____
23. I put myself in the shoes of the character in the film and found I could relate to the character. ____

Appendix D: Reappraisal Adherence Measure Open-Ended Item, Pre-Regulation Period

We asked you during the first part of the film to try to watch the film naturally, allowing any emotions you experienced to arise without trying to block or change your emotions. Trying the best you can, we want you to describe in your own words below what you **actually** did during this part of the film. Try to describe in as much detail as you can any strategies that you may have used to try to do this, and any difficulties you had in sticking to the instructions we gave you.

Appendix E: Reappraisal Adherence Measure Open-Ended Item, Regulation Period

We asked you during the second part of the film to try to watch the film like a scientist, adopting an emotionless attitude and watching the film as if you were an objective observer. Trying the best you can, we want you to describe in your own words below what you **actually** did during this part of the film. Try to describe in as much detail as you can any strategies that you may have used to try to do this, and any difficulties you had in sticking to the instructions we gave you.

Appendix F: Affect Ratings

Please rate the extent to which each of the emotions below describes how you are feeling **right now.**

A. **SAD**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**

B. **TENSE**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**

C. **HAPPY**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**

D. **DEPRESSED**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**

E. **ANXIOUS**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**

F. **IRRITABLE**

1	2	3	4	5	6	7	8	9
Not at all				**Moderate**				**Extremely**