Implicit Regulation of Emotion: Priming Non-Conscious Reappraisal and Suppression During Stress

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IMPLICIT REGULATION OF EMOTION: PRIMING NON-CONSCIOUS REAPPRAISAL AND SUPPRESSION DURING STRESS

by

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ABSTRACT
IMPLICIT REGULATION OF EMOTION: PRIMING NON-CONSCIOUS REAPPRAISAL AND SUPPRESSION DURING STRESS

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As individuals experience the world, they must also appropriately modulate their responses to fit their environment. The manner in which one regulates their emotion can vary greatly and influence a number of factors, including self-reported affect and respiratory sinus arrhythmia (RSA). The majority of research on emotion regulation examines the deliberate, or explicit, regulation of emotion. However, the automatic or implicit regulation of emotion is an important cognitive process that yields several benefits. Recent research demonstrates benefits of using implicit reappraisal; however, no work has been done to examine other implicit strategies. The current study primed implicit reappraisal and suppression prior to two rounds of a distressing math task. Participants ($N = 65$) rated subjective emotional experience and RSA was recorded at three time points. Results demonstrated a main effect of time for affect, such that affect deteriorated over time. RSA significantly increased during the first round but decreased during the second round of the math task compared to baseline. No significant differences by condition were observed, possibly indicative of comparable implicit regulatory responses by both groups when called to regulate during a lengthy and arduous task. Therefore, more work is needed to examine if various strategies can be primed implicitly, depending on context, and how they may influence functioning.

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Introduction

Emotions greatly influence experience and behavior. Further, the manners in which emotions are regulated direct how they guide behavior (Mauss, Bunge, & Gross, 2007). Previous literature demonstrates that specific emotion regulation strategies can yield a variety of consequences. To date, the majority of this research has centered on understanding the deliberate, or explicit, regulation of emotion. However, in recent years, implicit emotion regulation has come to the forefront as an important cognitive process that yields several benefits when implemented. For instance, implicit emotion regulation can serve as a non-conscious guide for individuals to satisfy goals and regulate emotions more efficiently than explicit regulation (Fitzsimmons, & Bargh, 2004). Preliminary research has supported the benefits of using implicit over explicit emotion regulation. Yet, additional work is needed to more fully understand the effects of implicit emotion regulation. The purpose of this project was to investigate the affective and physiological effects of implicit emotion regulation.

Experiencing and Regulating Emotion

Emotions serve as a vital tool and functional guide in human behavior. When emotional circumstances arise, cognition related to emotion supersedes other cognitive processes to allow attention, memory, and judgment to be focused on the event (Johnson-Laird, & Oatley, 1992). Emotion develops as a result of the perception of stimuli, past experiences, and physiological and phenomenological responses to stimuli (Feldman-Barrett, Mesquita, Ocshner, & Gross, 2007). These components come together to guide and form appropriate reactions to the world around us. As individuals process and experience the world, they must also modulate their responses to fit the environment. Emotion regulation encompasses how individuals experience, manage, and express their emotions (Gross, 1998a). Emotion regulation, similar to emotions themselves, is crucial to functioning and interacting with the environment (for review, see Gross, 2015).

The body of research on emotion regulation strategies is varied and the use of strategies has been examined in many populations and contexts. Although several frameworks have been proposed to conceptualize how individuals regulate their emotions, the *process model* is the most widely used (Gross, 2001; Gross, & John, 2003). The process model distinguishes strategies by when they occur temporally in relation to emotion generation. Strategies that occur before or during emotion generation are antecedent focused, and strategies following emotion generation are response focused. Specifically, antecedent focused strategies occur before emotional and physiological reactions fully develop and influence the emotions that arise. Response focused strategies occur once the emotion has developed and serve to modulate the already occurring emotional and physiological effects of an event. As such, the process model conceptualizes strategies primarily by their temporal development in conjunction to an event.

One highly researched antecedent focused strategy is reappraisal, which involves a cognitive change in interpretation. Specifically, it encompasses reinterpreting the meaning and impression of an experience to change the emotional response. The positive outcomes of reappraisal are demonstrated in a number of studies focused on the emotional, cognitive, and physiological aspects of emotion. Indeed, reappraisal can decrease self-reported negative emotion and increase positive emotion in a number of settings (Demaree, Robinson, Pu, & Allen, 2006; Gross, 1998a). To demonstrate, following an anger induction procedure in which participants received negative feedback, individuals who had higher trait reappraisal reported less anger (Memedovic, Grisham, Denson, Moulds, 2010). Similarly, when viewing aversive photos, participants who were instructed to use reappraisal reported less negative affect over four consecutive in-lab sessions (Denny, & Oschner, 2013). Additionally, reappraisal results in an overall calming of the body as indicated by increased parasympathetic activation, measured by respiratory sinus arrhythmia (RSA), decreased somatic activation, measured by finger temperature and skin conductance (Demaree et al., 2006; Gross, 1998a), and decreased facial expression of negative affect (Ray, McRae, Oschner, & Gross, 2010).

Alternatively, response focused strategies occur once the emotional response is already developed and aim to change the experiential, behavioral or physiological aspects of the emotional reaction. Suppression, a response focused strategy, attempts to inhibit the expression of emotion yet the internal physiology and cognitions are still experienced. Although suppression is typically successful at reducing expressions of negative or positive affect, past literature indicates that suppression tends to have maladaptive effects (Gross, 1998a). For example, trait suppression can lead to increased negative emotion and decreased positive emotion following video clips and daily journaling (Brans, Koval, Verduyn, Lim, & Kuppens, 2013; Gross, 1998a). While suppression is typically conceptualized as inhibiting the expression of emotion, one meta-analysis examined three types of suppression used in studies: suppressing the outward expression of emotion, suppressing the internal experience of emotion and suppressing the thoughts one has about the emotion-eliciting event (Webb, Miles, & Sheerman. 2012). The meta-analysis revealed that while various studies instruct participants to use these multiple forms of suppression, it was only the suppression of emotional expression that demonstrated small to medium effects on emotional outcomes. Suppressing the experience of emotion or thoughts of the event did not reliably change emotional outcomes demonstrating that successful suppression appears to be behavior focused once an emotion has been elicited. Yet, there remain conflicting results in the literature on the relationship between suppression and physiology. Several studies show increased somatic activation as measured by skin conductance, finger temperature, and blood pressure when suppressing (Gross, 1998a; Richards & Gross, 1999). However, others indicate no change in autonomic activation as measured by RSA or heart rate following suppression (Demaree, et al., 2006 Dunn, Billotti, Murphy, & Dagliesh, 2009). Although it may be presumed that suppression has consistent negative physiological consequences, due to the effort required to continually diminish emotional expression, the findings are not consistent.

In addition to differences in emotional and physiological outcomes, reappraisal and suppression appear to have different cognitive loads. Cognitive loads can be examined by assessing other cognitive processes, such as memory, in conjunction with implementation of a specific emotion regulation strategy (Schmeichel, & Tang, 2013). It is assumed that as the cognitive load of one task increases, the efficiency or effectiveness of another cognitive task decreases. As such, reappraisal minimally taxes cognitive resources, in part due to its timing in the emotion generation process. Since reappraisal alters the emotional impact before it is fully developed, it alters the course of the emotional development. Conversely, suppression requires more effort as the individual continually monitors the emotional experience already elicited and suppresses the emotional expressions that continue to surface (Gross, & John, 2003). The difference in the cognitive load of both strategies has been demonstrated by assessing memory. For instance, following instructed use of reappraisal individuals demonstrate no impact to their memory of social information, whereas the use of suppression yields deficits (Richards, & Gross, 2000). Further, individuals are less successful implementing suppression while holding something in working memory (Wenzlaff, & Wegner, 2000). Thus, reappraisal may yield additional benefits beyond emotional and physiological measures, such as less taxation on cognitive resources.

Still, there are situations in which suppression may be an optimal choice and many have reconsidered the idea that strategies can only ever be categorically beneficial or harmful (Bonanno, & Burton, 2013). This is largely occurring through the study of flexible emotional responding (Aldao, Sheppes, & Gross, 2015). For example, Aldao and colleagues (2015) provide an illustration of employing suppression in the workplace when dealing with an annoying coworker as advantageous based on the context of the situation and environment. Additionally, one study required participants to switch between suppression and emotion enhancement, a strategy in which one increases an emotional response, as they viewed distressing images. Participants who were best able to suppress, enhance, and switch between the two strategies had decreased distress between multiple time points (Bonanno, Papa, O'Neill, Westphal, & Coifman, 2004). Contrary to past studies, this same study demonstrated that suppression did not tax cognition via a memory task compared to the enhancement condition. In a study that compared suppression to acceptance when viewing videos of traffic accidents, the authors found that those in the suppression condition experienced less fear but no difference in electrodermal responses and heart rate relative to the control group (Dunn, Billotti, Murphy, & Dagliesh, 2009). Therefore, it appears that suppression can successfully and adaptively regulate emotions depending on the context.

Interestingly, context may matter greatly when examining suppression, and as stated previously, under specific circumstances, suppression may be beneficial. To demonstrate, one study found that individuals in relationships reported greater well-being and increased relationship quality when they suppressed while sacrificing for their partner (Le, & Impett, 2013). In that case, suppression proved beneficial in part due to the circumstances of sacrificing for a partner. Successful suppression also depends on the context and stimuli that participants are told to suppress. Suppression may be most beneficial in situations where it occurs more naturally. For instance, when asked to suppress relatively uncommon stimuli, such as the image of a white bear, participants are not successful. Further, participants who suppressed in response to someone they were uninterested in (i.e., a stimulus they may not often suppress) they were less successful than those who suppressed in response to an ex-romantic partner in whom they still had interest (i.e., a stimulus that they may often suppress; Wenzlaff & Wegner, 2000). This indicates that suppression may be beneficial and advantageous when it occurs in certain scenarios. Although reappraisal is touted as favorable, adding reappraisal when already suppressing while viewing negative movie clips led to no difference in RSA between those using reappraisal than those who were not. This suggests that reappraisal did not provide additional physiological flexibility when suppression was already in use (Demaree, et al., 2006). Together, this research challenges the idea that suppression is always damaging, necessitating future research on the matter.

Emotion Regulation and Physiology

In addition to affecting cognitive and emotional outcomes, emotions influence our physiology. For instance, emotion, among a variety of other factors, affects heart rate. Heart rate is used to inform how the body is reacting to its environment such that a heightened response to stimuli is evident in an increased heart rate. Yet, measuring overall increases in heart rate is too gross a measurement to fully understand how the nervous system is responding; therefore, parsing out components of heart rate can provide a more detailed picture. Heart rate variability (HRV), for example, is one component that is particularly informative when studying the influence of emotion regulation on physiology (Grossman, & Taylor, 2007). HRV measures the variation of peak-to-peak intervals between each heartbeat. The two branches of the autonomic nervous system influence HRV (Grossman & Taylor, 2007). This variability results from both the sympathetic and parasympathetic branches' ability to affect the sinoatrial node, which is responsible for heart rate (Berston et al., 1997). The influence of each branch can be isolated by measuring specific frequency bands of heart rate. For example, sympathetic activation, captured by low frequency HRV (measured from 0.04 to 0.15 Hz), is an indication of physiological arousal (Bernston et al., 1997). Conversely, parasympathetic activation can be measured by high frequency HRV (measured from 0.15-0.40 Hz; Berntson et al., 1997), indicating physiological relaxation. Specifically, the parasympathetic branch slows the heart rate down in an attempt to maintain homeostasis. Given that parasympathetic activation slows heart rate and causes the intervals between beats to increase, this activation also leads HRV to increase (Thayers, Ahs, Fredirikson, Sollers, & Wager, 2012). Therefore, high frequency HRV demonstrates an individual's ability to regulate successfully, by bringing HR back to homeostasis, and serves as a proxy for flexibility in response to arousing stimuli (Berntson et al., 1997; ChuDuc, NguyenPhan, & NgyuyenViet, 2013).

In addition to emotion, respiration also plays an influential role in HRV (Bernston et al, 1997). Respiratory sinus arrhythmia (RSA) is a measure of HRV that accounts for respiration and its influence on the heart. RSA is indicative of regulation since respiration works in conjunction with the parasympathetic nervous system in slowing down the heart during expiration of the breath (Frazier, Strauss & Steinhauer, 2004). Additionally, individuals with higher resting RSA levels show flexibility in switching between regulation techniques and ability to regulate their emotions when needed depending on context (Butler, Wilhelm, & Gross, 2006; Demaree, Robinson, Everhart, & Schmeichel, 2004). Therefore, RSA can be used in studies on regulation to better account for multiple mechanisms' influence on heart rate and as a measure of emotional flexibility.

As previously described, the physiological responses to reappraisal and suppression have been examined in several contexts. With respect to RSA specifically, engaging in reappraisal demonstrated increased RSA when thinking about an interpersonal offense (Witvliet, Knoll, Hinman, & DeYoung, 2010) or when viewing an anger inducing video (Denson, Grisham, & Moulds, 2011). However, those who viewed the same anger inducing video while suppressing had no change in RSA (Denson et al., 2011). In another study, both suppression and reappraisal showed increases in RSA when discussing an upsetting video with another person. Yet, reappraisal yielded less negative emotional experience during the discussion (Butler et al., 2006). Taken together, these studies suggest that reappraisal yields greater RSA than suppression as well as less negative emotional responding. As for suppression, although there is some inconsistency in results, a review of experimental studies found that suppression typically results in decreased HRV in conjunction with negative emotional experience (Cutili, 2014). Thus, while there are physiological benefits of implementing reappraisal, there is less certainty about the physiological effects of suppression.

Explicit and Implicit Emotion Regulation

As demonstrated in the aforementioned literature, to examine emotion regulation strategies and their effects, explicit training in emotion regulation strategies and in-lab distressing tasks are often employed. Explicit emotion regulation occurs when regulation is a conscious effort, and individuals are actively aware of the need to modify their emotions. Therefore, typically in experimental studies, participants are trained to employ specific emotion regulation strategies in response to an emotion-eliciting event. This process makes emotion regulation conscious to participants; however, outside of the laboratory, emotion regulation often occurs non-consciously, or implicitly, which has largely yet to be explored (Bargh, & Williams, 2006**;** Koole, & Rothermund, 2011; Koole, Webb, & Sheeran, 2015).

By circumventing explicit emotion regulation, researchers can access a process of emotion regulation that is a common form of daily regulation. Despite the challenge of examining a non-conscious process, it is worthwhile to understand how regulation is initiated in many everyday situations. Implicit emotion regulation, or automatic regulation, encompasses accessing non-conscious cognitive processes that automatically modify an emotional trajectory (Mauss et al., 2007). Specifically, the goals of implicit emotion regulation are to moderate emotional experience and elicit regulation when emotional reactions deviate from what is a desired response (Koole & Rothermund, 2011; Koole et al., 2015). Further, the nature of implicit emotion regulation suggests that there may be several benefits of its implementation. For instance, the repetitive use of various strategies leads to the development of default patterns of regulation in a variety of settings. As individuals rely on mental representations of past experiences and successfully achieve emotion regulation through specific techniques, their regulation becomes implicit and efficient. For instance, when given negative feedback in front of peers, one may automatically inhibit the negative affect that such comments elicit. By relying on natural or automatic regulation, the individual can continue to be engaged in the conversation without diverting resources to consciously regulate their behavior. The goals of regulation are determined by mental representations of similar experiences that inform individuals on how to achieve the activated goal (Bargh, & Williams, 2006).In contrast, explicit emotion regulation relies on the current situation to provide context for conscious consideration of the individual's thoughts and environment. Therefore, deliberate regulation leads to slower processing than automatic regulation as a result of the additional factors that are incorporated into regulation (Bargh, & Williams, 2013).

Moreover, Bargh and Williams (2013) proposed that using implicit emotion regulation leads to greater flexibility in emotional responses and more efficient regulation. Research also suggests that this flexibility allows for greater coping in response to stressful events (Mauss et al, 2007). As an automatic cognitive process, implicit emotion regulation may also require less cognitive effort and fewer resources (Bargh, & Thein, 1985; Dijksterhuis, Bos, Nordgren, & van Baaren, 2006). Considering the various positive outcomes of using implicit regulation, several studies have examined automatic emotion regulation in greater depth. Initially, this was through self-report questionnaires, such as the Emotion Regulation Questionnaire (ERQ; John, & Gross, 2002) that target individuals' trait emotion regulation techniques rather than trained emotion regulation use. However, other studies have used repeated practice of explicit training methods to eventually elicit implicit emotion regulation. Through repetitive use of reappraisal, researchers found that with explicit practice, participants' implicit reappraisal abilities improved and demonstrated increased HRV, which was attributed to the automatic use of reappraisal (Christou-Champi, Farrow, & Webb, 2014). Even so, these methods do not successfully measure unconscious regulation that occurs naturally without deliberate training.

Within the past decade, researchers have begun to use cognitive strategies to induce automatic emotion regulation (Macleod, & Bucks, 2011), such as priming a specific regulation technique (Koole, & Rothermund, 2011). Priming itself has been effective at inducing emotion and subsequent emotional responses to video clips (Quirin et al., 2011). Furthermore, priming can influence the interpretation of stimuli (Gordon, Chesney, & Reiter, 2016). Given that priming techniques have been effective at inducing specific affective responses, it is plausible that these techniques may be effective at priming specific emotion regulation strategies.

One form of priming is cognitive bias modification. This method can serve to prime several cognitive processes, including attention, memory, and the interpretation of ambiguity. Specifically, cognitive bias modification is used to alter negative threat biases, or the tendency to interpret ambiguous stimuli as threatening, through implicit training, or priming individuals, to attend to positive stimuli over negative stimuli (Macleod, &

Bucks, 2011). Negative threat bias is often seen in individuals with anxiety who tend to maintain a consistent negative interpretation of their environment. However, this can be seen in non-clinical samples when primed to feel anger beforehand (Gordon, Chesney, & Reiter, 2016). As such, understanding the patterns of how individuals interpret their daily environment and regulate their emotions is informative of functioning.

As a result of these interpretation patterns, cognitive bias modification has the ability to correct the cognitive tendency to interpret situations negatively by implicitly training individuals to attend to stimuli in a more adaptive manner. These methods are ideal for implicit emotion regulation use because, similar to threat bias, default patterns of regulation occur naturally as a response toward ambiguous stimuli. There are several ways to modify participants' interpretational tendencies. Methods include reading and completing stories with a positive or negative word, or unscrambling words to form a priming sentence. These tasks tend to be more successful than other cognitive bias methods primarily because participants are required to exert more cognitive effort: it is not simply attending to stimuli, but responding with an appropriate answer (Hallion, & Ruscio, 2011). Multiple interpretation methods, such as those previously mentioned, demonstrate effective results with participants responding to stimuli consistent with the priming condition. Furthermore, in a sample of individuals with anxiety, training reduced negative thoughts and threatening interpretations of stimuli (Hertel, & Mathews, 2011). Overall, in a meta-analysis conducted by Hallion and Ruscio (2011), interpretation methods had a greater effect on modifying cognitive bias as compared to attention training methods. The interpretation method is a successful and proactive approach and is the sole focus of the remainder of the study.

This method presents an ideal manner for targeting and modifying emotion regulation, since implicit emotion regulation strategies can be primed and elicited during an event (Krebs, Hirsch, & Mathews, 2010). Considering the cognitive nature of reappraisal, as well as its occurrence early on in an emotional situation, priming reappraisal has been a successful first step in studying implicit emotion regulation. Currently, it is unclear if other emotion regulation strategies would yield comparable results from priming due to the variability in how they modify emotion. For instance, reappraisal utilizes cognitions to change the interpretation of the event whereas suppression regulates the expression of emotion without necessarily altering cognitions. Although less cognitively oriented, it is possible that suppression could be successfully primed, particularly in a social context that requires an individual to maintain composure (Aldao, et al., 2015). To date, only three studies implemented these priming methods with regulation, one of which primed emotion control and two that primed reappraisal (Mauss et al., 2006; Williams, Bargh, & Nocera, 2009; Yuan, Liu, & Yang, 2014).

The first study to adapt cognitive bias modification priming to elicit a form of emotion regulation was conducted by Mauss and colleagues (2006). The authors used a sentence unscramble task, to prime either emotional expression or emotional control to access either expression or restraint of emotions. Although emotional control is broad in description, it shares a goal with suppression to inhibit emotions before they reach the surface. Subsequently, individuals typically express less self-reported negative emotions, such as anger, when asked to suppress (Gross, 1998a). In their study, following a frustrating counting task, participants primed to use emotional control reported less anger and negative emotion than the emotional expression group, indicating promise in this priming method for suppression.

Williams and colleagues (2009) used similar methods but primed reappraisal, rather than emotional control. The authors used the sentence unscrambling task to prime implicit reappraisal and compared it to explicit reappraisal and a control group. For the implicit reappraisal condition, sentences included words such as “reassessed” or “perspective” to elicit reappraisal use. Following the unscrambling task, stress was induced by having participants create and present a speech. Comparing the three conditions, the authors found that implicit and explicit reappraisal yielded less heart rate reactivity, indicating less emotional arousal, than the control group. Additionally, trait reappraisal use was examined to determine if explicit or implicit priming yielded different results in individuals who are high or low reappraisers. There were no significant physiological differences for high reappraisers in either condition. This indicates that the conscious and non-conscious elicitation of reappraisal in individuals who already use reappraisal naturally produced the same effect. However, low reappraisers in the implicit priming group had less physiological reactivity then those in the explicit group. This demonstrates possible benefits such as more adaptive physiological responding when regulation training is implicit rather than explicit.

Similarly, Yuan and colleagues (2014) utilized a sentence unscrambling task to prime implicit reappraisal in comparison to explicit reappraisal and a control group during a frustrating counting task. Similar to Williams and colleagues (2009), both the explicit and implicit reappraisal groups experienced less heart rate reactivity than the control group. Notably, the explicit reappraisal group reported the lowest levels of subjective negative emotion as measured by the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegan, 1988). The studies conducted by Williams and colleagues and Yuan and colleagues provide evidence that priming implicit reappraisal yields comparable physiological responding to explicit reappraisal demonstrating both are beneficial in lab settings. Interestingly, when assessing self-reported emotions, explicit reappraisal appears to show greater benefits. This could possibly be due to the explicit nature of such an assessment measure and possible demand characteristics whereas physiology in these studies is unable to be manipulated consciously. However, considering that implicit regulation occurs more often in everyday life, establishing its benefits remains valuable.

Overall, these studies developed foundational methods and initial support of the ability to elicit specific emotion regulation strategies implicitly. Initial results indicate that implicit priming of reappraisal yields at least comparable physiology to explicit reappraisal during distressing tasks. Further, there is promise of training individuals to use strategies that they may not typically employ, as indicated by the low reappraisers showing more adaptive physiological responding when implicitly primed compared to explicit methods (Williams et al., 2009). Nevertheless, these studies use only one strategy, reappraisal, and subjective emotional experience measures yield inconsistent results compared to physiology. Although initial success is evident, this pattern could be due to the cognitive nature of reappraisal and cognitive bias methods enhancing its goals. It is has yet to be determined if these priming methods are successful at inducing strategies such as suppression that focus on expressive regulation. Therefore, determining if priming techniques are successful beyond reappraisal is essential.

If successful, employing implicit regulation holds the promise of circumventing problematic methods of explicit regulation and can enhance our understanding of the typical or daily regulatory responses. (Macleod, & Bucks, 2011). One of the most significant limitations of studies on explicit emotion regulation is the assumption that making emotion regulation conscious to the individual signifies that they are actually using those methods, whether through training or questionnaires. While these methods can succumb to the possibility of demand characteristics, priming will hopefully circumvent this limitation, by eliciting an automatic response that is elicited without direct instruction or assessed retrospectively through self-report measures. Furthermore, the potential to then adopt these methods to guide and modify individuals' emotion regulation tendencies would be groundbreaking. Examining the influence of priming other strategies is the first step in order to increase the validity and generalizability of emotion regulation priming.

Current Study

The current study used a sentence unscrambling task to prime two emotion regulation strategies (reappraisal and suppression; Hallion, & Ruscio, 2011). Since regulation is most effectively measured during moments of distress, two rounds of the Paced Auditory Serial Addition Task (PASAT; Gronwall & Sampson, 1974) were used to induce distress. Despite its original function in cognitive assessment, several studies have established the usefulness of the PASAT as a distressing task for emotion regulation research (Feldner, Leen-Feldner, Zvolensky, & Lujuez, 2004; Leen-Feldner, Zvolensky, Feldner, Lejuez, 2004). The study expanded on the implicit emotion regulation research by investigating whether additional emotion regulation strategies beyond reappraisal can be successfully primed through these methods. Reappraisal and suppression were primed to compare the previous success of reappraisal as well as further evaluate the effects of suppression. To our knowledge, no studies have examined more than one implicitly primed emotion regulation strategy and none have primed suppression.

Based on past research investigating the effect of emotion regulation on feelings of distress we hypothesized the following regarding emotional and physiological responses:

1. Positive affect would decrease following each round of the PASAT. Additionally, we expected an interaction such that those in the suppression condition would have a larger decrease than those in the reappraisal condition. Conversely, negative affect would increase over time and those in the reappraisal condition would report less of an increase as compared to those in the suppression condition.

2. RSA would increase for both the reappraisal and suppression conditions following the first round of the PASAT, demonstrating their effectiveness as regulation strategies. In the second round, participants in the reappraisal condition would maintain an increased RSA but those in the suppression condition would yield a decrease in RSA. This is expected because, although suppression can be beneficial in physiological reactivity in certain contexts, as the difficulty and duration of the PASAT increases, its limits as a successful strategy will be demonstrated.

Method

Participants

Participants (*N* = 65) were recruited from psychology courses at a Midwestern, Jesuit university and received partial course credit for their participation. Sample size was determined using the effect sizes of previous studies, which ranged from small to medium effects (partial η^2 = .14 -.35; Williams & Bargh, 2009; Yuan et al. 2014). The analysis that required the largest sample is the 2 (Condition) X 3 (Time) ANOVA examining RSA. A power analysis (G*power; Faul, Erdfelder, Lang, & Buchner, 2007; with power = 0.80, and α = 0.05) using these parameters suggested a sample size of 56 participants. The sample primarily consisted of White/European American undergraduates (66.3%), followed by Asian (14.1%) and African Americans (10.9%). The sample ranged in ages from 18-24 (*M* = 19.14, *SD* = 1.25). Table 1 indicates the means, standard deviations and range for the following self-report questionnaires. The sample reported moderate levels of reappraisal on and minimal levels of suppression. The sample showed relatively little psychopathology with most participants endorsing only mild anxiety symptoms and depressive symptoms. As such, they were not utilized as additional covariates. Anxiety and depressive symptoms were not significantly different between groups; as such, they were not utilized in further analyses.

Materials

Priming Stimuli. Participants completed a sentence unscrambling task which included 10 sentences that prime an emotion regulation strategy and five neutral sentences. Stimuli were initially developed using previous studies that primed reappraisal as a model (Williams & Bargh, 2009; Yuan et al., 2014). The five neutral sentences were taken from Mauss and colleagues (2007). These stimuli were further developed such that one sentence stem could prime both reappraisal and suppression. For example, the sentence stem "He ____ his judgment" would be unscrambled using the word reassessed in the reappraisal condition ("He *reassessed* his judgment") and concealed in the suppression condition ("He *concealed* his judgment"). Following development, stimuli were normed using an undergraduate sample (N = 148). Fifty-three students rated the priming words on their relatedness to suppression and reappraisal, how understandable, and how familiar participants were with the word. Sentences were rated by 52 students to determine difficulty of unscrambling and 43 students determined how well the word primes fit within the sentence. To select the final set of stimuli, sentences were excluded if more than 15% of participants incorrectly unscrambled the sentence. Sentence selection was finalized by balancing relatedness across conditions, which was determined through examining differences in an independent sample t-test. There were no significant differences on mean (*SD*) word relatedness for suppression (2.67±.56) or reappraisal (2.36±.34), t = 1.56, p = .14.

Paced Auditory Serial Addition Task (PASAT). The PASAT (Gronwall, & Sampson, 1974) is a serial addition task originally used as an assessment measure of attention in samples with cognitive deficits such as traumatic brain injury or multiple sclerosis. The PASAT involves listening to a string of numbers and adding each subsequent number to the number heard prior. The PASAT can vary in difficulty through the inter-stimulus interval, which typically ranges from 1.6 – 3.0 seconds. Although the PASAT was originally developed to measure cognitive abilities, it has been used to induce stress in studies examining emotion regulation due to the challenging nature of the PASAT even when the stimuli are presented with a greater inter-stimulus-interval. Indeed, research supports the PASAT as an important component toward measuring emotion regulation (Holdwich, & Wingenfeld, 1999; Lejuez, Kahler, & Brown, 2003; Leyro, Zvolensky, & Bernstein, 2010). Holdwick and Wingenfeld (1999) found that the PASAT is successful at inducing a negative mood. Additionally, it increases physiological arousal in a lab setting (Lejuez et al., 2003). Overall, several studies and reviews have found the PASAT to be a successful in-lab stressor with both inducing negative mood and physiological arousal (Holdwick, & Wingenfeld, 1999; Lejuez et al., 2003; Leyro et al., 2010).

Physiological recording. Respiratory sinus arrhythmia was recorded using physiological recording equipment, Biopac ® 4.4, a noninvasive method of measuring heart rate. Three self-adhering electrodes were applied in a standard three lead configuration: one below the heart on the left ribcage, one on the right collarbone, and one on the right ribcage. This system measured continuous heart rate at a sampling rate of 1000 throughout the study. RSA was analyzed using Acqknowledge and Kubios software with a low correction applied to the data. RSA is reported in normalized units (HF [ms^2]/(total power [ms^2] − VLF [ms^2]) in order to reduce the large between subjects variability often seen in HRV analyses (Burr, 2007).

Procedure

Upon arrival, all participants were taken through the informed consent process where the purpose, length of study, expectations and risks were explained. Once participants gave their written consent, they were randomly assigned to one of the two conditions: implicit reappraisal, or implicit suppression.

To begin, all participants were connected to the physiological recording equipment. Following set-up, the research assistant ensured that the heart rate recording looked appropriate and began a 90-second baseline measure of heart rate. Next, participants were placed in front of a computer with E*Prime (Psychology Software Tools, Inc., 2013) for the presentation of the stimuli. To start, participants completed emotion ratings. Emotions ratings were collected using 10 cm visual analogue scale (VAS), anchored with 0 (*not at all*) and 10 (*extremely*). Nine emotion ratings were presented: Aggressive, Angry, Annoyed, Anxious, Aroused, Cheerful, Excited, Happy, and Joy.

Following baseline measures, participants completed a task based on their assigned condition: implicit reappraisal, or implicit suppression. Participants completed a sentence unscramble task that primed words related to the specific emotion regulation technique. The emotion regulation sentences incorporated words related to suppression and reappraisal, such as “contained” and “evaluated,” respectively.

Participants then completed the PASAT (Gronwall, & Sampson, 1974). Participants were first instructed on how to perform the PASAT and given a practice round of a string of 11 digits to ensure comprehension. Following the practice trial, participants completed two 90-second trials; the first (PASAT 1) with the stimuli presented 3 seconds apart and the second (PASAT 2) presented 2 seconds apart. To induce social evaluative stress, throughout the task the researcher provided feedback on the participant’s performance with phrases such as “try harder” and noted when the participant made errors. Throughout the PASAT trials, continuous heart rate was collected and emotion ratings were completed immediately after each round of the PASAT. After the PASAT, the participants completed questionnaires on their typical use of emotion regulation. To conclude the study, participants were debriefed.

Results

Statistical analyses were conducted using SPSS 22.0 (IBM Corp., 2013) with an alpha level of .05. For any post hoc comparisons, the Bonferonni corrections were applied to control for multiple comparisons. In analyses where sphericity was violated the Greenhouse-Giesser correction was used.

Descriptive Analyses

The range of incorrect responses for the first round of the PASAT was 0 to 16 ($M = 5.08$, $SD = 4.30$) and for the second round was 4 to 31 ($M = 15.40$, $SD = 5.43$). Participants who missed more than three trials in a row were told to "jump back in," which occurred a maximum of three times in either trial. Baseline emotion ratings ranged from .00 to 10. For analyses of emotion ratings, positive and negative affect descriptors were summed to form composite positive and negative affect scores for each time point, with a maximum score of 40 for each composite indicating greater endorsement of emotion. Figures 1 and 2 illustrate composite emotion ratings across time; for baseline emotion ratings, participants showed moderately positive emotion but little negative emotion.

Emotion Ratings

To test the first hypothesis, two 2 (Condition) X 3 (Time) ANOVAs were conducted to assess change in emotion ratings. Figures 1 and 2 illustrate the main effects of time for positive and negative affect, respectively [positive: $F(1.60,118) = 53.04$, $p < .001$, partial $\eta^2 = .47$, power = 1.0; negative: $F(1.71,120) = 53.88$, $p < .001$, partial $\eta^2 =$

.47, power = 1.0]. Post hoc analyses demonstrate that all three time points were significantly different from one another for both positive and negative emotion. Mean (*SD*) positive emotion decreased progressively from baseline (23.60±6.80) to PASAT 1 (17.33±8.05) to PASAT 2 (15.34±8.34). For negative emotion, mean (*SD*) ratings increased progressively from baseline (5.86±6.21) to PASAT 1 (11.50±8.52) to PASAT 2 (16.66±9.83). There was no main effect of condition or significant interaction of condition by time.

Physiological Ratings

To test the second hypothesis, a 2 (Condition) X 3 (Time) ANOVA assessed if there were significant differences between baseline, PASAT 1 and PASAT 2 RSA by condition. Figure 3 illustrates the main effect of time [$F(2,110) = 1032.60$, $p =. 008$, partial $\eta^2 =.084$, power=.807]. Post hoc analyses reveal a significant difference between RSA during the first and second rounds of the PASAT; however, neither PASAT round was significantly different from baseline. Specifically, mean (*SD*) RSA showed an increase from baseline (40.43±22.73) to the first round of the PASAT (42.46±17.44) but a decrease in round two (34.26±16.98). There was no main effect of condition or significant interaction of condition by time.

Discussion

The purpose of the current study was to examine if two different emotion regulation strategies could be implicitly primed and subsequently influence affect and emotion regulation measured via RSA during a stress induction task (i.e. PASAT). As such, hypothesis one was partially supported, such that the distressing task was successful at inducing negative affect and reducing positive affect. However, the implicitly primed regulation strategies did not differentially influence rating of affect. Hypothesis two was also partially supported, such that RSA increased during the first round of the PASAT yet decreased during the second round. The task successfully elicited physiological arousal, indicative of regulation, during the first round; however, during the second round of the task there was blunted regulation when difficulty and duration of the task increased. This was contrary to the expectation that those in the reappraisal condition would be able to sustain regulatory abilities throughout such a task. Notably, despite the empirically based hypotheses, there were no significant differences in affect or RSA between the primed emotion regulation strategies.

It is difficult to determine whether these findings are entirely inconsistent with previous studies. The two studies on which this study was modeled did not compare specific implicit strategies to one another as was done here. In those studies, implicit and explicit strategies showed comparable heart rate reactivity (Williams, 2009; yuan 2014). It is possible that they very act of regulating improves HRV regardless of whether it is implicit or explicit. For instance, in an examination of explicit instructions to regulate compared to instructions to enhance emotions and no instructions at all, Webb and colleagues (2012) found the smallest effects of regulation were produced when comparing explicit regulation to no instructions. This was thought to be due to the fact that participants were naturally regulating despite receiving no prompts. If, for previous studies, small effects are found when comparing explicit regulation to a control of natural regulation, the current study may have experienced smaller than anticipated effects since both conditions were implicitly primed. It would follow that RSA would be similar between implicit suppression and reappraisal in the current study.

Furthermore, different methodologies of studying emotion regulation can lead to varying effect sizes. For instance, both duration of regulation and number of trials can influence overall effect. Indeed, greater effects of regulation are observed when multiple trials were conducted (Webb, et al., 2012). This is likely due to the practice effects in regulating during a frustrating task. This is notable because Yuan and colleagues (2014) employed 20 trials of a challenging counting task. Whereas the current study had two trials, the difficulty of the task increased during the second trial yet the trials of the counting task from the previous study were consistently rated as “moderately difficult.” Additionally, the length of each task requiring regulation can influence successful regulation. In their meta-analysis on emotion regulation strategies, Augustine and Hemenover (2009) found that the shorter the duration of the regulation period, the more effective the regulation. Therefore, whereas multiple trials may lead to practice effects, the longer durations of each trial leads to decreased overall effects. This suggests that as individuals need to regulate for longer periods of time, they are less successful at regulating their emotion.

Another, key difference between the previous studies and the current one is the distressing task. While the current study utilized the PASAT, a validated induction procedure, it may have induced more intense emotion and required more cognitive effort than either of the previous implicit emotion induction techniques. Indeed, across all participants affect was negatively impacted by the PASAT. These findings are consistent with previous literature demonstrating that the PASAT is a successful mood induction task that further increased physiological arousal (Holdwich, & Wingenfeld, 1999; Lejuez, Kahler, & Brown, 2003; Leyro, Zvolensky, & Bernstein, 2010). However, it is possible that the task may have been overly distressing and mentally taxing. For instance, in a review of the PASAT, Tombaugh (2006) found that although the PASAT is a successful measurement of cognitive functioning, its reliance on processing speed, language abilities, sufficient mathematical abilities, and sustained attention makes the task unduly anxiety provoking. While we chose to use the PASAT as a stressor, the complexity of the task may have elicited higher arousal and negative affect due to its demands.

Indeed, the intensity of emotion is a nuanced moderator on the effectiveness of emotion regulation (Webb et al., 2012). For instance, Webb and colleagues (2012) found that the type of mood induction procedure used to elicit an emotion that was later regulated mattered. For example, the authors found that while images and film clips produce larger effects on regulation, feedback failure, or being given feedback that the participant was inadequate, produced smaller effects. Smaller effects of feedback failure could be, in part, due to the intensity of the experienced emotion as well as the personal relevance of such emotion. The authors speculated that both of these factors might make the emotion too intense to regulate. The PASAT was selected as the stress induction procedure to replicate and extend the previous implicit priming paradigm's use of a challenging math task (Yuan, et al., 2014.) However, in the current study, the PASAT was both cognitively stressful due to the challenging math task and socially stressful due to the discouraging feedback from the research assistant. It is possible that the task may have been overly distressing and mentally taxing due to its reliance on processing speed, verbal abilities, mathematical abilities, and sustained attention (Tombaugh, 2006). As such, the mood induction task may have shifted from one that may elicit effective regulation to a task that elicited unduly intense emotion that was challenging to regulate in the laboratory environment.

There is evidence to support this finding given the initial increase in RSA and subsequent decrease during the second round of the PASAT. While increased RSA can be indicative of successful regulation, depending on the task, it could be influenced by other factors. (Berston, et al. 1997; Grossman, & Taylor, 2007.) Specifically, whereas high RSA is suggestive of greater regulation, low RSA can be indicative of greater cognitive effort being elicited in tasks that require working memory or heavier workloads. Hjorstkov and colleagues (2004) examined the effect of increasing workload and working memory on high frequency HRV. The authors found that though participants self-reported stress levels did not change when the task was more challenging, high frequency HRV decreased. Similarly, in an integrative review of executive functioning, neuroimaging and HRV, Ryu and Myung (2005) examined the interaction of baseline HRV and cognitive workload. It appeared that individuals with low baseline HRV performed worse in tasks that required greater working memory than those with high baseline HRV. However, this was not found for tasks that had less workload. Again, it is possible that for the current study the cognitive effort and workload of the second round of the PASAT superseded any emotion regulation that occurred. A necessary increase in effort and greater requirement of working memory during the second round could explain the decrease in RSA across both conditions.

In conjunction with the distressing task eliciting unduly intense emotions, it is possible that the strength of the sentence unscrambling task may have been minimal. As such, this may have resulted in two possible outcomes. First, the implicit strategies demonstrated comparably small effects in response to a demanding and distressing task. Second, the priming manipulation may not have elicited the desired implicit strategy leading participants to utilize their own natural and preferred strategies for regulation. As such, given the nature of implicit regulation, it is difficult to understand the internal processes that occurred while participants underwent the distressing task.

Limitations

Therefore, while this study was the first of its kind to compare multiple implicit strategies there were some methodological limitations. To start, the current study used two priming conditions to serve as comparison groups. This is a common practice in previous literature (Webb et al., 2012); however, the lack of a non-experimental control group is a limitation. Without a control there is no manner to assess how simply priming may yield differences compared to no prompt. Further, given that previous literature suggests that when given no explicit prompt individuals tend to regulate naturally, assessing implicit priming methods to a no-prompt control group could yield informative results and allow us to further delineate if participants in the priming conditions are truly utilizing the primed strategy. Although the results from previous studies suggest that priming can elicit a specific strategy, it is difficult to know if individuals are engaging in a particular strategy. Further, given that implicit regulation, similar to other cognitive tasks, relies on default patterns to guide individuals to a desired response, participants could simply be primed to use whatever strategy has worked in the past (Koole & Rothermund, 2011; Koole et al., 2015.)

A final limitation to the study was the use of RSA and further assumption that RSA is associated to regulation. As previously mentioned, due to the challenging nature of the PASAT and the increase in difficulty from round 1 to round 2, RSA may have not been the ideal physiological measurement and indicative of both regulation and working memory demands. Further, due to the limitations of the PASAT and the implicit nature of the priming task, it is difficult to parse apart the cause of the resulting RSA measurements. While successful regulation is associated with increased RSA, greater cognitive load is associated with decreased RSA, muddying the ability to interpret results and suggesting that these two systems were likely working against each other.

Future Directions and Implications

As such, there are several proposed directions for future research on implicit regulation. While it appears that cognitive bias modification can successfully prime implicit reappraisal, it remains uncertain if these methods can successfully prime other strategies. Future work should consider both priming new strategies, such as suppression, and incorporating both explicit strategies and control groups into their studies. Furthermore, it would be worthwhile to consider implicitly priming more cognitive strategies, such as acceptance, compared to suppression, which works primarily on the expression of emotion.

Additionally, given the methodological concerns of the current study, future work should consider using mood induction paradigms that require less cognitive load and present fewer confounding cognitive processes. The PASAT, though clearly a successful mood induction paradigm, may have been overly demanding on several cognitive processes including working memory, regulation and processing speed. Considering that the assessment of implicit regulation is in its infancy, establishing the effectiveness of the priming methods should be the primary goal. As such, using mood inductions with fewer confounding effects is an important first step. However, once established, it would be important to assess the effectiveness of these priming methods in various settings, including ones that demand more effort or invoke multiple cognitive processes.

Again, considering the infancy of this research, future work should consider the use of multiple physiological measures to assess regulation. Given the impact of regulation on subjective emotional and psychological experiences along with physiological experiences, it is important to incorporate multiple assessments of regulation. Heart rate and its derivatives, HRV and RSA, though clearly associated with emotion regulation, are tied to multiple systems including sympathetic and parasympathetic activation. Though previous literature has managed to isolate particular aspects of HRV and RSA to draw conclusions about regulation, additional physiological measures can provide supplementary evidence of successful emotion regulation.

The current study sought to extend our knowledge of the largely unexamined world of implicit emotion regulation. Although implicit regulation is thought to be a vital cognitive process and important to adaptive functioning, little work has been conducted to study implicit regulation in response to distress. Cognitive bias modification appears to be a useful first step in eliciting implicit regulation in order to study how it affects responses to various tasks. Further, while we are only just beginning to attempt to manipulate implicit regulation, the strategies that individuals use to regulation nonconsiously are rooted in adaptive and efficient patterns. As such, it will likely be challenging work to determine whether we are accessing specific strategies or ones that are programed to respond to specific settings. Though the current study failed to observe differences in priming two implicit strategies, there remains promise of assessing implicit regulation in the future. Furthermore, this study highlighted the importance of considering the overall demands we place on the brain as a system. Indeed, this system is both efficient and complex, with regions interacting and affecting multiple systems at once. As such, it is vital to acknowledge the multiple cognitive processes that can interact and subsequently influence implicit emotion regulation. With that, we can move forward and continue the exploration of this vital process.

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Table 1.

Descriptive Statistics on Emotion Regulation and Psychopathology Questionnaires (N=65)

	M	*SD*	Range
Emotion regulation questionnaire (ERQ)			
Cognitive reappraisal	29.60	6.27	6 – 42
Expressive suppression	14.85	4.62	4 – 28
Beck Anxiety Inventory (BAI)	7.75	8.05	0 – 63
Beck Depression Inventory (BDI)	7.18	6.99	0 – 63

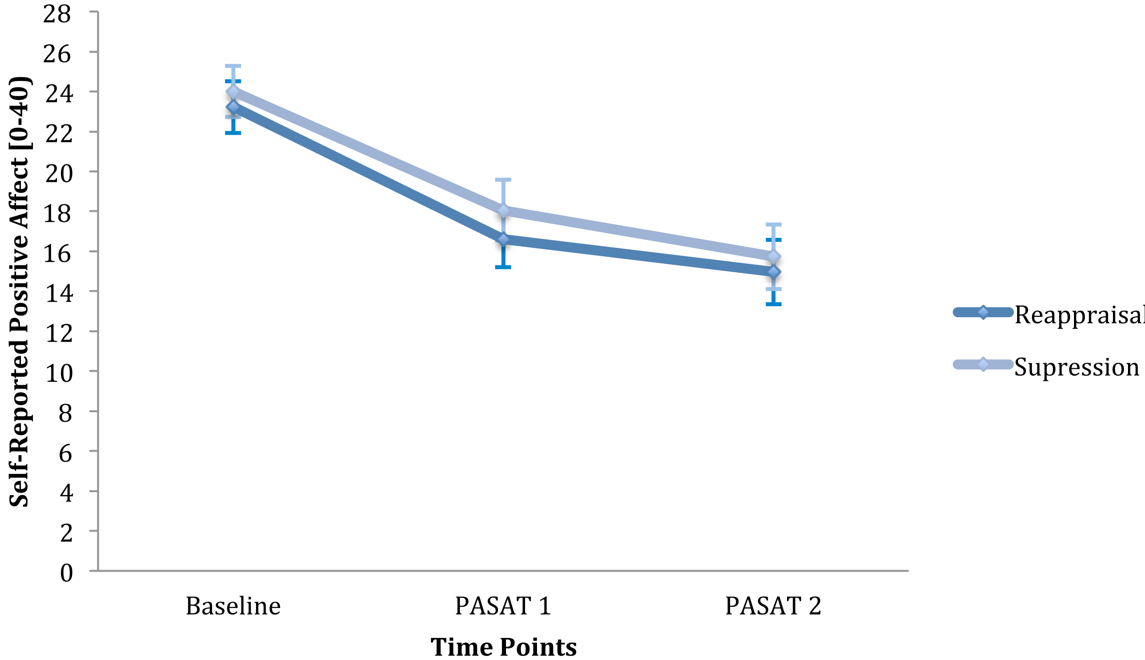

Figure 1. Composite positive affect scores across three time points. This figure illustrates mean self-reported composite positive affect scores for participants at baseline, and following the first and second rounds of the PASAT. The scores are presented by the two conditions: reappraisal and suppression. Results showed a main effect of time.

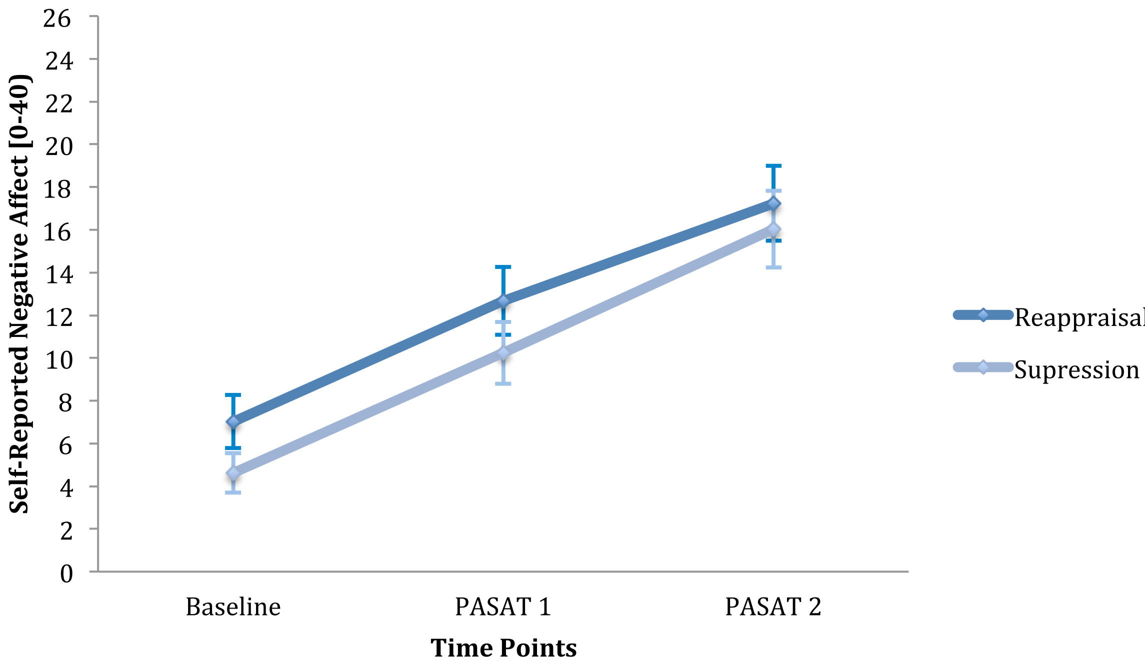

Figure 2. Composite negative affect scores across three time points. This figure illustrates mean self-reported composite negative affect scores for participants at baseline, and following the first and second rounds of the PASAT. The scores are presented by the two conditions: reappraisal and suppression. Results showed a main effect of time.

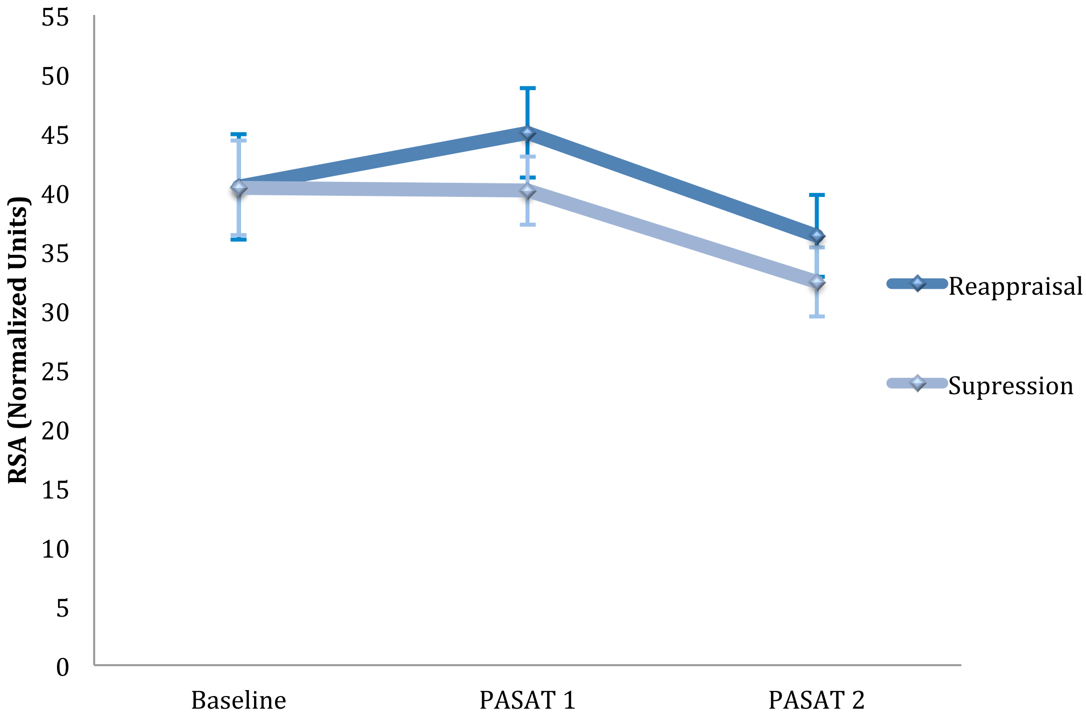

Figure 3. Mean respiratory sinus arrhythmia across time points. This figure illustrates mean respiratory sinus arrhythmia in normalized units for participants at baseline, and following the first and second rounds of the PASAT. The scores are presented by the two conditions: reappraisal and suppression. Results showed a main effect of time.