THE ATTENTIONAL DEMANDS OF POSITIVE REAPPRASIAL IN A DUAL-TASK PARADIGM

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IN A DUAL-TASK PARADIGM

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ABSTRACT

Emotion regulation refers to the ability to modulate experienced and expressed emotions. A specific emotion regulation strategy, cognitive reappraisal, has received extensive attention in the literature, as the strategy is widely viewed as adaptive. Cognitive reappraisal effectively alters emotional experiences through a processes of reinterpreting a stimulus, situation or event before an emotion has been fully generated. By changing the meaning of a situation before an emotion fully develops, individuals have the potential to alter the extent to which they feel certain emotions. This strategy has been associated with a wide array of beneficial health and psychological outcomes, and is also used in treating different forms of psychopathology. Despite extensive evidence documenting the effectiveness of cognitive reappraisal, researchers have recently investigated potential negative outcomes associated with this strategy. Notably, researchers have demonstrated that cognitive reappraisal requires attention, and that the attentional demands required to use this strategy can impact performance in other areas. The present study sought to expand on these findings by examining an understudied type of cognitive reappraisal: positive cognitive reappraisal. Furthermore, the present study examined how the attentional demands associated with positive cognitive reappraisal change while the strategy is being implemented as opposed to after implementation. These goals were accomplished by having participants view unpleasant and neutral images, and positively reappraise a subset of unpleasant images while performing a concurrent reaction-time (RT) task, with stimuli for the RT task presented at pseudo-random SOAs during image presentation. Results revealed greater RT during the positive reappraisal condition compared to the negative image viewing condition, and this difference changed depending on when the RT stimuli were presented. A final exploratory question examined the extent to which self-reported worry might interfere with task performance, with results revealing no impact of worry on the pattern of RT observed across conditions. The results of this study demonstrated that engaging in positive cognitive reappraisal can interfere with the ability to respond to other environmental stimuli, suggesting the strategy requires attentional resources, and that the attentional resources required to use the strategy change during the regulatory process.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the College of Arts and Sciences, have examined a thesis titled "The Attentional Demands of Positive Reappraisal in a Dual-Task Paradigm," presented by Andrew David Wiese, candidate for the Master of Arts degree, and certify that in their opinion it is worthy of acceptance.

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LIST OF ABBREVIATIONS

Auditory Discrimination Task = ADT

Attention Bias Modification = ABM

Electroencephalogram = EEG

Electromyography = EMG

Electrooculogram = EOG

Event Related Potentials = ERPs

Inter-Trial Interval = ITI

Intolerance of Uncertainty = IU

Late Positive Potential = LPP

Reaction Time = RT

Serial Response = SR

Stimulus Preceding Negativity = SPN

Stimulus Onset Asynchrony = SOA

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CHAPTER 1

INTRODUCTION

Emotion research has existed as a formal science since the late nineteenth century, with Charles Darwin suggesting that emotions serve as information about an individual's wellbeing, and that emotions can result in behaviors to better promote wellbeing (1872). Contrary to Darwin, both William James and Carl Lange independently suggested that emotions arise as the automatic, end-result of stimulus perception, which is then followed by physiologic responses. More contemporary theories have expanded on those theories, with greater emphasis placed on cognition and appraisal of emotion inducing stimuli.

Researchers have allocated extensive time and effort to understand how emotions can affect individuals. Only recently, however, has an emphasis been placed on examining how and why individuals attempt to influence emotions. This top-down process of manipulating emotions has been referred to as *emotion regulation*. Broadly, emotion regulation has been conceptualized as a *goal-driven process*, where an emotional state is incompatible with one's goals, and thus, is changed in order to achieve the goal (Gross, Sheppes & Urry, 2011). Just as an athlete attempts to increase arousal before competing, a lecturer seeks to calm any pre-presentation nerves before delivering a speech or an employee attempts to assuage feelings of anger before speaking to a boss about a disagreement, all humans seek to change their emotions to best match goals and demands of their environments. In addition to increasing the likelihood of accomplishing proximal or immediate goals, effective emotion regulation is associated with many beneficial outcomes, including but not limited to better mental and physical health, interpersonal well-being, and enhanced executive functioning (Gross & John, 2003; Hofmann, Schmeichel & Baddeley, 2012; Mennin, Heimberg, Turk, & Fresco, 2005). With these examples, it is clear that effective emotion regulation is an important ability to possess.

The *process model* of emotion regulation is a widely accepted model of emotion regulation, which suggests that emotions develop over time, or as a generative process, and that different emotion regulation strategies can be used at different points in time depending on how fully developed an emotion is (Gross, 2015a). With this, emotion regulation can be broken into two distinct categories: *antecedent-focused* strategies, or strategies that can be used prior to or during the development of an emotion, and *response-focused* strategies, which can be used after an emotion has been fully generated. Cognitive reappraisal is a particularly well studied antecedent-focused strategy that involves the reinterpretation of an event or stimulus to alter an emotion (Gross, 2001). Compared to other strategies, cognitive reappraisal has been well-represented in the literature, where it has predominantly been found to be effective at modulating emotions (Aldao, Nolen-Hoeksema & Schweizer, 2010).

Despite the effectiveness of cognitive reappraisal, relatively few studies have examined the potential down-side of using this strategy. A proposed adverse feature of cognitive reappraisal is that the strategy may have relatively high attentional demands that could make the strategy difficult to use when attentional resources are diminished, or when they are required for other tasks. Only a handful of studies have investigated this suggestion, even though the process model of emotion regulation posits that all emotion regulation strategies should require attentional resources (Gross, 2001; Keng, Robins, Smoski, Dagenbach, & Leary, 2013; Ortner, Zelazo & Anderson, 2013; Richards, 2004; Richards & Gross, 2000; Sheppes et al., 2014; Sheppes, Catran, & Meiran, 2009; Sheppes & Meiran, 2008). Furthermore, a growing body of literature suggests that emotion regulation strategies are not ubiquitously effective or ineffective, but rather, their utility is dependent upon an individual's situation. Emotion regulation strategies are differentially effective, with some strategies better-suited for situations of low emotional intensity, and others for situations of high emotional intensity (Sheppes et al., 2014). Consequently, researchers still need to clarify how and when cognitive reappraisal requires attentional resources, as this may elucidate when cognitive reappraisal is an optimal strategy for regulating emotions.

While some research has investigated the attentional demands required to use emotion regulation strategies, the present study expands on previous findings by examining a specific type of cognitive reappraisal, as well as examining how attentional demands change over time during the use of this strategy. To address this issue, participants were asked view to images of negative and neutral valence, and reappraise a sub-set of the negative images. During image presentation, participants were presented with a secondary, auditory stimulus, which required them to respond by pressing a button as quickly and accurately as possible. The RT stimulus was presented at varying time points, or stimulus onset asynchronies (SOAs) during the task in order to examine changes in attentional demands over time. It was predicted that if reappraising unpleasant images requires more attentional resources than simply viewing unpleasant images, then reaction time (RT) to the auditory stimulus would be significantly slower in the reappraise condition and that the attentional demands would be greater during early stimulus processing and early reappraisal phases, as demonstrated by a slower RT to the auditory stimulus at earlier SOAs compared to later time points. An exploratory question asked to what extent did worry serve as a factor that impacted participant performance during the RT task. This was examined by exploring whether participants with a high level of self-reported worry might show a higher attentional cost during reappraisal and negative image viewing conditions than participants with a low level.

CHAPTER 2

REIVEW OF THE LITERATURE

What is emotion and emotion regulation?

The scientific study of emotions has existed for nearly 150 years, and despite the extensive time researchers have allocated to understanding emotions, there is no consensus definition of what emotions are (Cabanac, 2002). Early research viewed emotion through an evolutionary lens, suggesting that emotions are hereditary and allow individuals to signal information to others to better promote survival (Darwin, Ekman, & Prodger, 1998). From this perspective, emotions can be used to attract mates, deter potential threats or even to invite help from others. While psychological research has viewed emotions as adaptive and informative, early psychologists conceptualized emotions as the result of an automatic process, where the perception of a stimulus elicits physiologic changes that are in turn, interpreted as an emotion (James, 1884; Lange & James, 1922). Walter Cannon, a prominent critic of this James-Lange theory, suggested that physiologic changes are a response to emotions, rather than the precipitator of emotions (Cannon, 1927). Despite this disagreement regarding the order in which physiologic responses are elicited, neither perspective viewed cognitive influences as prominent features of emotions.

Contemporary theories of emotion state that cognitive processes plays an integral role in emotion. Evidence provided by neuroimaging research indicates that brain regions associated with cognitive processes (i.e., memory, attention and problem solving) are also involved in the experience of emotion, and that these two phenomena cannot be disentangled from one another (Pessoa, 2008). With this inseparable link between emotions and cognition, researchers have turned their attention to how cognitive processes can be used to change, or regulate emotional experiences. *Emotion regulation* is the term used to describe this alteration of an emotion, and is often thought of as how, when and what emotions we express and experience (Gross, 1998b). Even though researchers have studied how emotions influence humans for close to 150 years, only recently have researchers begun to understand how individuals can use emotion regulation to influence their emotions.

Emotion regulation is a top-down processes and is used by all individuals, as it appears to be a basic aspect of the human condition. As an example of how common emotion regulation is, image an individual's boss has given them an aggressive deadline for a project. If this person's goal is to have the deadline extended, they may need to regulate any negative emotions in order to convince their boss to extend the deadline. Additionally, a presenter who feels nervous before to delivering a speech to colleagues may look to regulate their emotions through positive self-talk, or inhibiting any physical signs of nervousness in hopes of delivering an effective presentation. While these exact situations may not be experienced by all people, readers most likely can recall previous instances where they needed to regulate emotion to better ensure a desired outcome. Regardless of the context or situation, all persons experience these processes of regulating emotions (Morris & Riley, 1987).

As mentioned earlier, emotion regulation is commonly used when an affective state is incompatible with a desired outcome (e.g. inhibiting physical signs of nervousness before a speech) (Gross, 2015b). Because of this, emotion regulation has been considered a goal-driven process, where attempts are made to influence emotions that elicit a more favorable outcome (Gross, Sheppes, & Urry, 2011). Regulating emotions to better achieve goals can be done effortfully or automatically, intrinsically or extrinsically, for purely hedonic reasons, or even to fit social norms, when expression of an emotion is not appropriate for a given context (Gross, 1998b; Gross, 2015a; Larsen, 2000).

Outcomes associated with emotion regulation

Psychological wellbeing

While emotion regulation is helpful in modulating emotions, certain individuals may experience difficulty regulating emotions. Emotion dysregulation is the inability to respond to, understand, react and manage emotions (Mennin et al., 2005). Because emotion regulation is such a fundamental part of the human condition, its antithesis, emotion dysregulation, has been associated with a wide range of psychopathologies, including but not limited to: generalized anxiety disorder (Marganska, Gallagher, & Miranda, 2013; Mennin, 2004; Mennin, Heimberg, Turk, & Fresco, 2005; Turk, Heimberg, Luterek, Mennin, & Fresco, 2005; Tsypes, Aldao, & Mennin, 2013), borderline personality disorder (Carpenter, & Trull, 2013; Glenn & Klonsky, 2009; Gratz, Rosenthal, Tull, & Lejuez, 2006; Scott, Stepp, & Pilkonis, 2014), mood disorders (Joormann, & Gotlib, 2010; Martin, & Dahlen, 2005; Nolen-Hoeksema Wisco, & Lyubomirsky, 2008) schizophrenia (Henry, Rendell, Green, McDonald, & O'Donnell, 2008; Kavanagh, 1992), and anorexia nervosa (Harrison, Sullivan, Tchanturia, & Treasure, 2009; Nandrino, Doba, Lesne, Christophe, & Pezard, 2006).

The Center for Disease Control and Prevention (CDC) estimates that 25% of the United States population meet criteria for a psychological disorder at any given time, and that half of the population will develop a psychological disorder at some point in their life (CDC, 2011). With extensive evidence identifying emotion dysregulation as a common thread across pathologies, and the high prevalence rate of psychopathology, researchers and clinicians have worked to develop treatments focused on improving emotion regulator abilities. Specifically, Acceptance and Commitment Therapy (ACT; Blackledge, & Hayes, 2001), Cognitive Behavioral Therapy (CBT; Beck, Rush, Shaw, & Emery, 1987), Dialectical Behavioral Therapy (DBT; Goodman et al., 2014; Linehan, 1987), Attention Bias Modification (ABM; MacLeod & Grafton, 2015) and Emotion-Focused Therapy (EFT; Greenberg, 2004) all incorporate emotion regulation strategies to address symptoms.

Physical wellbeing

Traditionally, physical and mental health have been examined independently from one another. A growing area of research has sought to understand how these two domains of health are related. One specific area in which this relationship has been examined is in the overlap of emotion dysregulation and physical health outcomes, with evidence suggesting that emotion dysregulation is associated to a large number of adverse physical health outcomes (Cole, 2015). These outcomes associated with emotion dysregulation include, but are not limited to: cardio vascular disease (Appleton, Buka, Loucks, Gilman, & Kubzansky, 2013; Appleton, Loucks, Buka, & Kubzansky, 2014), cancer progression (Giese-Davis, et al., 2002; Gross, 1989; Spiegel, Kraemer, Bloom, & Gottheil, 1989; Spiegel, & Giese-Davis, 2003), HIV/AIDS (Carrico, Antoni, Weaver, Lechner, & Schneiderman, 2005; Chesney, Folkman, & Chambers, 1996; DeGenova, Patton, Jurich, & MacDermind, 1994) chronic pain (Berna, et al., 2010; Kökönyei, Urbán, Reinhardt, Józan, & Demetrovics, 2014) and gastrointestinal diseases (Drossman et al., 2003; Lackner et al., 2006; Tillisch, Mayer, & Labus, 2011).

Cole (2015) describes emotion dysregulation as *emotional inhibition,* or, an inability to express emotions, and that this may explain how emotion dysregulation is associated with adverse health outcomes. Cole (2015) has proposed that emotional inhibition results in elevated sympathetic nervous system (SNS) activity, which in turn, alters physiologic homeostasis, and puts the body at greater risk to perpetuate disease and related disease processes. Elevated SNS activity may reduce an individual's ability to engage in healthy behaviors, or their body's ability to ward off disease, both of which create a greater risk for adverse health outcomes. Emotion regulation, which works to influence psychological processes that change physiologic responses, may serve as a protective factor against pathology by ultimately reducing SNS activity.

The process model of emotion regulation

It is clear that the ability to regulate emotions is vital, but how do we conceptualize all of the different ways in which emotions can be regulated across settings, times and persons? Gross (1998a), proposed a *process model* of emotion regulation that views emotion and emotion regulation as generative processes, where different strategies can be utilized at different points in time, depending on the extent to which an emotion has developed. *Antecedent-focused* strategies are those that can be used before the emotion has fully developed, while *response-focused* strategies are used after an emotion has developed.

Gross (1998a; 1998b) elaborates on antecedent-focused strategies by proposing four distinct strategies. The first strategy that can be used during the generative process of an emotion is *situation selection*, or the self-selection of certain situations that will elicit a desired emotional state. After selecting a situation, an individual may use *situation modification*, in which the individual alters the environment to better fit their desired emotional experience. For example, if someone were watching a horror film, he or she could turn the movie off to modify the situation and reduce any negative affect.

Additionally, someone could use *attentional deployment*, which regulates emotion by attending to or neglecting certain features of the environment. As opposed to situation modification, where someone would turn off the horror film, attentional deployment would result in someone diverting attention away from the horror film and attending to something more positive, such as a pet or a picture on the wall.

The final antecedent-based strategy in the process model is *cognitive change*, where an individual reinterprets a situation or their ability to handle the situation, which alters the emotional impact on the individual (Gross, 1998a; Gross, 1998b; Gross, 2001; Gross, 2015a). *Cognitive reappraisal* is a particularly well studied type of cognitive change that is typically used to reduce negative affect. This is accomplished by interpreting an emotionally relevant stimulus in such a way that its emotional relevance is diminished (Gross, 1998a). Someone could engage in self-talk while watching a horror film, telling him or herself that the characters are fake and that nothing on the screen is real. This specific type of cognitive reappraisal is referred to as *detached* reappraisal, where an individual reinterprets an event or emotion from an objective standpoint. A variation of this strategy is *positive reappraisal*, in which attention is directed towards the emotional aspects of a scene and the scene is interpreted to be more positive, or to have a more positive outcome (Folkman & Moskowitz, 2000; Shiota & Levenson, 2009). To do this, someone could tell themselves that the individuals in the horror film will escape from the antagonist, and they will go on to live happy and safe lives. While these strategies influence emotion by changing emotions before or while they are developing, other strategies can be used after emotions have developed.

After an emotion has fully developed, emotion regulation strategies from the processes model can still be used, but they can only be response-focused strategies. *Response modulation* is the phrase used to group these response-focused strategies, where experiential, behavioral or physiologic aspects of an emotion are purposefully and effortfully altered to change an experienced emotion (Gross, 2015a). Engaging in deep-breathing following a stressful event, or physical activity after experiencing hardship are both examples of response modulation, where effortful behaviors are used to alter an affective state. Within the response modulation category, most research has focused on *expressive suppression*, in which emotion-expressing behaviors are inhibited. For example, this could be accomplished by preventing facial reactions to a horror movie. While this strategy may cause someone to present as unaffected by emotions or stimuli, it is relatively ineffective at changing emotions compared to antecedent-focused strategies (Moore, Zoellner, & Mollenholt, 2008).

Measures of emotion and emotion regulation

Emotion regulation, by definition, is a *change* in emotional intensity or experience, and therefore can only be indexed by comparing a measured emotion at different points in time (Gross, 2013). Using physiology to index of emotions is a well-supported methodology, as measures of physiology are relatively unbiased compared to both self-report and behavioral measures. While physiologic measures are unable to discern specific emotions from each other (e.g. happiness, sadness, anger, excitement), they are sensitive to arousal and valence, two constructs that have received extensive attention in the emotion and emotion regulation literatures (LaBar & Cabeza, 2006).

Regarding specific physiologic measures of emotion, the autonomic nervous system (ANS) has been a central component of emotion research, tracing back to both James and Cannon (Levenson, 1992). The ANS is subdivided into the excitatory, SNS, and the inhibitory, parasympathetic nervous system (PNS), both of which can be monitored as measures of emotion. Cardiovascular activity is an ANS measure that has been used extensively as a measure of emotional reactivity (Sinha, Lovallo, & Parsons, 1992). Heart rate variability (HRV), a specific type of cardiovascular activity, has also been used to measure emotional reactivity. HRV is the variation between beat-to-beat intervals and is sensitive to both SNS and PNS activity, however, like other measures of cardiovascular activity, only sensitive to arousal and not valence (Brosschot, & Thayer, 2003; Lane et al., 2009).

In the context of emotion regulation, HRV has been proposed as a measure of emotion regulatory ability (Appelhans & Luecken, 2006). Geisler and colleagues (2010) expand upon this by providing evidence that greater HRV is associated with better subjective well-being, and that this relationship is fully mediated by "executive emotion regulation strategies". These strategies include both reappraisal and attentional deployment, two strategies from Gross' process model of emotion regulation.

In addition to cardiovascular activity and HRV, facial electromyography (EMG) has been used as a measure of emotional reactivity. Charles Darwin was one of the pioneers of using observable facial reactivity as a measure of emotion, but due to the difficulty in differentiating emotions and their observable corresponding facial reactions, facial EMG has been used as a more reliable and valid measure of emotion in examining arousal and valence (Cacioppo, Martzke, Petty, & Tassinary, 1988). Broadly, facial EMG is a measure of electrical activity that originates in different facial muscles. Facial EMG is sensitive to both stimulus arousal and valence, depending on where on the face electrodes are placed. Activity around the mouth, at the *zygomaticus major,* is associated with smiling, or positive valence, and activity around the brow, at the *corrugator supercilii*, is associated with a scowl, or negative valence (Cacioppo, Petty, & Losch, 1986). While stimulus valence appears to determine which muscles are used to elicit an EMG signal, the strength of the signals are sensitive to stimulus arousal, or intensity, with more arousing stimuli eliciting larger, or potentiated, measures of EMG. Since facial EMG can be used to measure affective states, it has also been used as a valid measure of emotion regulation (Hagemann, Levenson, & Gross, 2006).

A specific type of EMG, the *startle eye-blink,* has also been used to index emotion and emotion regulation. The startle eye-blink is an automatic, defensive reaction that can be elicited by an intense stimulus, such as a 105 dB white-noise burst (Verschuere, Crombez, Koster, Van Bockstaele, & De Clercq, 2007). Following the presentation of the white-noise burst, there is pronounced eye-blink that can be measured using EMG. The startle eye-blink is reliably potentiated or attenuated, depending on the affective state of a participant prior to the startle tone presentation. Vrana, Spence and Lang (1988) were able to demonstrate this by presenting participants with aversive and pleasant images, which were immediately followed by a startle tone. The presentation of the aversive images resulted in a facilitation of the startle eye-blink, while the presentation of pleasant images resulted in an attenuated startle eye-blink (Vrana, Spence & Lang, 1988). Because the startle eye-blink is sensitive to emotion, it can therefore be used as a measure of emotion regulation. Hagemann and colleagues indicate that expressive suppression, or the inhibition of a physical response associated with an affective state, can attenuate the startle eye-blink (2006). Additionally, in 2010, Ray and colleagues examined startle eye-blink responses after participants were asked to use cognitive reappraisal to up- or down-regulate negative emotions during the presentation of neutral and unpleasant images. While the participants reappraised their emotional experience, they were presented with a startle eliciting sound. The data revealed that in both conditions (neutral and unpleasant), up-regulation (i.e. increasing negative emotional experience through reappraisal) potentiated the startle eye blink, while down-regulation (i.e. decreasing negative emotional experience through reappraisal) attenuated the startle eye-blink (Ray, McRae, Ochsner, & Gross, 2010). These data indicate that reinterpreting a negative emotional experience as less intense can actually inhibit a defensive reaction to a startle eliciting tone, and that reinterpreting an emotional experience to be more intense can result in an exaggerated defensive reaction, as measured by the startle eye-blink. Taken together, this means that top-down emotion regulation is able to alter automatic, physiologic reactions.

Event related brain potentials (ERPs) are another physiologic measure that has been used better understand emotion and emotion regulation. Researchers conceptualize ERPs averaged measures of electrical activity, specific to time and scalp location that originate from the brain and are recorded at the scalp through electroencephalography (EEG; Luck, 2014). This measure has been an integral and influential measure of emotion in psychological research, as ERPs are sensitive to arousal and valence, as well as attention and appraisal (Hajcak, Weinberg, MacNamara, & Foti, 2012). Additionally, ERPs provide excellent temporal resolution, which allows researchers to examine how emotions unfold over time with millisecond precision (Davison, 1998; Hajcak et al., 2010).

The *late positive potential* (LPP) is the ERP component that has received extensive attention in emotion and emotion regulation literature, as it is used as a measure of stimulus valence and arousal (Hajcak et al., 2010). The LPP is a positive going waveform sensitive to emotional content, with greater positivity for stimuli of pleasant and unpleasant valence, compared stimuli of neutral valence (Proudfit, Dunning, Foti & Weinberg, 2015). Unlike other physiologic measures, such as startle eye-blink, LPP is robust to habituation across trials, and can also be elicited using as few as 12 experimental trials (McIntosh, & Gonzalez-Lima, 1991; Moran, Jendrusina, & Moser, 2013; Olofsson, & Polich, 2007). These characteristics make LPP a flexible measure of emotion, as it provides a millisecond-by-millisecond account of emotional reactivity, is robust over many trials, and is easy to elicit in experimental paradigms.

Because LPP has been documented as a measure of emotion, it has also been used as a reliable measure of emotion regulation. In a 2006 paper, Hajcak and Nieuwenhuis demonstrated that LPP was attenuated during trials in which participants reappraised emotion-eliciting images. More recently, observed LPP responses elicited during conditions of cognitive reappraisal and expressive suppression were compared in an experiment that required participants to use these strategies while viewing emotionally relevant images (Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). The results indicated that both strategies attenuated LPP, but that attenuation happened more quickly following attentional deployment than cognitive reappraisal (Thiruchselvam et al., 2011). One potential explanation for this is that cognitive reappraisal may require more effort, as the stimulus must first be encoded and understood by the participant before it can be reinterpreted as less affectively relevant. Attentional deployment does not require the participant to encode and reinterpret the stimulus. To use attentional deployment, the participant simply needs to divert attention away, which causes LPP, a measure of emotional reactivity, to attenuate quickly.

All of the aforementioned physiologic responses have been used as valid and reliable measures of both emotion and emotion regulation. While these indices can provide insight regarding emotion regulatory processes, different experimental paradigms or manipulations can be used answer different types of questions about emotion regulation. With different combinations of physiologic measures and experimental paradigms, researchers have been able pair different measures and methods to answer a wide range of questions about emotion regulation.

Emotion regulation and experimental paradigms

Experimental research has historically used three different approaches to investigate emotion regulation: (1) instructions to use a specific emotion regulation strategy are provided while the participant views an emotional stimulus, (2), instructions to use a specific emotion regulation strategy are provided right before the participant views an emotional stimulus, or (3) participants are allowed to select which strategy they want to use during stimulus presentation (Sheppes & Gross, 2011). These three approaches can be used to compare specific emotion regulation strategies to each other, or to compare an emotion regulation strategy to a control condition where participants are instructed to respond to the stimuli as they naturally would.

Early emotion regulation literature relied on instructed emotion regulation, in which participants were asked to use an emotion regulation strategy part way through stimulus presentation. Jackson, Malmstadt, Larson, & Davidson (2000) presented their participants with a series of unpleasant images, with each image presented for eight seconds. Four seconds into the viewing of each image, participants received an instruction to suppress, increase, or maintain their emotional reaction. Each image was then displayed for four seconds following the manipulation, totaling eight seconds. This manipulation allowed the researchers to examine how the emotion changed within trials, by comparing emotional responses in the first four seconds of each trial, to the final four seconds of each trial (Jackson et al., 2000). Relying on an alternative approach, some researchers present participants with instructions prior to stimulus presentation so they are better able to understand how early-use of a strategy can affect the trajectory of an emotion. This manipulation has been referred to as *anticipatory regulation*, and has been found to have an effect on different ERP components related to emotion regulation (Proudfit et al., 2015).

Although these two approaches are commonly used, they have been criticized by researchers, with concerns of generalizability across situations and persons. Outside of the laboratory, people are rarely, if ever, told which emotion regulation strategies, or combination of emotion regulation strategies, to use or how to use them (Opitz, Cavanagh, & Urry, 2015; Urry, & Gross, 2010). With concerns of generalizability stemming from the two aforementioned methods, a growing trend in the literature has been to use a different methodology, where participants are taught how to use emotion regulation strategies prior to experimentation, and are then allowed to select which strategies they use during stimulus presentation (Sheppes & Gross, 2012). This approach has allowed researchers to address question left unanswered by other approaches, and has provided evidence that situational parameters may influence which strategies individuals decide to use. A number of studies have now demonstrated that participants prefer to use attentional deployment over cognitive reappraisal when stimuli are highly-arousing, and that it is also more effective than cognitive reappraisal when stimuli are highly-arousing (Sheppes, Catran, & Meiran, 2009; Sheppes & Meiran, 2007; Sheppes & Meiran, 2008). While this approach may provide information regarding individual differences in choice and effectiveness, it may not be an appropriate methodology in all contexts, especially when the research is concerned with basic effects of emotion regulation strategies.

Potential cost of cognitive reappraisal

In the emotion regulation literature, a burgeoning area of research has begun to examine how different strategies affect attentional and cognitive processes. Prior to a 2008 publication by Sheppes and Meiran, little experimental evidence existed to suggest that cognitive reappraisal had cognitive and attentional costs. In the study by Sheppes and Meirans (2008), participants were assigned to a reappraisal or distraction condition, and were instructed to use their assigned strategy part way through viewing an unpleasant emotion eliciting film. After viewing the film, participants performed a color-word Stroop task, along with a surprise memory task. The authors indicated that the Stroop effect can be used to measure attention, since reading is an automatic process, and inhibiting automatic processes requires attentional control. Sheppes and Meiran (2008) were able to demonstrate that reappraisal resulted in a larger Stroop effect than distraction, and that distraction resulted in poorer memory recall of the film compared to reappraisal. This study was one of the first to demonstrate that the potential attentional demands specific to cognitive reappraisal.

These findings were followed by a 2009 study, where skin conductance level (SCL) served as a measure of inhibitory self-control during an emotion regulation task (Sheppes, Catran, & Meiran, 2009). Sheppes and colleagues (2009) drew from previous studies which suggested that greater SCL is a measure of effortful attention. Specifically, they cite that SCL has been linked to greater self-restraint and purposeful avoidance (Pennebaker & Chew, 1985), as well as greater suppression of emotional thoughts (Wegner & Gold, 1995). With these findings, Sheppes and colleagues (2009) sought to use SCL as a measure of effortful attention during an emotion regulation task.

Sheppes and colleagues (2009) used a design in which participants were randomly assigned to one of three conditions (cognitive reappraisal, distraction, or a control condition). Similar to Sheppes and Meiran's 2008 protocol, participants watched an unpleasant, emotion eliciting film and were presented with an instruction based on their condition assignment part way through the film presentation. SCL recordings were compared both between (i.e. emotion regulation instruction) and within conditions (i.e. before or after instruction). As they predicted, cognitive reappraisal was associated with a significant increase in SCL in the regulation period compared to the pre-regulation period, while both distraction and control conditions exhibited a significant decrease in SCL (Sheppes et al., 2009). The authors attribute this increase in SCL to greater attentional demands associated with cognitive reappraisal compared to both the distraction and control conditions.

Ortner, Zelazo and Anderson (2013) examined the attentional demands of emotion regulation using a concurrent emotion regulation and auditory discrimination task. In their study, participants were instructed prior to viewing emotion eliciting images to use cognitive reappraisal, expressive suppression or no emotion regulation strategy. While images were presented, a high or low frequency tone was played at SOAs of three, five, or seven seconds into image presentation. The auditory discrimination task required participants to make a dichotomous decision about which tone they heard (Ortner, Zelazo, & Anderson, 2013). The results of the study show that reaction time, when viewing negative images, was slower for reappraisal and suppression compared to no emotion regulation strategy. This suggests that these two emotion regulation strategies require more attentional resources than using no strategies (Ortner, Zelazo, & Anderson, 2013).

Another 2013 publication used a between-subjects design to compare the effect of cognitive reappraisal and mindfulness on attention during a sad-mood induction, autobiographical recall, followed by a color-word Stroop task (Keng, Robins, Smoski, Dagenbach, & Leary, 2013). Similar to Sheppes and Meiran (2008), they used the Stroop task to measure the attentional or cognitive demand associated with emotion regulation. Results from Keng et al. (2013) indicate that cognitive reappraisal and mindfulness are equally as effective in reducing sadness compared to a control condition. However, reappraisal resulted in a Stroop effect equal to control, and both of these were greater than the Stroop effect associated with mindfulness. These findings indicated that cognitive reappraisal is more taxing on attention than mindfulness, despite the fact that they are equally effective in modulating sadness.

The literature reviewed above provides strong evidence to suggest that cognitive reappraisal requires attentional resources. This effect could be exaggerated in the context of psychopathology, as many disorders interfere with cognitive processes and emotional processes (Beck, Brown, Steer, Eidelson, & Riskind, 1987). Anxiety is a class of psychopathology that may lend itself nicely to examining this effect, as anxious individuals often exhibit deficits in regulating emotions, as well as abnormalities in attentional processing (Marganska et al., 2013). With this, the attentional demands of cognitive reappraisal could be even greater in anxious individuals.

Worry, attention and emotion regulation

The Attentional Control Theory (ACT) of anxiety posits that bottom-up attentional processes can override top-down systems in individuals with elevated levels of anxiety (Eysenck, Derakshan, Santos, & Calvo, 2007). Worry, a feature of a wide array of anxiety disorders, may interfere with the ability to use cognitive reappraisal (Newman, Llera, Erickson, Przeworksi, & Castonguay, 2013). Stimuli that are reappraised are generally aversive and attention grabbing, increasing the potential for bottom-up attentional capture in anxious individuals. Results from fMRI research indicate that individuals with generalized anxiety disorder (GAD), a disorder strongly linked with worry, exhibit reduced dorsal anterior cingulate cortex (dACC) activation while using cognitive reappraisal compared to healthy controls (Blair et al., 2012). Activation of the dACC is essential for effective cognitive reappraisal, and reduced activation in individuals with GAD suggests that they are less able to use cognitive reappraisal (Blair et al., 2012; Kalisch, 2009). This reduced effectiveness may be attributed to the associated bottom-up attentional capture that overrides the top-down goal of reappraising stimuli.

Along with the ACT's suggestion that anxious individuals are less able to perform top-down processes (e.g. cognitive reappraisal) in the presence of salient environmental stimuli, anxious individuals generally rely on ineffective or inappropriate strategies to change emotions, and that often perpetuates anxiety (Moore, Zoellner & Mollenholt, 2008). A 2002 study compared individuals with elevated levels of anxiety, as assessed by the SCL-90, to a non-anxious control group and found that the control group self-reported greater use of cognitive reappraisal than anxious participants (Garnefski et al., 2002). Collectively, individuals high in worry show preference against using cognitive reappraisal, demonstrate reduced effectiveness when relying on cognitive reappraisal, and show attentional bias towards bottom-up salience over top-down goals. These findings suggest that individuals high in worry could exhibit attentional deficits while using cognitive reappraisal.

Current study

Early research on cognitive reappraisal suggested that it was an emotion regulation strategy free of cognitive or attentional consequences (Gross, 2001; Richards, 2004; Richards & Gross, 2000). More recently, however, research has called this claim into question, as a number of studies have demonstrated that cognitive reappraisal may in fact result in attentional consequences (Keng,et al., 2013; Ortner, Zelazo & Anderson, 2013; Sheppes, Catran, & Meiran, 2009; Sheppes & Meiran, 2008). Despite evidence that cognitive reappraisal may have taxing effects on attention, it is unclear how attention is affected for the duration of stimulus presentation while individuals are using positive cognitive reappraisal, and whether the attentional demands required to use reappraisal are so pronounced that they can affect performance in a very simple task, such as a speeded RT task.

Due to their research designs, both Sheppes and Meiran (2008) and Keng et al. (2013) are unable to explain how attentional capacities are affected by cognitive reappraisal *during* regulation. In their paradigms, participants performed a Stroop test after using emotion regulation strategies in response to an emotion eliciting film and an autobiographical recall, respectively. The data in these two studies suggest that there is a sustained effect on attention, as indexed by a greater Stroop effect found for cognitive reappraisal, but it is unclear how attention was affected *while* participants were regulating their emotions. Their experiments, along with Ortner et al. (2013) relied on participant self-reported use of emotion regulation, which can be biased through demand characteristics of the experiment. It is difficult to conclude, in the absence of a more objective, physiologic measure of emotion regulation that participants followed the experimental instructions.

As discussed earlier, a commonly used manipulation in the emotion regulation literature is to instruct participants to use emotion regulation strategies part way through stimulus presentation. Both Sheppes & Meiran (2008) and Sheppes, Catran, & Meiran (2009) used this approach to suggest that cognitive reappraisal affects attentional capacities, as indexed by the Stroop effect and memory, and SCL, respectively. By instructing participants to regulate part way through stimulus presentation, however, the research is unable to answer how attention is affected during anticipatory and early regulation phases.

Ortner and colleagues (2013) used an auditory discrimination task, where stimuli were presented at late SOAs during their image presentation. Their experiment demonstrated that cognitive reappraisal requires enough attentional resources to delay discrimination between the two auditory stimuli. While the results of Ortner et al. (2013) may suggest that cognitive reappraisal is an attention demanding strategy, they do not explain how attentional demands are affected early on during cognitive reappraisal. Additionally, their auditory discrimination task, with two separate auditory stimuli, required participants to attend to the stimuli, differentiate, and then respond to the correct stimulus using the appropriate response button. If the authors were to have used a simpler RT task, they may not have found an effect on attention. The authors also indicate that other types of cognitive reappraisal should be examined, as all of the aforementioned studies had participants use *detached* cognitive reappraisal, where participants were required to interpret the emotion eliciting stimulus from an objective standpoint.

Therefore, the goal of the current study was to elucidate how attentional processes are affected by positive cognitive reappraisal in a dual-task paradigm that included concurrent emotion regulation and RT tasks. Specifically, the study required participants to view neutral and unpleasant images, and positively reappraise a sub-set of unpleasant images, while pressing a button in response to an auditory stimulus presented at pseudo-random SOAs of one, two, three, four or five seconds following image onset. The study also utilized psychophysiologic measures to index emotion regulation, an approach that has been underutilized in previous studies seeking to understand how cognitive reappraisal affects attentional resources. The hypotheses and exploratory research question for the present study were:

Hypotheses

Hypothesis 1. If reappraising unpleasant images requires more attentional resources than viewing unpleasant images, then reaction time (RT) to the auditory stimulus should be significantly slower in the reappraisal condition.

Hypothesis 2. If reappraising unpleasant images requires attentional resources, the attentional demands should be greater during stimulus processing and early reappraisal phases, as demonstrated by a slower RT to the auditory stimulus at earlier SOAs compared to later SOAs.

Exploratory Research Question. To what extent does worry served as a factor that impacted participant performance during the RT task? This was examined by exploring whether participants with a high level of self-reported worry might show a higher attentional cost during reappraisal and negative image viewing conditions than participants with a low level.

CHAPTER 3

METHODOLOGY

Participants

A total of 60 undergraduates voluntarily participated in the study. The study was posted on the University of Missouri – Kansas City's online research recruitment system, Psych Pool. All participants were awarded credit as a part of an undergraduate course requirement or course extra credit.

All participants reported being right-hand dominant and having normal or normal-to-corrected vision and hearing. Forty-seven participants (78%) were female, with a mean age of 22.33 (range 18-51; SD = 5.184). Of the sample, 39 participants (65%) reported their ethnicity as Caucasian, 10 (16.6%) reported African American, 4 (6.6%) reported Asian, 4 (6.6%) reported Latino/Hispanic, 1 (1.6%) reported American Indian, 1 (1.6%) reported Other and 1 (1.6%) indicated they would not like to reveal their ethnicity. One participant was excluded from the behavioral data analysis due to technical errors during the experiment, and another participant withdrew from participation early. The participant who withdrew completed 4 of 6 experimental blocks, so the participant's data were left for analysis, resulting in 59 participants with behavioral data. ERPs were collected for all participants, however, data for 14 participants were excluded due to technical difficulties. An additional 16 participants were excluded due to excessively noisy data, resulting in a total of 30 participants with usable ERP data.

Materials and equipment

Images of unpleasant and neutral valence were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2008). A total of 80 unpleasant images and 40 neutral images were randomly selected from previous emotion regulation studies, with half of the unpleasant images randomly assigned to a positive reappraisal condition (Bradley, Codispoti, & Lang, 2006; Bradley, Miccoli, Escrig, & Lang, 2008; Hajcak, Dunning, & Foti, 2009; Murata, Moser & Kitayama, 2013; Thiruchselvam, Blechert, Sheppes, Rydstrom, & Gross, 2011). The remaining 40 unpleasant and 40 neutral images were assigned to control conditions.

A 220 Hz sine-wave, played at 60 dB, lasting for 80ms serves as the secondary, auditory stimulus to which participants were asked to respond to as quickly and accurately as possible. This stimulus was presented during the image presentation at pseudo-random SOAs of 1000, 2000, 3000, 4000 or 5000ms during image presentation. A serial response (SR) recorded RTs to the auditory stimulus. All stimuli were presented on a Dell computer with E-Prime 2.0 software.

Experimental task

The experimental paradigm utilized a within-subjects design with three image viewing conditions, and five secondary stimulus SOAs distributed in pseudo-random order across the image viewing conditions. To account for potential biased effects of viewing condition and secondary-stimulus SOAs, five versions (A, B, C, D, & E) of the experimental paradigm were designed, so that each image could be presented with each secondary-stimulus SOA across the sample. Aside from the different combinations of IAPS image and secondary-stimulus SOAs, all versions of the experimental paradigm were identical to one another. Participants were assigned to condition A through E with a random number generator.

The experiment consisted of six blocks, each containing 20 IAPS images, randomly drawn from the 80 unpleasant and 40 neutral images. Each block was followed by a break, lasting as long as the participant desired. Trials began with a fixation cross presented for 2500ms, followed by an instruction cue for 2000ms. The instruction cue was then proceeded by another fixation cross for 2500ms. Following this, an IAPS image was displayed for 6000ms, and was accompanied by the secondary, auditory stimulus. Participants responded to the secondary, auditory stimulus using the SR box, where speed and accuracy were equally emphasized. Each trial concluded with an inter-trial interval (ITI) of 1000ms. This paradigm is similar to those used in other emotion regulation and image viewing studies.

Three instruction cues used were: *View Neutral, View Negative* and *Reappraise Negative*. View Neutral and View Negative conditions were identical to one another, except for the IAPS image valence associated with these two conditions, as the cues precede neutral or unpleasant images, respectively. For these conditions, participants were asked to attend to the images and to allow their emotions run their natural course. For the Reappraise Negative condition, participants were asked to view the unpleasant IAPS image in such a way that they felt their negative emotions less strongly. More specifically, they were asked to imagine a more positive outcome in the pictured image. This operationalization of positive reappraisal has been used in previous research, and has been found to results in different effects on emotion compared to control conditions (Jamieson, Knock, & Mendes, 2012; Ochsner et al., 2004; Shiota & Levenson, 2009). Upon finishing the experimental task, participants were asked to complete a series of self-report questionnaires.

Self-report measures

The Penn State Worry Questionnaire (PSWQ; Meyer, Miller, Metzger, & Borkovec, 1990) was used to assess worry, a symptom commonly found across anxiety and depressive disorders (Newman et al., 2013). The PSWQ is a well-validated, 16-item measure that asks participants respond to items using a 1 (not at all typical of me) to 5 (very typical of me) Likert scale. The PSWQ has been found to have strong internal consistency ($\alpha = .95$), good split-half reliability ($r = .90$) as well as strong test-retest reliability ($r = .92$) (Behar, Alcaine, Zuellig, & Borkovec, 2003; Meyer et al. 1990). Additionally, the PSWQ has normative values that differentiate individuals as *high* (PSWQ = 60-80), *moderate* (PSWQ = 40-59) and *low* (PSWQ = 16-39) worriers, with higher levels of worry suggestive of problematic and potentially pathologic levels of worry (Gillis, Haaga, & Ford, 1995).

During data collection, participants were also asked to complete the Anxiety Depression Distress Inventory – 27 (ADDI-27; Osman et al., 2011), the Emotion Regulation Questionnaire (ERQ; Gross, & John, 2003), the Pittsburgh Sleep Quality Inventory (PSQI; Buysse, Reynolds, Monk, Berman & Kupfer, 1989), basic demographic questions and a single item asking participants "To what extent did you follow the image viewing instructions". Participants responded to this single item using a five-point Likert scale. Data from the ADDI – 27, ERQ and PSQI are not examined in the current study.

Physiologic recordings

Continuous encephalographic (EEG) activity was recorded using the ActiCHap system, developed by Brain Vision LLC (www.brainvision.com/actichamp.html).

Recordings were taken from 32 Ag/AgCl electrodes, consistent with the 10-20 and guidelines outlined by Picton and colleagues (2000). Auxiliary Ag/AgCl sensors were used to record electrooculogram (EOG) activity from the left and right outer canthi, the left orbicularis oculi and the left corrugator supercilii.

During data acquisition, Fpz served as an online reference. All data were sampled online at 500 Hz using Brain Vision PyCorder software. Offline analyses were conducted using MATLAB, a commercial package statistical and modeling software, with ERPLAB add-on software (version R2016a, The MathWorks Inc., 2016; Lopez-Calderon & Luck, 2014). Offline, EEG data were resampled at 250 Hz and rereferenced to Cz. The EEG data were epoched 200ms prior to image onset, through the 6000ms image presentation for all 3 image viewing conditions. Blink artifacts rejection was conducted using a peak-to-peak moving window with a voltage thresholds of +/- 100 uV, and a moving window of 200ms. The data were filtered using a high-pass filter with a cutoff of 0.1 Hz and a low-pass filter with a cut-off of 30 Hz, with a 36 dB/oct roll-off. The LPP was averaged across all participants, and examined at electrode site Pz, at time-windows of 400-700ms, 700-1000ms and 1000-2000ms following image onset. These time-windows have been used in previous research examining cognitive reappraisal (Krompinger, Moser, & Simons, 2008; Thiruchselvam, Blechert, Sheppes, Rydstrom & Gross, 2011).

Manipulation checks

For the present study, LPP served as the primary manipulation check. Previous research has demonstrated that reappraising unpleasant stimuli attenuates LPP amplitude compared to simply viewing unpleasant images (Hajcak & Nieuwenhuis, 2006; Thiruchselvam et al., 2011). The present study relied on this well-establish feature of reappraisal to help ensure that participants followed image viewing instructions. A secondary manipulation check was also used, the single item question asking participants "To what extent did you follow the image viewing instructions".

Procedure

Upon arrival, participants were welcomed to the laboratory and asked to provide informed consent for the study. Following this, EOG electrodes were applied and participants were fitted with an EEG cap and electrodes. Once all equipment was set up and recording with impedance below 15 kΩ, the practice trials began.

Participants were asked to complete three practice tasks prior to initiating the experiment. First, they introduced to the RT task and asked respond to the auditory stimuli with the SR box, 15 times, with a random assortment of all five SOAs. Following this, participants were introduced to the image-viewing paradigm. They are presented with five images, consisting of one View Negative, one View Natural, and three Reappraise Negative trials. None of these images were re-used in the experiment. Participants were asked to verbalize their reactions to the images, based on the instruction during the practice trials to ensure they understood the different conditions. Upon completion, a final practice block was administered, which combined both the image-viewing and RT tasks, and re-used the 5 images from the second practice task. This final practice task was identical to the procedure used in the experiment.

Once participants completed the practice tasks, the experiment was administered. Upon completion of the experiment, all EEG and EOG equipment were removed, and the questionnaires were administered. Participants were then provided with course-credit compensation, and dismissed form the laboratory.

CHAPTER 4

RESULTS

Hypothesis 1

Descriptive statistics for RT data as a function of condition and SOA are displayed in Table 1. Hypothesis 1 states that if reappraising unpleasant images requires more attentional resources than viewing unpleasant images, then RT to the auditory stimulus should be significantly slower in the reappraisal condition. To test this hypothesis, a 2 X 5 (condition X SOA) repeated-measures ANOVA was computed to compare RTs across conditions. The neutral image viewing condition was excluded from this analysis to allow for a comparison between trials where the only conditional difference was instruction type, with image valence held constant. Results revealed a significant main effect of condition $F(1, 58) = 27.71$, $p < .001$, demonstrating that RT was different between View Negative and Reappraise Negative conditions. Additionally, results revealed a significant main effect of SOA, $F(4, 232) = 67.26$, $p < .001$, demonstrating that RT was affected by when the auditory stimulus was presented during image viewing. A Mauchly's test indicated that the assumption of sphericity was violated for the SOA variable, χ^2 (9) = 215.97, $p < .001$, therefore, degrees of freedom were corrected using Greenhouse-Geiser estimates of sphericity ($\epsilon = .345$). A significant interaction was also observed between SOA and condition, $F(4, 232) = 5.83$, $p = .001$. Mauchly's test for the interaction term also indicated the assumption of sphericity was violated, χ^2 (9) = 73.78, $p < .001$, therefore degrees of freedom were corrected using Greenhouse-Geiser estimates of sphericity ($\epsilon = .665$). Results are displayed in Figure 1.

Table 1

Descriptive Statistics for View Negative, Neutral and Reappraise Negative Conditions

	View Negative		Reappraise Negative		View Neutral	
SOA	M	SD	M	SD	M	SD
1s	496.57	247.59	558.01	260.33	440.05	175.41
2s	388.26	175.87	438.52	221.27	378.66	146.04
3s	369.9	156.36	389.3	173.72	353.07	145.47
4s	343.92	160.23	360.47	159.88	341.87	125.22
5s	335.2	117.6	349.25	127.73	328.23	115.54

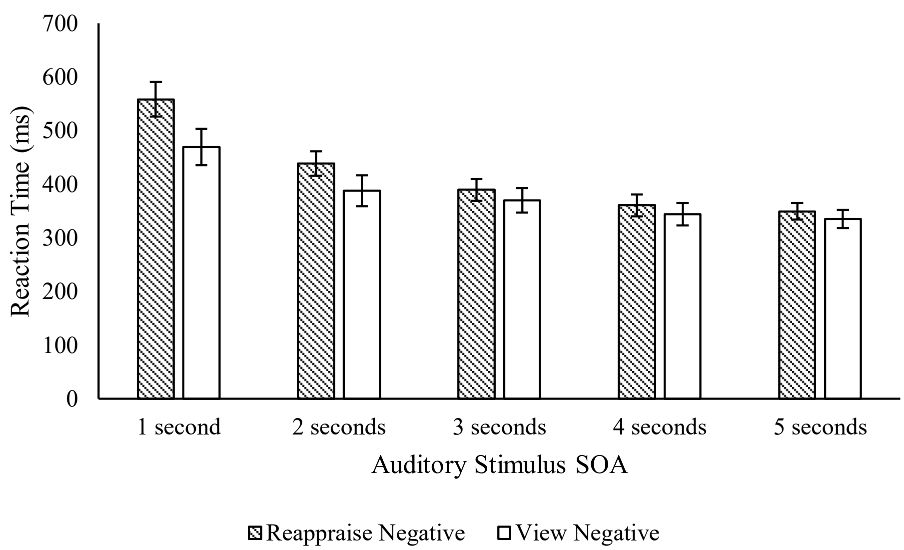

Figure 1. Average Reaction Time between View Negative and Reappraise Negative

Hypothesis 2

Hypothesis 2 states that if reappraising unpleasant images requires attentional resources, the attentional demands should be greater during early stimulus processing and early reappraisal phases, as demonstrated by a slower RT to the auditory stimulus at earlier

SOAs compared to later SOAs. In order to test this hypothesis, paired samples t-tests were used to examine differences in RT between the two conditions of interest, View Negative and Reappraise Negative, at each SOA. As showing in Table 1, RT was found to be significantly slower in the reappraise negative condition than the view negative condition at all SOAs except the five second SOA.

Table 2
Descriptive statistics and t-test results for View Negative and Reappraise Negative conditions

	View Negative		Reappraise Negative			95% CI for Mean Difference			
SOA	M	SD	M	SD	n		r	t	df
1s	496.57	247.59	558.01	260.33	59	-86.38, -36.49	0.93*	-4.9*	58
2s	388.26	175.87	438.52	221.27	59	-78.96, -21.57	0.87*	-3.5*	58
3s	369.9	156.36	389.3	173.72	59	-36.19, -2.61	0.93*	-2.3*	58
4s	343.92	160.23	360.47	159.88	59	-25.48, -4.61	0.96*	-2.8*	58
5s	335.2	117.6	349.25	127.73	59	-28.40, .29	0.9*	-2	58

* $p < .05$

Exploratory research question

The exploratory question asked to what extent did worry serve as a factor that impacted participant performance during the RT task. This was examined by exploring whether participants with a high level of self-reported worry might show a higher attentional cost during reappraisal and negative image viewing conditions than participants with a low level. If participants high in worry have reduced attentional resources, then they may exhibit slower RT than participants low in worry while reappraising negative images. To test this, participants were first categorized as *low*, *moderate* or *high* worriers from guidelines developed by Gillis and colleagues (1995), based on normative Penn State Worry Questionnaire (PSWQ) data. Descriptive statistics can be found in Table 2.

Next, a 3 X 2 X 5 (group X condition X SOA) repeated-measures ANOVA was computed with worry group entered as a between-subjects factor. Identical to the findings in hypothesis 1, there was a significant main effect of condition and SOA, as well as a significant interaction between SOA and condition. There was no significant main effect of worry, $F(2, 56) = .201$, $p = .818$. This finding indicates that individuals performed equally as fast in the RT task regardless of their level of worry, as measured by the PSWQ.

Table 3

Mean RT Across Worry Groups During Reappraise Negative Condition

	Low Worry			Moderate Worry			High Worry		
SOA	M	SD	n	M	SD	n	M	SD	n
1s	544.86	426.18	14	573.45	194.93	29	541.52	181.11	16
2s	422.98	304.92	14	426.48	179.58	29	473.96	216.07	16
3s	371.69	293.03	14	382.4	115.77	29	417.22	126.65	16
4s	347.70	270.61	14	356.87	111.85	29	378.18	107.29	16
5s	306.33	182.40	14	346.01	91.84	29	392.7	121.45	16

Manipulation checks

Late positive potential (LPP)

To examine whether or not participants were adherent to image viewing and emotion regulation instructions, LPP amplitudes were compared between image viewing conditions. The LPP data were segmented into three separate time-windows, 400-700ms, 700-1000ms, and 1000-2000ms. The LPP waveforms for each condition, averaged across participants, are shown in Figure 2. Each of these time-windows were submitted to a 3 x 3 (Conditions x Time-window) repeated-measures ANOVA. Follow-up paired samples t-tests were used to elucidate the results of the omnibus analysis.

Results of the repeated-measures ANOVA revealed a significant main effects of condition, $F(2, 58) = 67.16$, $p < .001$, suggesting that LPP amplitude was different between the three conditions. Additionally, results revealed a significant main effect of time-window, $F(2, 58) = 9.32$, $p < .001$, suggesting that LPP amplitudes were different across the three LPP time-windows. There was no significant interaction found between condition and time-window, $F(4, 116) = 2.06$, $p = .09$.

In order to determine where significant differences existed between conditions, planned t-tests were computed to compare LPP amplitudes from each condition at each time-window. Results of a paired-samples t-tests revealed non-significant differences for average LPP amplitude at the 400-700ms time-window for View Negative (M = 6.45, SD = 5.19) and Reappraise Negative conditions (M = 7.03, SD = 5.47); $t(29) = 1.29$, $p = .21$, the 700-1000ms time-window for View Negative (M = 6.46, SD = 5.2) and Reappraise Negative conditions (M = 6.60, SD = 5.84); $t(29) = .186$, $p = .85$, and the 1000-2000ms time-window for View Negative (M = .88, SD = 3.90) and Reappraise Negative conditions (M = .13, SD = 4.12); $t(29) = 1.45$, $p = .16$. These post-hoc analyses indicate that LPP amplitudes were indistinguishable between reappraisal and negative image viewing conditions, making it difficult to conclude from LPP alone whether participants followed image viewing instructions.

Because the LPP data did not show the predicted difference between the reappraise negative and view negative conditions, an important next step was to be sure that the LPP measure showed the well-established pattern of being larger to emotional stimuli than neutral stimuli. To do this, average LPP amplitudes for each time-window were compared between View Negative and View Neutral conditions. The Reappraise Negative condition was not compared to View Neutral, as the stimulus valance and instructions were different, making it difficult to draw causal claims about potential LPP differences. Results reveled a non-significant difference at the 400-700ms time window for View Negative (M =6.46, SD = 5.20) and View Neutral conditions (M = 5.63, SD = 5.11); $t(29) = 1.89$, $p = .07$. Significant differences in average LPP amplitude were observed for both 700-1000ms time-window for View Neutral (M = 4.44, SD = 4.7) and View Negative conditions (M = 6.45, 5.2); $t(29) = 2.60$, $p < .05$, and the 1000-2000ms time-window for View Neutral (M = -1.01, SD = 3.54) and View Negative conditions (M = .88, SD = 3.90); $t(29) = 3.25$, $p < .05$. These findings reveal greater positivity from 700-2000ms for the View Negative compared to View Neutral condition, suggesting that viewing negative images was more emotionally relevant than viewing neutral images (Hajcak et al., 2010; Proudfit et al., 2015).

Self-report

Participants completed a single-item measure asking them “To what extend did you follow the image viewing instructions”, to which they responded using a five-point Likert scale. Frequency data are shown in Table 3. These data suggest that participants were largely compliant with the experimental instructions, with 27 individuals reporting that they followed image viewing conditions “most of the time” and 30 individuals following image viewing conditions “all or almost all of the time”.

A final analysis combined the two manipulation checks, and compared LPP in View Negative and Reappraise Negative conditions for individuals who reported following the image viewing instructions “all or almost all of the time”. The results revealed non-significant differences in this between View Negative and Reappraise Negative conditions for this sub-group.

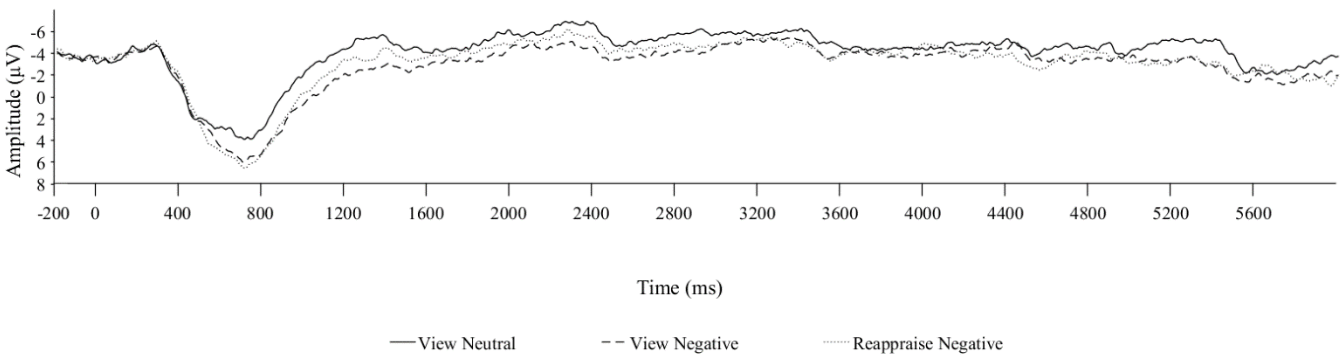

Figure 2. Picture-locked ERPs at centro-parietal site, Pz. LPP was submitted to statistical analyses for time-windows 400-700ms, 700-1000ms and 1000-2000ms. On the x-axis, 0 represents picture onset.

Table 4
Self-reported manipulation check frequencies

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	0	0	0	0
	2	1	1.7	1.7	1.7
	3	1	1.7	1.7	3.4
	4	27	45.8	45.8	49.2
	5	30	50.8	50.8	100
Missing System		0	0		
Total		59	100	100	

1 = None or almost none of the time
2 = Some of the time
3 = Half of the time
4 = Most of the time
5 = All or almost all of the time

CHAPTER 5

DISCUSSION

The focus of the current study was to investigate the attentional demands associated with a specific emotion regulation strategy, positive reappraisal. Emotion regulation refers to the ability to change experienced and expressed emotions to make a desired outcome more likely (Gross, 2015; Thompson, 1994). Cognitive reappraisal is defined as a reinterpretation of environmental stimuli that subsequently alters an emotion (Gross, 2015). Cognitive reappraisal is one emotion regulation strategy that has received extensive attention in the literature, and has largely been thought of as adaptive, as it is effective in reducing negative affect, increasing positive affect, and has also been associated with a wide range of beneficial health and psychological outcomes (Troy, Shallcross, & Mauss, 2013).

There is ample evidence to suggest that cognitive reappraisal is effective in regulation emotions, however, a newer body of literature has just begun to uncover potential negative outcomes associated with this strategy. Specifically, researchers have demonstrated that cognitive reappraisal requires attentional resources, and that allocating attentional resources to engage in reappraisal may impact one's ability to perform other tasks (Keng et al., 2013; Ortner et al., 2013; Sheppes et al., 2009; Sheppes & Meiran, 2008).

The present study was designed to expand on current findings that cognitive reappraisal requires attentional resources by focusing on a specific type of cognitive reappraisal. More precisely, this study examined how using *positive reappraisal* disrupts an individual's ability to attend and respond to environmental stimuli during a speeded RT task. To do this, participants were asked to respond as quickly and accurately as possible to an auditory stimulus while viewing neutral or unpleasant images or reappraising a subset of unpleasant images.

It was hypothesized that if reappraising unpleasant images requires more attentional resources than viewing unpleasant images, then RT to the auditory stimulus would be significantly slower in the reappraisal condition, and that the attentional demands would be greater during stimulus processing and early reappraisal phases, as demonstrated by a slower RT to the auditory stimulus at earlier SOAs compared to later SOAs. Both of these hypotheses were supported, with results revealing that participants performed more slowly during the positive reappraisal condition compared to the unpleasant image viewing condition, and that slowed task performance could be observed at all except for the five second SOA. The implication of these findings are discussed in further detail.

Hypotheses 1 & 2

Regarding the first and second hypotheses, current findings are similar to those of previous researchers, but expand on the current state of the literature in three important ways; (1) by demonstrating that *positive* reappraisal requires attentional resources, (2) by demonstrating that the attentional resources required to use this strategy change during the regulatory process, and (3) by demonstrating that the attentional demands associated with positive reappraisal can disrupt performance in very simple task, such as a speeded RT task. Collectively, these findings provide greater clarity about the role of attention in regulating emotions.

Previous research has suggested that detached cognitive reappraisal can result in attentional deficits, as demonstrated by a greater Stroop effect, greater RT during an auditory discrimination task (ADT), as well as increased skin conductance, a physiological measure thought to reflected increased cognitive effort (Keng et al., 2013; Ortner et al., 2013; Sheppes et al., 2009; Sheppes & Meiran, 2008). The present study contributes to these findings by suggesting that the increased attentional resources needed to regulate emotions are not specific to detached cognitive reappraisal, but that positive reappraisal also requires increased attentional resources.

These findings related to positive cognitive reappraisal are exciting, as cognitive reappraisal research has primarily focused on detached cognitive reappraisal, where an individual takes an objective stance that allows them to lessen their emotional experience (Cristea, Tatar, Nagy, & David, 2012). Positive reappraisal is different from detached reappraisal, as it requires the individual to attend to negative information in their environment while recognizes and emphasizes positive aspects and potential positive outcomes associated with the environment (Shiota & Levenson, 2009; Shiota & Levenson, 2012). With an underrepresentation of positive reappraisal in the emotion regulation literature, and with the recent emergence of emotion regulation research focused on attention, it is understandable that the attentional demands of positive reappraisal have been understudied. Despite this dearth of research, a recent publication called for an investigation of the attentional demands required in different types of cognitive reappraisal, such as positive reappraisal (Ortner, Marie, & Corno, 2016). The present study appears to be one of the first attempts at addressing this limitation in the field.

In addition to highlighting an understudied type of reappraisal, the current study provides greater clarity about how attentional demands associated with positive reappraisal change during the regulatory process. Through using a paradigm where participants were instruction *before* an image presentation, inferences can be made about the attentional demands during anticipatory and early regulatory phases (Proudfit, 2015). Other researchers have used paradigms where attentional demands are measured *after* a reappraised stimulus is removed, and have suggested through this manipulation that there is a sustained effect on attention (Keng et al., 2013; Sheppes & Meiran, 2008). These findings are inconsistent with those of the present study, as the present study did not find a difference in RT at the five second SOA, making it difficult to suggest there was a sustained effect on attention after the reappraised stimulus was removed that could be attributed to having used positive reappraisal. This inconsistency, however, may be due to the nature of the attentional tasks used, where the two aforementioned studies (Keng et al., 2013; Sheppes & Meiran, 2008) relied on a Stroop task, and the present study relied on a speeded RT task.

Notably, one study that used a paradigm closely resembling that of the present study found that cognitive reappraisal during a concurrent image viewing and auditory discrimination task (ADT) resulted in greater RT during reappraisal compared a control condition, at SOAs of three, five and seven seconds (Ortner et al., 2013). The present study replicates Ortner and colleagues' (2013) finding that RT differences existed at the three second SOA, however, it does not replicate their finding that RT differences existed the five second SOA. This partial replication may be attribute to difference in the RT tasks used, as the present study relied on a simple RT task, and Ortner et al. (2013) used an ADT. This may suggest that a performing a simple RT task requires less attention than an ADT.

In addition to this partial replication, the present study is able to make suggestions that Ortner and colleagues (2013) were not able to. By using SOAs of one, two, three, four and five seconds, the present study is able to suggest that cognitive reappraisal requires greater attentional resources as early as one second and as late as four seconds during reappraisal, and that at five seconds, the attentional resources required to use reappraisal are equivalent to those in the control condition. Due to the study design used by Ortner and colleagues (2013), where SOAs of three, five and seven seconds were used, it was unclear what the attentional demands looked like early on in the regulatory process. The present study has helped to elucidate this deficit in the current literature by using more and shorter SOAs.

The current study may also have implications it neuroscience, as delayed RT as late as four seconds into a mental process, such as positive reappraisal, is notable. Simple movements, such as pressing a button in response to an auditory stimulus, originate from the motor cortices, and take less than one-tenth of a second following stimulus presentation for transmission and movement initiation to begin (Georgopoulos, Kalaska, Caminiti, & Massey, 1982). The speed at which an individual can initiate motor movements is vital for survival, as could be the case if a vehicle suddenly stopped on the freeway, or a truck unexpectedly swerved towards another vehicle. Initiating movements as quickly as possible could save one's life. The current results suggest that the act of positively reappraising a negative stimulus may interfere with even very simple motor task. This could mean if someone tries to positively reappraise an earlier event or interaction, they may be less likely to notice potential dangers. Additionally, using positive reappraisal while initiating complex motor movements, such as responding to the demands of traffic, could result in even greater slowing. Complex motor movements require not only the motor cortices, but also the prefrontal cortex, a region that is also engaged during reappraisal (Goldin, Manber-Ball, Werner, Heimberg, & Gross, 2009; Kolb & Whishaw, 2015). Because of the competing need for the prefrontal cortex, limited resources could slow reactions to an even greater extent when complex movements are required.

Consistent with the suggestion that cognitive reappraisal may be inappropriate in attention demanding situations, a growing literature suggests that the effectiveness of emotion regulation strategies may be dependent on situational parameters, and that some strategies may be better suited for certain situations. In both 2011 and 2014 papers, Sheppes and colleagues demonstrated that experimental parameters can influence the self-selection of emotion regulation strategies, where attentional deployment was preferred over reappraisal when the stimuli were of high intensity, and reappraisal was preferred when stimuli were of low intensity (Sheppes, Scheibe, Suri, & Gross, 2011; Sheppes et al., 2014).

The results of the current study complement those of Sheppes and colleagues by providing evidence that the attentional demands associated with certain situations may also impact the effectiveness of emotion regulation strategies (Sheppes et al., 2011; Sheppes et al., 2014). The present study revealed that the LPP in View Negative and Reappraise Negative conditions were equivalent to one another, which may mean that situations requiring divided attention can interfere with the ability to effectively regulate emotions. If this is in fact true, effective emotion regulation strategy selection may not limited to just stimulus intensity (Sheppes et al., 2011; Sheppes et al., 2014), but also the attentional demands required in certain situations.

In summary, evidence from the present study supported Hypothesis 1 and Hypothesis 2 by showing that positive reappraisal results in greater RT than simply viewing negative images, and that RT differences changes depending on when during image presentation a secondary stimulus is present. These findings are significant, as they (1) demonstrate that positive reappraisal requires attentional resources, (2) demonstrate that the attentional resources required to use this strategy change during the regulatory process, and

(3) demonstrate that the attentional demands associated with positive reappraisal can disrupt performance in very simple task, such as a simple RT task.

Exploratory research question

The exploratory research question asked to what extent does worry served as a factor that impacted participant performance during the RT task. This was examined by exploring whether participants with a high level of self-reported worry showed a higher attentional deficits during reappraisal and negative image viewing conditions than participants with lower levels. Data from the present study revealed no observable group differences in RT in reappraisal and negative image viewing conditions, suggesting that worry was not a factor that influenced performance in the RT task.

The Attentional Control Theory (ACT) of anxiety posits that individuals experiencing high levels of anxiety (state-anxiety) exhibit atypical attentional processes compared to individuals experiencing low levels of anxiety, and are subject to bottom-up attentional capture that overrides top-down directed goals (Eysenck et al., 2007). Eysenck and colleges indicate that worry may be a component of anxiety that leads to the bottom-up attentional capture described by the ACT. In the present study, however, self-reported worry did not affect participant performance. A potential reason for this may be that participants where not worried while performing the experiment, even though a number of participants self-reported high levels of trait-worry. Eysenck and colleagues (2007) state that very few studies examine state-worry, and that it is difficult to manipulate how worried participants are during an experiment. Even though the present study had individuals high in trait-worry, there are no data to suggest that they experienced elevated trait-worry during the experiment, potentially making their task performance identical to other particpants.

While this is one potential explanation as to why worry did not serve as a factor that affected task performance, other explanations exist.

An additional explanation for the non-observable difference in performance could be the predictable nature of the task, where participants were aware of the demands of each trial, as well as the upcoming stimulus valence. Intolerance of uncertainty (IU), or the overestimation of a negative outcome when outcomes are unpredictable, is a characteristic often associated with anxiety disorders, and is strongly linked to elevated levels of worry (Dugas, Freeston, & Ladouceur, 1997; Ladouceur, Gosselin, & Dugas, 2000; Thielsch, Andor, & Ehring, 2015). In previous research, individuals high in worry and IU exhibited slowed decision making when confronted with ambiguous stimuli (Tallis, Eysenck & Matthews, 1991; Vasey & Borkovec, 1992). Additionally, elevated IU can result in exaggerated emotional reactivity, as demonstrated by greater insula activation following the presentation of ambiguous faces, suggesting individuals high in IU interpret them more negatively (Simmons, Matthews, Paulus, & Stein, 2008). These findings suggest worried individuals are generally prone to exhibit elevated IU, that IU results in difficulties performing tasks when the tasks are marked by ambiguity, and that ambiguity results in more negative emotional responses. These findings may explain why worried individuals performed equally as well as individuals low in worry in the present study.

In the context of the present study, participants were aware of experimental parameters prior to each trial, removing the possibility for an exaggerated emotional response that could have disrupted task performance in worried individuals. The worried participants did not have to confront uncertainty, and despite the well-establish association between worry and IU, the predictability of the task allowed individuals high in worry to perform equally as well as others in the RT task while using positive reappraisal. With this, it is possible that individuals high in worry could have performed worse if image viewing instructions were presented part way though the stimulus presentation, as each trial would have a greater degree of uncertainty associated with it than in the present study.

Limitations and future directions

The present study has limitations that should be examined in future research to help further the understanding of how attention is implicated during emotion regulation. Most notably, the present study relied on LPP as a manipulation check to ensure participants used cognitive reappraisal when instructed. Previous research has demonstrated that reappraising compared to simply viewing unpleasant stimuli can attenuate LPP amplitude (Hajcak & Nieuwenhuis, 2006). However, this finding was not replicated in the present study.

The simplest explanation for indistinguishable LPP in the negative image viewing and reappraisal conditions is that participants did not follow the experiment instructions. While possible, this explanation is unlikely as there were observable differences in RT between the conditions suggesting that participants *were* engaged in an additional task during the reappraisal condition. Additionally, self-report data indicate that a large portion of participants followed image viewing instructions, with 96% of participants reporting they followed the instructions “all of the time” or “most of the time”.

More likely, this non-significant difference between conditions could be attributed secondary RT task. If reappraisal and the RT task both require attention, participants may have been unable to allocate sufficient resources to successfully reappraise the unpleasant stimuli. Hajcak and Nieuwenhuis (2006) provide evidence that reappraisal, compared to a control condition, can attenuate LPP amplitude, and that attenuated LPP amplitude is suggestive of a dampened emotional experience. Since the present study revealed indistinguishable LPP amplitudes in negative image viewing and reappraisal conditions, it is likely that reappraisal did not modulate emotion due to the attentional demands required by the RT task.

Future research may remedy this shortcoming of LPP through examining other ERP components. The *stimulus preceding negativity* (SPN) is one such candidate. The SPN can be elicited before participants view or reappraise images, negating the potential for a secondary auditory stimulus to interfere with the measurement of reappraisal. The SPN is a measure of anticipated relevance for upcoming stimuli and has been used in both emotion and emotion regulation research (Böcker, Baas, Kenemans & Verbaten, 2001; Moser, Krompinger, Dietz, & Simons, 2009). Moser and colleagues (2009) demonstrated that compared to cues that asked participants to simply view negative images, cues that asked participants to reappraise upcoming images resulted in an exaggerated SPN response prior to image onset. They attributed this facilitation to increased orientation and attention needed to reinterpret the upcoming emotionally relevant stimulus (Moser, Krompinger, Dietz, & Simons, 2009). This finding has since been replicated by others, which provides additional evidence that cognitive reappraisal can be measured not only with LPP, but also with SPN (Shafir, Schwartz, Blechert, & Sheppes, 2015; Thiruchselvam, Blechert, Sheppe, Rydstrom, & Gross, 2011; Yuan, Zhou, & Hu, 2014).

Future research should also look to establish which emotion regulation strategies have lower attentional demands than cognitive reappraisal, as these strategies may be more appropriate to use in situations where attention is divided across multiple tasks (i.e. driving). Attentional deployment is an emotion regulation strategy that could be examined using a similar manipulation as in the present study. This strategy is the key mechanism of Attentional Bias Modification (ABM), which has recently been assessed as a treatment for anxiety and substance related disorders (MacLeod & Grafton, 2015; Schoenmakers et al., 2010). This intervention may be effective because it requires relatively few attentional resources compared to other emotion regulation strategies. This future research would also support Sheppes and colleagues' (2011, 2014) suggestion that strategy effectiveness is dependent upon situation specifics, and not the emotion regulation strategy being used.

In addition to using other ERP components and emotion regulation strategies, future research should examine how the attentional demands associated with emotion regulation differ across different populations. The presents study relied on a convenience sample of university students, and because of this, cannot make strong claims regarding the attentional demands of positive reappraisal in either children or older adults. McRae and colleagues (2012) indicate that the cognitive reappraisal becomes more effective as individuals progress from childhood to young adulthood, and that this may be due to improved cognitive functioning with age. If this is in fact true, the findings of McRae et al. (2012), paired with those of the present study, may suggest that children would be less effective in using cognitive reappraisal due to the high attentional demands associated with this strategy. This suggestion, however, should be explicitly tested by using a paradigm similar to that of the present study with children.

On the other end of the age spectrum, evidence suggests that older adults use cognitive reappraisal less often than younger adults, possibly due to reduced cognitive functioning associated with old age (Urry & Gross, 2010). With results of the present study suggesting that cognitive reappraisal has large attentional demands, this may be a potential explanation as to why older adults do not use it as often as younger adults, who have yet to experience cognitive decline. As suggested with children, this potential explanation as to why older adults do not use cognitive reappraisal needs to be more formally assessed.

Despite the current study's limitations, and the need for future research to build on the present findings, the present study offers novel and important contributions to the field of emotion regulation. Results of the present study suggest that positive reappraisal requires attentional resources and that the attentional demands associated with this strategy change as the strategy is used. This study appears to be one of the first to demonstrate the attentional cost of reappraising is not specific to detached reappraisal, but that positive reappraisal also requires attentional resources.

APPENDIX

MEASURES

A-1 Penn State Worry Questionnaire

Instructions: Rate each of the following statements on a scale of 1 (“not at all typical of me”) to 5 (“very typical of me”). Please do not leave any items blank.

	Not at all typical of me				Very typical of me
1) If I do not have enough time to do everything, I do not worry about it.	1	2	3	4	5
2) My worries overwhelm me.	1	2	3	4	5
3) I do not tend to worry about things	1	2	3	4	5
4) Many situations make me worry.	1	2	3	4	5
5) I know I should not worry about things, but I just cannot help it	1	2	3	4	5
6) When I am under pressure I worry a lot					
7) I am always worried about something.	1	2	3	4	5
8) I find it easy to dismiss worrisome thoughts	1	2	3	4	5
9) As soon as I finish one task, I start to worry about everything else I have to do.	1	2	3	4	5
10) I never worry about anything	1	2	3	4	5
11) When there is nothing more I can do about a concern, I do not worry about it anymore	1	2	3	4	5
12) I have been a worrier all my life.	1	2	3	4	5
13) I notice that I have been worrying about things	1	2	3	4	5
14) Once I start worrying, I cannot stop.	1	2	3	4	5
15) I worry all the time.	1	2	3	4	5
16) I worry about projects until they are all done.	1	2	3	4	5

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VITA

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