UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

ATTENTIONAL DEPLOYMENT IN EMOTION REGULATION

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

DOCTOR OF PHILOSOPHY

By

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Norman, Oklahoma
2009

ATTENTIONAL DEPLOYMENT IN EMOTION REGULATION

A DISSERTATION APPROVED FOR THE
DEPARTMENT OF PSYCHOLOGY

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ACKNOWLEDGEMENTS

I would like to express sincere gratitude to my major professor, Dr. Kirby Gilliland. He created an educational environment that provided a singular blend of support, guidance, creativity, rigor, and freedom of thought. This not only allowed me extraordinary personal and intellectual growth but has provided me with a unique skill set that I believe will provide lifelong success. For this, I am truly indebted to him.

I would also like to thank Dr. Scott Gronlund and Dr. Joseph Rodgers. Their course instruction, research collaboration, support, and guidance not only helped me to be successful in graduate school but has provided me a significant breadth of expertise. They also fundamentally contributed to my academic and personal growth.

Thanks to Dr. Eugenia Cox-Fuenzalida and Dr. Robert Schlegel for their support and guidance as committee members, course instructors, and as research collaborators at all stages of my graduate school career.

Last but certainly not least I would like to thank my family (especially my wife, Steph) and friends for their relentless love, support, and encouragement. This is not an individual accomplishment. Rather, it is one I share with all that I have mentioned and many others I have not. I will remain indebted to you all.

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ABSTRACT

Attentional deployment is a primary strategy individuals employ to regulate emotion. Study 1 investigated whether visuo-spatial, goal-directed, attentional deployment to emotional faces serves as an effective mechanism for emotion regulation and whether individual differences in this ability predicts more effective emotion regulation. Participants given a goal to focus on positively valenced faces reported nearly three times less frustration in reaction to a stressful anagram task compared to those not given this goal. In addition, those with a greater ability to focus on happy faces and avoid angry faces persisted significantly longer on a stressful anagram task. In Study 2, a measure of an individual's ability to deploy attention toward and away from emotional mental representations was developed. This measure of attentional control capacity for emotion (ACCE) adapted an explicit-cuing task switching paradigm where participants had to shift between emotional and neutral mental sets. Results showed that those higher in trait anxiety and worrisome thoughts took longer to switch from a neutral to an emotional mental set. In Study 3, participants were given a stressful anagram task and those who switched more efficiently from a neutral set to an emotional set were *more* frustrated by the stressful task. In addition, those who switched more efficiently from an emotional set to a neutral set persisted longer on the stressful task. These studies demonstrated that both visuo-spatial attentional deployment and attentional deployment to emotional mental representations are important to an individual's ability to regulate emotion.

Attentional Deployment in Emotion Regulation

Often we encounter an anxiety-provoking or frustrating task that we must complete, whether it be speaking in public or simply clearing annoying spam from our email box. Yet most people are able to keep their emotions in check effectively enough to complete these tasks. Individuals have an extraordinary capacity to regulate emotion and employ numerous strategies that determine the magnitude of its impact. One of the primary strategies individuals employ to regulate emotion is attentional deployment (Gross & Thompson, 2007; Ochsner & Gross, 2005).

Attentional deployment is one of the first emotion regulation processes to appear in development and continues to be used in late adulthood (Mather et al., 2004; Mather & Carstensen, 2005; Rothbart & Sheese, 2007). Infants deploy their attention by shifting their gaze away from an emotion-eliciting stimulus to reduce their emotional reactivity (Rothbart & Sheese, 2007). According to socioemotional selectivity theory, older adults preferentially deploy their attention away from negative stimuli and toward positive stimuli as a goal-directed behavior to effectively regulate emotion (Carstensen, 1995; Knight et al., 2007; Mather & Carstensen, 2005).

There is extensive evidence in the anxiety literature to suggest that dysregulation of attentional deployment processes is fundamental to the etiology and maintenance of clinical and nonclinical anxiety (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & IJzendoorn, 2007, and Mathews & MacLeod, 2005, for reviews). The primary finding in this literature is that those high in anxiety selectively deploy attention toward threatening or negative stimuli. The most common paradigm used to assess this attentional bias toward threat is the dot-probe paradigm (MacLeod, Mathews, & Tata, 1986). In the picture version of this task, individuals are first presented two pictures simultaneously, where one is a negative picture and the other is emotionally-neutral. These pictures are then immediately replaced by a simple probe that appears behind just one of the pictures. The faster a participant responds to the probe following the negative picture, compared to the neutral picture, the stronger the attentional bias toward negative stimuli. This task relies on spatial orientation attentional processes through which the individual reveals their attentional deployment processes by orienting toward negative stimuli more than neutral or positive stimuli (Bar-Haim et al., 2007; Mogg, Bradley, Miles, & Dixon, 2004; Rohner, 2002).

However, studies of attentional biases tend to focus on automatic or preconscious attentional deployment rather than goal-directed attention. Bar-Haim et al. (2007) integrated a number of attentional bias theories and proposed that a guided threat evaluation system can override an automatic threat-evaluation and redirect attention to perform goal-directed behavior. This is compatible with emotion regulation theory that suggests goal-directed attentional deployment is a primary mechanism through which people regulate emotion (Gross & Thompson, 2007). However, these hypotheses remain largely untested and have not been integrated.

Mogg et al. (2004) provided support for the hypothesis that some anxious individuals can override an automatic attentional threat-bias. They gave high trait-anxious, low-trait anxious, and blood-fearful individuals a picture version of the dot-probe task. These pictures were presented for multiple durations to assess both preconscious and conscious attentional processing. The results showed that both high-trait anxious and blood-fearful individuals had a bias toward threat at preconscious attentional processing. In contrast, given more time, at the conscious attentional processing, the threat-bias was no longer present for high anxious individuals and blood-fearful individuals reversed their bias and shifted it away from threat. This study highlights the importance of the time course in attentional processing and suggests that some individuals are able to override an attentional bias toward threat later in the time course of attention (also see Derryberry & Reed, 2002; Garner, Mogg, & Bradley, 2006).

Other evidence related to whether those high in anxiety can override an initial automatic bias toward threat is mixed. For example, MacLeod and Mathews (1988) showed that when state anxiety was high for all participants, high trait-anxious participants demonstrated an attentional bias toward threat. In contrast, low trait-anxious participants demonstrated an attentional bias away from threat. The results of this study suggest some individuals are able to override a bias toward threat, and even direct attention away from threat when under stress. In contrast, Mogg, Mathews, Bird, and Macgregor-Morris (1990) had high and low trait-anxious participants perform a stressful anagram task and showed that all participants, irrespective of anxiety level, exhibited an attentional bias toward threat. This suggests that under stress people exhibit an attentional bias toward threat and do not override this bias. However, neither study investigated the time course of the attentional bias under stress. Therefore, it is unclear whether individuals exhibited an initial bias toward threat, and then later used controlled attention to avoid threat.

Although limited, there is also evidence that goal-directed attentional deployment serves as a generalized mechanism of emotion regulation. There is emerging evidence in the aging literature that suggests older adults preferentially deploy their attention toward positive stimuli and away from negative stimuli, whereas younger adults do not (Carstensen & Mikels, 2005; Mather & Carstensen, 2005). In a recent study, both younger and older adults demonstrated an initial bias toward emotional pictures. In contrast, only older adults deployed their attention away from threat later in the time course of attention (Rosler et al., 2005). In another recent study, older and younger adults were given pictures of negative-neutral scene pairs (Knight et al., 2007). Older adults deployed their attention away from threat for longer durations than the younger adults. Socioemotional selectivity theory suggests the tendency for older adults to avoid threat and attend to positive stimuli is a goal-directed behavior that contributes to increased emotion regulation ability (Carstensen, 1995; Mather & Carstensen, 2005).

These findings from both the anxiety and aging literatures are consistent with the hypothesis that individuals use goal-directed attentional deployment to regulate emotion. However, none of these studies actually manipulated an emotional goal to preferentially deploy attention toward or away from emotional stimuli. Some recent studies have trained individuals to exhibit an attentional bias away from threat or toward positive stimuli. They have shown this to be an effective way to enhance emotion regulation effectiveness (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Wadlinger & Isaacowitz, 2008). However, an explicit emotional goal related to attentional deployment was not given. The previous studies employed the dot-probe paradigm and modified the task so that the location of the probe was completely predictable. Specifically, the probe always followed either a neutral stimulus (as opposed to a threatening stimulus) or a positive stimulus (as opposed to a threatening stimulus) so that participants would learn to avoid threat and focus attention on either neutral stimuli or positive stimuli. Minimal demand was placed on goal-directed attention because no goal was given. To place a significant demand on goal-directed attention, an emotional goal should be given that instructs individuals to focus on a particular emotional category. In addition, the location of the probe should be unpredictable so that individuals must maintain the emotional goal throughout the entire task.

In order to determine the effectiveness of goal-directed attentional deployment, the choice of criterion measures of emotion regulation is critical. Subjective measures of emotional reactivity most often serve as the criterion measures of effective emotion regulation. However, objective measures of behavior provide important convergent (or divergent) information regarding the effectiveness of emotion regulation. Baumeister, Vohs, and Funder (2007) observed that while examining inner cognitive and experiential processes are important in psychology, behavior should be just as important, and yet it is rarely measured. In addition, the experiential, physiological, and behavioral outcomes of emotion and emotion regulation are often loosely coupled and sometimes discrepant (Bradley & Lang, 2000; Hubert & de Jong-Meyer, 1990; Mauss, Evers, Wilhelm, & Gross, 2006; Mauss, Levensen, McCarter, Wilhelm, & Gross, 2005). Therefore, both self-report and behavioral outcomes should be assessed to gain a more complete picture of emotion regulation effectiveness.

Studies of attentional control and anxiety, or emotion in general, tend to focus on visuo-spatial attention processes. In contrast, numerous theories of emotional dysregulation emphasize attentional control deficits for emotional imagery and thought content. There are numerous groups of individuals who exhibit a deficient ability to deploy attention away from emotional thought content and imagery including high trait-anxious individuals, neurotics, depressive ruminators, and clinical anxiety patients (Davis & Nolen-Hoeksema, 2000; Robinson, Wilkowski, Kirkeby, & Meier, 2006; Sarason, 1986; Sibrava & Borkovec, 2006; Watkins & Mason, 2002). Theories of nonclinical and clinical anxiety purport that intrusive worrisome thoughts are a primary source of anxiety (Eysenck, Derakshan, Santos, & Calvo, 2007; Sarason, 1986; Sibrava & Borkovec, 2006). Eysenck et al.'s (2007) attentional control theory of nonclinical anxiety purports that high anxious individuals suffer from a general attentional control deficit, especially in mental set-shifting and inhibition. In contrast, Sibrava and Borkovec's (2006) cognitive avoidance theory of clinical anxiety suggests that those high in anxiety avoid attention to emotional imagery, but this avoidance increases worrisome thoughts. Davis and Nolen-Hoeksema (2000) hypothesized that depressive ruminators exhibit an "attentional inflexibility," that is, a deficient ability to shift attention away from negative ruminative thoughts. Recently, Whitmer and Banich (2007) directly linked multiple types of rumination to mental set-shifting ability and inhibition. Those who were more efficient at shifting between tasks or inhibiting previous mental sets exhibited lower levels of rumination. In sum, these studies suggest that an individual's ability to apply attentional control to emotional mental representations is critical to effective emotion regulation.

While crucial to our understanding of emotional dysregulation, the literature lacks a measure of the ability to apply attentional control to emotional mental representations. As a result, one goal in these studies will be to develop such a measure and determine whether this ability predicts emotion regulation effectiveness. Individual differences in this ability will be measured by adapting a task switching paradigm and measuring the time it takes individuals to switch from an emotional mental set to a neutral mental set and from a neutral set to an emotional set (Johnson, in press a). This measure of emotional attention set-shifting assesses attentional control capacity for emotional representations (ACCE). The task measuring ACCE will capitalize on the theoretically rich area of task switching (Monsell, 2003). Generally, it takes more time to switch between tasks than to perform the same task repeatedly. The additional time required to switch between tasks has been termed switch cost. Switch cost is thought to reflect multiple executive processes required to reconfigure a task set and other attentional processes unrelated to task set reconfiguration (Logan, 2003; Monsell, 2003; Rogers & Monsell, 1995; Rubinstein et al., 2001). Accordingly, individual differences in emotional attention set-shifting will be measured by the magnitude of switch cost.

Vogel and Awh (2008) noted that recently cognitive neuroscientists have begun to use individual differences in cognitive processes to constrain cognitive theory. This is an example of Cronbach's (1957) call for the integration of correlational and experimental psychology – a challenge often heralded but rarely employed. Studies of attentional deployment in emotion regulation theory offer an excellent opportunity to capitalize on individual differences. Therefore, the current studies will integrate experimental and individual-difference approaches to determine whether attentional deployment can serve as a mechanism of emotion regulation.

This paper reports three studies including one study of the role of visuo-spatial goal-directed attention in anxiety and emotion regulation and two studies that investigate the relationship between emotional attention set-shifting (measuring ACCE) and emotion regulation effectiveness. In Study 1, it is predicted that those given the emotional goal to deploy attention toward positive emotional stimuli under stress will exhibit less emotional reactivity to a subsequent stressor (e.g., report lower levels of frustration) and persist longer on a subsequent stressful task. In addition, individual differences in the ability to employ goal-directed attention to positive emotional stimuli under stress will also be predictive in that those with a greater ability to deploy attention will exhibit less emotional reactivity to a subsequent stressor and greater persistence on a subsequent stressful task. The literature is conflicted regarding the role of anxiety in one's ability to employ goal-directed attention. Anxiety's role will be investigated by testing whether it moderates individuals' ability to strategically deploy attention to positive emotional stimuli and away from negative emotional stimuli.

Study 2 examines whether ACCE is related to both trait anxiety and current levels of worrisome thoughts. Eysenck et al.'s (2007) attentional control theory suggests those higher in anxiety should exhibit a deficit in switching ability, particularly in disengaging attention from emotional stimuli. As a result, those higher in anxiety should exhibit an increased emotional-to-neutral switch cost and a reduced neutral-to-emotional switch cost. In contrast, Sibrava and Borkovec's (2006) cognitive avoidance theory predicts those higher in anxiety avoid attention to emotional imagery and therefore should exhibit an increased neutral-to-emotional switch cost and a reduced emotional-to-neutral switch cost. To distinguish ACCE from general attentional control capacity, working memory capacity (WMC) will also be measured. Individual differences in attentional control capacity have been captured well by WMC as measured by complex span (Unsworth, & Engle, 2007). Those higher in WMC demonstrate superior inhibition ability (Kane & Engle, 2003; Conway, Cowan, & Bunting, 2001), switching ability (Kane, Bleckley, Conway, & Engle, 2001; Unsworth, Schrock, & Engle, 2004), and updating ability (Oberauer, 2005).

Study 3 investigates the role of ACCE in general emotion regulation. The cognitive and social neuroscience literatures offer important insight into how emotional attention set-shifting may be related to emotion regulation. In one functional magnetic resonance imaging study, participants were given compound stimuli that consisted of faces on which a word was superimposed (Yeung, Nystrom, Aronson, & Cohen, 2006). They had to switch between judging the gender of the face and the number of syllables of the word on that face. Yeung et al. (2006) found that activity in the brain regions selective for the currently irrelevant task predicted the magnitude of the switch cost. For example, participants exhibited a larger switch cost of switching from a gender-to-word judgment when their brain activity indicated they failed to disengage the gender mental set during the word judgment. Similarly, Winston, O'Doherty, and Dolan (2003) showed that brain regions that respond to emotional expressions (i.e., amygdala and fusiform gyrus) were active whether participants were making an emotionally-neutral judgment or an emotionally-directed judgment (see also Winston, Strange, O'Doherty, & Dolan, 2002).

These findings suggest two predictions for the relationship between emotional attention set-shifting and emotion regulation. First, individuals with less effective emotional attentional control may exhibit difficulty disengaging the emotional mental set and reconfiguring to the neutral set. This will result in a larger switch cost for the emotional-to-neutral task switch. Similarly, if those with less effective emotional attentional control have difficulty disengaging the emotional mental set, then switching from a neutral set back to an emotional set should be facilitated. This will be reflected in a reduced neutral-to-emotional mental set switch cost. Like Study 1 and Study 2, emotion regulation effectiveness will be assessed using both self-report of emotional reactivity to a stressful task and by measuring persistence time on this task.

Study 1

Method

Participants

Participants were 109 (67 female) undergraduate psychology students who volunteered to participate as one alternative for supplemental course credit. All participants had normal or corrected to normal vision. The average age was 19.03 years (*SD* = 1.59).

Materials

Dot-probe task. To test whether an individual can use goal-directed attention on emotional stimuli, a modified dot-probe task was used (MacLeod, Mathews, & Tata, 1986). In this task, participants are visually presented a pair of faces, one above another, and these faces are then removed and a dot-probe appears in the previous location of just one of the faces. Participants respond as quickly as possible to the dot-probe by indicating whether one or two dots are presented. Stimuli were 36 faces with the highest validity ratings from MacBrain Face Stimulus Set (Tottenham et al., 2002). Each face pair consisted of the same person, where one picture had a happy expression and the other picture had an angry expression. Only happy and angry faces of high intensity were used (Tottenham et al., 2002). To assess the point in the time course of attentional processing when participants are able to deploy goal-directed attention, the face pairs were presented for three durations, 17ms (including a neutral-pair mask for 68ms that immediately followed a happy-angry pair), 500ms, and 1250ms (Milders, Sahraie, & Logan, 2008; Mogg, Philippot, & Bradley, 2004). The 17ms presentation period was used to assess preconscious attentional processing (Milders et al., 2008). The 500ms presentation period was used because it represents the most common presentation period and represents both preconscious and conscious attentional processing. The 1250ms presentation was used to provide ample time for controlled attention processes.

Stressful anagram task. The anagram task was designed to place a demand on emotion regulation (i.e., elicit anxiety and frustration) where participants had to unscramble a group of letters to make a single word (MacLeod et al., 2002). Four anagrams were presented. Two were insoluble anagrams, and two were difficult, multi-syllable anagrams. To increase the anxiety and frustration elicited by the task, participants were instructed not to write anything down during the task. To place an additional demand on emotion regulation, they were informed that at the end of the session they would be asked to recall what strategies they used to solve the anagrams without the ability to write anything down. The primary dependent variable was the duration of time participants persisted in trying to solve the anagrams.

Questionnaires. Trait anxiety was measured using the Trait Anxiety Inventory (Speilberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Feelings of state anxiety and state frustration were monitored repeatedly using a brief, two-item Likert scale (1-10) questionnaire.

Procedure

Participants first completed baseline measures of state anxiety and state frustration and the trait anxiety scale. Then, they were administered the first anagram task followed by a second assessment of state anxiety and frustration. This first administration of the anagram task ensured participants were under stress when taking the dot-probe task. Next, participants were randomly assigned to either a *goal* or *no goal* condition ($N = 54$ in the goal condition; $N = 55$ in the no goal condition). They were given either *goal* instructions that instruct participants to focus their eyes on happy faces, and avoid focusing their eyes on angry faces, or the *no goal* instructions that only instructed the participants how to perform the dot-probe task. In addition, participants in the goal condition were told that whether the probe appeared behind a happy or angry face was completely random, so they should keep their eyes focused on the happy faces no matter where the probe may appear.

The dot-probe task consisted of 16 practice trials followed by two blocks of 72 test trials, each with 24 trials for each stimulus duration. The stimulus duration of 17ms, 500ms, or 1250ms was randomized by participant. The location of the dot-probe, that is, whether it appeared in the upper or lower location, or behind either face of a particular face-pair was randomized by participant with the constraints that the dot-probe had to appear an equal number of times behind happy and angry faces, and at the top and bottom of the screen.

Following the dot-probe task, participants completed the measure of state anxiety and frustration a third time. Then, they completed a second administration of the anagram task. Four new anagrams were used for this second administration. To conclude the session, participants completed a fourth assessment of state anxiety and frustration.

Results and Discussion

Operationalization of Goal-Directed Attentional Bias

To operationalize whether individuals could employ goal-directed attention and deploy their attention toward happy faces, and away from angry faces, a bias index was created that was similar to what is used commonly in the attentional bias literature (e.g., Wilson & MacLeod, 2003). A difference score was created by taking an individual's mean reaction time to probes following happy faces and subtracting it from the mean reaction time to probes following angry faces. It will be called a Positive Bias Index, where positive scores indicate a bias toward happy faces, and negative scores indicate a bias toward angry faces. Prior to creating the Positive Bias Index, reaction times shorter than 150ms and longer than three standard deviations above an individual's mean reaction time were excluded from all analyses.

Effect of Emotional Goal on Attentional Bias

Prior to testing differences between the conditions, individuals in the goal condition were tested to determine if they were able to focus their attention on happy faces and avoid angry faces. Differences between reaction times for probes following angry faces and probes following happy faces were tested by performing three repeated-measures ANOVAs at each stage of the time course. In the goal condition at the preconscious stage of the time course (i.e., at 17ms), individuals responded significantly faster to angry probes (M = 632.88, SD = 112.19) than to happy probes (M = 662.60, SD = 129.84), thereby indicating a bias toward angry faces, $F(1, 53) = 4.20$, $p = .045$. There was no significant bias at the midpoint in attentional processing. However late in the time course (i.e., at 1250ms), individuals were able to follow the emotional goal and responded significantly faster to probes following happy faces (M = 614.44, SD = 108.35) than to angry faces (M = 655.09, SD = 161.37), thereby exhibiting a bias toward happy faces, $F(1, 53) = 4.41$, $p = .040$. Thus, as Figure 1 demonstrates, those in the goal condition were able to override an automatic bias toward threat, and use goal-directed attention to deploy their attention away from threat late in the time course. Trait anxiety did not moderate any of these differences.

In contrast, in the no goal condition at the midpoint in the time course (i.e., 500ms), individuals responded significantly faster to angry probes (*M* = 578.10, *SD* = 81.43) than to happy probes (*M* = 601.80, *SD* = 98.66), $F(1, 54) = 4.16$, $p = .046$ (See Figure 1). There was not a significant attentional bias at the preconscious or late stage of the time course. Thus, those in the no goal condition did not strategically deploy attention toward happy faces, but instead exhibited a bias toward angry faces at the midpoint in attentional processing. It is unclear why those in the no goal condition did not exhibit an automatic bias toward angry faces at the preconscious stage of processing, like those in the goal condition. However, while trait anxiety did not moderate any of these differences, trait anxiety was moderately lower in the no goal condition, $F(1, 106) = 3.03$, $p = .085$). This trend could help account for a reduced (and somewhat reversed) bias toward angry faces early in attentional processing in the no goal condition.

To test whether those in the goal condition followed the emotional goal and deployed attention to happy faces more than those in the no goal condition, the Positive Bias Index was compared across conditions at the 500ms and 1250ms time in processing, when goal-directed attention is possible. Two univariate analyses of variances (ANOVAs) were performed, where condition (goal vs. no goal) served as the independent variable, and a Positive Bias Index for each point in the time course served as each dependent variable. Figure 1 shows that those in the goal condition successfully deployed attention away from threat at the late stage of processing (i.e., 1250ms) significantly more than those in the no goal condition, $F(1, 107) = 7.78$, $p = .006$, $\eta^2 = .07$. Trait anxiety did not moderate these differences.

Mood Reactivity: Goal vs. No Goal Comparison

To test whether the first administration of the anagram task was stressful for individuals in both conditions, a repeated-measures ANOVA was run in each condition on frustration scores from before to after the first anagram task. Frustration increased significantly in the goal and no goal conditions, $F(1, 53) = 42.06$, $p < .0001$, $F(1, 52) = 49.42$, $p < .0001$, respectively. Anxiety also increased significantly in the goal and no goal conditions, $F(1, 53) = 10.00$, $p = .003$, $F(1, 52) = 10.34$, $p = .002$, respectively.

To test whether goal-directed attentional deployment to happy faces led to a mood induction before the second anagram task, a one-way ANOVA was performed on both anxiety and frustration scores immediately after the dot-probe task. Deploying attention to happy faces did not have a direct effect on mood as no condition differences emerged, for frustration ($p = .312$) or anxiety ($p = .447$).

To test whether goal-directed attentional deployment to happy faces predicted reactivity differences in frustration and anxiety in response to the second anagram task, two 2 X 2 mixed ANOVAs with a multivariate approach were performed, where condition served as the between-subjects factor and either frustration or anxiety before and after the second administration of the anagram task served as the within-subjects factor. There was a significant interaction between condition and frustration reactivity from before to after the second anagram task, $F(1, 106) = 3.93$, $p = .049$. Follow-up contrasts revealed that frustration scores in the goal condition increased significantly less from before to after the second anagram task (before: $M = 4.72$, $SD = 2.20$, after: $M = 5.87$, $SD = 2.53$, $F(1, 52) = 10.23$, $p = .002$, $\eta^2 = .16$, compared to the increase in frustration scores in the no goal condition (before: $M = 4.27$, $SD = 2.34$, after: $M = 6.38$, $SD = 2.42$, $F(1, 54) = 42.43$, $p < .0001$, $\eta^2 = .44$. Trait anxiety did not moderate this difference. The effect size of the increase in frustration was almost three times larger in the no goal condition. Thus, those who were instructed to deploy attention toward happy faces and away from angry faces responded with significantly less frustration to the stressful anagram task. It is important to reiterate the dot-probe task itself did not induce a mood difference between the conditions. Consequently, the frustration reactivity difference between the conditions cannot be explained by a prior mood difference.

Mood Reactivity: Individual Differences in Attentional Deployment

For participants given the emotional goal, it is important to test whether individual differences in the ability to deploy attention toward happy faces and away from angry faces also predicted mood reactivity to the second anagram task. Those with a greater ability to focus on happy faces (i.e., a larger Positive Bias Index) did not report significantly less anxiety or frustration at any point in the time course of attentional processing. Trait anxiety did not moderate these relationships.

It is possible that among participants in the no goal condition, there were individual differences in spontaneous generation of an emotional goal to deploy attention toward happy faces. Similar to the goal condition, individual difference in attentional bias toward happy faces did not predict anxiety or frustration at any point in the time course of attentional processing. Trait anxiety did not moderate these relationships.

Persistence on the Anagram Task: Goal vs. No Goal Comparison

To test whether those in the goal condition persisted significantly longer on the second anagram task, an ANOVA was performed where condition served as the independent variable and the time spent on the anagram task served as the dependent variable. Those in the goal condition did not persist significantly longer on the anagram task, $p = .21$.

Persistence on the Anagram Task: Individual Differences in Attentional Deployment

For those in the goal condition, individual differences in the ability to deploy attention toward happy faces and away from angry faces were investigated by testing the correlations between the Positive Bias Index and the time spent on the anagram task at the midpoint and late in the time course. Individuals with a greater ability to employ goal-directed attention toward happy faces persisted longer on the second anagram task for both the midpoint in attentional processing, $r(53) = .29$, $p = .036$, and late in attentional processing, $r(53) = .32$, $p = .018$. Figure 2 shows a positive relationship between an individual's ability to deploy their attention to happy faces and anagram persistence. It is important to note that these relationships did not emerge between the Positive Bias Index and persistence on the first administration of the anagram task. Therefore, individual differences in the ability to deploy attention to happy faces under stress were related to reactivity to a subsequent stressor. In addition, trait anxiety did not moderate these relationships.

Again, it is possible that some participants in the no goal condition spontaneously generated an emotional goal and deployed attention toward happy faces. However, individual differences in attentional bias toward happy faces did not predict persistence on the second anagram task at any point in the time course of attentional processing. Trait anxiety did not moderate these relationships.

The purpose of this study was to investigate whether goal-directed attentional deployment toward positive stimuli and away from negative stimuli could serve as a mechanism for emotion regulation. While long thought to be a major mechanism of emotion regulation, this study may be the first to directly link goal-directed attentional deployment to more effective emotion regulation. The results indicated that deploying attention toward positive faces and away from angry faces substantially lowered frustration reactivity to a stressful anagram task. In addition, individual differences in the ability to deploy goal-directed attention toward happy faces and away from angry faces predicted actual behavior during emotion regulation. Specifically, those who were better at deploying attention to happy faces persisted longer on the stressful anagram task.

While this study demonstrates the importance of goal-directed visuo-spatial attentional deployment to emotion regulation, the purpose of studies two and three are to determine whether attentional deployment to internal emotional mental representations is also important to emotion regulation. These studies investigate the importance of internally focused attentional deployment to anxiety, worry, and emotion regulation in general.

Study 2

Method

Participants

One hundred and eighteen participants volunteered to participate in the study for course credit. All participants were undergraduate psychology students and had normal or corrected-to-normal vision (80 women; age, $M = 19.21$, $SD = 2.32$).

Materials

Attentional Control Capacity for Emotion (ACCE) Task (Johnson, in press a). This task adapted the explicit task-cuing paradigm to measure an individual's ability to shift attention between emotional and neutral mental sets. Participants performed one of two judgments on a compound stimulus that consisted of a face with a shape centered between the eyes. Figure 3 provides a graphical depiction of the task and trial types. For the emotional judgment, participants were to identify the emotional expression on the face that could be happy, angry, or neutral. For the neutral judgment, participants were to identify the type of shape centered between the eyes on the face; which could be a circle, square, or triangle. Prior to seeing a face with a shape on it, the participant was shown either a solid bar or a patterned bar on the computer screen. A solid bar served as a cue to the participant to attend and respond to the emotional expression of the face (emotional mental set), whereas a patterned bar cued the participant to attend and respond to the type of shape between the eyes of the face (neutral mental set). Stimuli were two individuals from the MacBrain Face Stimulus Set, each with happy, angry, and neutral facial expressions (Tottenham et al., 2002) that were matched for valence and intensity.

Moderators: General Attention Control Capacity, Trait Anxiety, and Worry. General attentional control capacity was assessed using a computerized version of the operation span task, called automated operation span (AOSPAN; Unsworth, Heitz, Schrock, & Engle, 2005). This task possesses good internal consistency (α = .78) and test-retest reliability (.83). In this task, participants are presented with a letter followed by a two-operation mathematical problem. The task varies the number of letters for memorization and subsequent recall of the letters must be in order. High span scores are achieved by holding a greater number of letters in memory, while maintaining a pre-specified math accuracy level (85% or higher). Each trial is paced so that a participant can only spend a fixed amount of time on a math problem. Each participant sets their own mathematical processing pace when performing the math task alone. The average time an individual spends on a math problem plus 2.5 standard deviations is set as the time limit for the math portion of the subsequent dual-task trials. For additional details regarding AOSPAN's task structure, scoring, and validity see Unsworth et al. (2005).

Trait anxiety was measured using the Trait Anxiety Inventory (Spielberger et al., 1983). The degree to which an individual is experiencing worrisome thoughts was measured using the Dundee Stress State Questionnaire (Matthews et al., 1999).

Procedure

Participants completed the measures in following order: trait anxiety scale, worrisome thoughts scale, AOSPAN, and the ACCE task. For the ACCE task, there were 25 practice trials to learn the response mappings for the emotional judgment that required participants to press the 1, 2, and 3 keys for the happy, angry, and neutral faces, respectively. Immediately prior to each face-shape combination, a solid bar was presented for either 200 ms or 1500 ms that served to cue the task set. Then, the face-shape combination stimulus was presented until the participant responded or until 5 s had elapsed. Feedback was provided after each response, so that "Correct!" or "Incorrect" was presented for 1500 ms after each response. If the participant did not respond within 5 s, "No response detected" was presented for 1500 ms. Then, an inter-trial interval (ITI) of 500 ms elapsed until the next cue was presented and the cycle started again. The cue-to-stimulus interval (CSI) was randomized so that half the CSIs were short (200 ms) and half were long (1500 ms). The cue remained on screen throughout the CSI because maintaining the presence of the cue until a stimulus is presented places a greater demand on attentional control (Verbruggen, Leifooghe, Vandierendonck, & Demanet, 2007). Verbruggen et al. (2007) showed that maintaining the cue throughout the CSI reduces individuals' self-initiation of a task switch during the CSI, thereby resulting in a greater demand on attentional control.

There were also 25 practice trials where participants learned the response mappings for the shape judgment that required participants to press the 1, 2, and 3 keys for the circle, square, and triangle, respectively. Each of these face-shape combinations was preceded by a patterned bar cue and otherwise was identical to the emotional judgment practice trials. For the final 25 practice trials, participants had to perform both emotional and shape judgments repeatedly and in alternation. Otherwise, these trials were the same as the previous practice trials.

Following the practice trials, test trials were given. To place a greater demand on attentional control, only 1/3 (or 40) of the total 120 test trials were switching trials, while the remaining were repetition trials (Dreisbach & Haider, 2006; Dreisbach, Haider, & Kluwe, 2002). Dreisbach and colleagues showed that when repetition trials were more frequent, there was a greater switch cost compared to when repetition trials were less frequent than switching trials. This suggests a greater demand on attentional control in the frequent repetition trial condition (although see Dreisbach & Haider, 2006, for discussion of repetition benefit versus shift trial slowing). It follows that if emotion repetition trials are more frequent than switching trials, it would be more difficult to disengage from emotion and engage a neutral set and easier to disengage a neutral set and engage an emotional set, due to proactive interference for an emotional task set (Allport & Wylie, 2000). The frequent emotion repetition trial manipulation was used because the goal of this study was to investigate attentional control for emotional mental representations, and this maximized the attentional control demand for disengaging an emotional task set. Therefore, the breakdown of the test trials was as follows; 20 neutral-emotion (NE) switching trials, 20 emotion-neutral (EN) switching trials, 60 emotion-emotion (EE) repetition trials, and 20 neutral-neutral (NN) repetition trials. Except for the constraint that the first 10 test trials were emotion judgments, one pseudo-randomized order for the different trial types was created and presented to all participants.

In addition, given that the goal of this study is to investigate emotional attention set-shifting, the contribution of participants' reaction to emotional faces during switching was minimized. It is quite possible that the emotional valence of a stimulus also influences the ability to switch between mental sets (as shown in Yeung et al., 2006; Winston et al., 2003). Therefore, the valence of the face was always neutral for the trial preceding a switching trial and the switching trial. For example, if the participant is first cued to make an emotional judgment and then on the next trial is cued to make a neutral judgment, the faces on both these trials were neutral. This was the case for all types of switching trials. Therefore, any effects of an increased difficulty in disengaging from an angry face, for example, are minimized in all measures of switch cost. While this does not completely remove the effects of stimulus valence, this does minimize the effects.

Preliminary Analyses

Prior to data analyses, data were screened for outliers by excluding reaction times (RTs) shorter than 130ms. In addition, excessively long RTs were screened by excluding RTs longer than 3 standard deviations above an individual's mean RT. This resulted in trimming a small percentage of the data as less than 1% (0.3%) of the total RTs were excluded. In addition, participants were screened to ensure all were performing above chance levels of accuracy, and all met this criterion.

Operationalization of Emotional Attention Set-Shifting Ability

A method commonly used in the task switching literature was used to operationalize individual differences in set-shifting ability for emotional and neutral mental representations. Switch costs were calculated by computing two difference scores (e.g., Friedman et al., 2006; Monsell, 2003; Verbruggen et al., 2007). The mean RT for the NN repetition trials was subtracted from the mean RT for the EN switching trials to obtain individual differences in EN Switch Cost. The mean RT for EE repetition trials was subtracted from the mean RT for NE switching trials to obtain individual difference in NE Switch Cost. These difference scores should not suffer from low reliability because the components of the difference score are not negatively correlated (Rogosa & Willett, 1983). The bottom portion of Figure 3 shows how EN Switch Cost and NE Switch Cost were calculated for the ACCE task.

It is important to note that each of these switch costs do not represent a single cognitive process; rather they include all the executive processes required to disengage a previous mental set and engage a different mental set. For example, EN Switch Cost represents multiple processes required to disengage attention from the emotional mental set and engage attention on the neutral mental set. In addition, because the emotion repetition trials were more frequent, the attentional control demand was increased for an emotional to a neutral task switch, and decreased for a neutral to an emotional task switch (see Dreisbach & Haider, 2006). Therefore, EN Switch Cost reflects an increased attentional control demand, and NE Switch Cost reflects a decreased attentional control demand. The primary goal in this study was to capture individual differences in the ability to switch between emotional and neutral mental representations. Regardless of which precise component processes are involved, EN Switch Cost requires an individual to both disengage an emotional mental set and engage a neutral set and NE Switch Cost requires the individual to both disengage a neutral set and engage an emotional set; thereby capturing the construct of interest. In addition, by making emotion repetition trials more frequent, the emotional set should be more difficult to disengage than the neutral set, thereby placing a greater demand on attentional control for disengaging emotional representations.

Results and Discussion

Emotional Attention Switch Cost

The purpose of these analyses was to determine, 1) whether the ACCE task placed a significant demand on task switching process, and 2) whether frequent emotion repetition trials increased the cost of switching from an emotional set to a neutral set and decreased the cost of switching from a neutral set to an emotional set.

A multivariate approach to a repeated-measures analysis of variance (ANOVA) on RT differences between EE, NN, NE, and EN trials revealed a significant main effect, $F(3, 115) = 69.99$, $p < .0001$. Bonferroni-adjusted contrasts revealed a significant NE Switch Cost, $F(1, 117) = 33.43$, $p < .0001$, $\eta^2 = .222$ and a significant EN Switch Cost, $F(1,117) = 129.82$, $p < .0001$, $\eta^2 = .526$. As shown in Figure 4, these differences could not be explained by a speed-accuracy tradeoff because accuracy scores decreased when RTs slowed. A repeated-measures ANOVA revealed that switching from an emotional set to neutral set ($M = 204.66$, $SD = 195.10$) took significantly longer than switching from a neutral set to emotional set ($M = 106.24$, $SD = 199.60$), $F(1, 117) = 13.41$, $p = .0004$, $\eta^2 = .103$. This provides evidence that disengaging an emotional set and engaging a neutral set placed a greater demand on attentional control than the reverse switch.

Moderators: General Attentional Control Capacity, Trait Anxiety, Worry

To test whether general attentional control capacity moderates switch cost, two regressions were run where each type of switch cost (i.e., EN Switch Cost and NE Switch Cost) served as the predictor and AOSPAN served the criterion variable. This tests whether the magnitude of switch cost was moderated by AOSPAN. Neither switch cost was significantly moderated by AOSPAN (p = .216, p = .427). This indicates general attentional control capacity could not account for the cost of switching attention between emotional and neutral mental sets.

Table 1 summarizes four regressions that test whether trait anxiety or worry moderates either EN Switch Cost or NE Switch Cost, where each type of switch cost served as a predictor variable and trait anxiety or worry served as the criterion variables. Both trait anxiety and worry significantly moderated NE Switch Cost so that those higher in trait anxiety and worry had a decreased ability to switch from a neutral mental set to an emotional mental set. However, the Fisher's z-transformation was used on all standardized beta coefficients from all the regressions. Bonferroni-corrected pair-wise comparisons were performed and none of the coefficients significantly differed. This suggests that while trait anxiety and worry appear to moderate emotional attention switch costs, the effect is modest and non-specific.

The ACCE task measured for the first time, to this author's knowledge, individual differences in emotional attention set-shifting ability. Those higher in trait anxiety and worrisome thoughts exhibited increased difficulty in switching from a neutral mental set to an emotional mental set. Importantly, the switch costs could not be explained by general attentional control capacity. This is important because it supports the idea that the switch costs measured by the ACCE task captured an attentional control capacity for emotional material specifically.

While this experiment demonstrated that performance on the ACCE task was related to trait anxiety and worry, it remains unclear whether ACCE performance is related to a generalized mechanism of emotion regulation. Therefore, it is important to test whether emotional attention set-shifting predicts emotion regulation effectiveness more directly.

Study 3

Method

Participants

Forty-two (30 women) undergraduate psychology students, who had normal or corrected-to-normal vision, volunteered to participate in the study for course credit.

Materials

The ACCE task was identical to that used in Experiment 1, except that the order of the practice trials (i.e., emotional vs. neutral mental sets) was counterbalanced. Trait anxiety was measured using the Trait Anxiety Inventory (Spielberger et al., 1983). To assess a participants' current feelings of anxiety and frustration at multiple times throughout the experiment, they were given a brief two-item Likert scale (1-10) questionnaire. This questionnaire asked participants to rate their anxiety from 1 (not anxious) to 10 (extremely anxious) and frustration from 1 (not frustrated) to 10 (extremely frustrated). Because participants answer these same items multiple times, this brief questionnaire was given in place of a full scale of state feelings to minimize questionnaire reactivity.

Stressful Anagram Task. The task designed to place a demand on emotion regulation (i.e., elicit frustration and anxiety) was an anagram task where participants had to unscramble a group of letters to make a single word (MacLeod et al., 2002). Four anagrams were given and consisted of two insoluble anagrams, and two difficult, multi-syllable anagrams. To increase the anxiety and frustration elicited by the task, participants were instructed not to write anything down during the task and were informed they would be asked to recall what strategies they used to solve the anagrams at the end of the session. The primary dependent variable was the total time participants persisted on the anagrams. Those who are better at regulating their emotion should be able to keep from being overwhelmed by frustration and anxiety and persist longer on the anagram task.

Procedure

Participants completed the measures in the following order: trait anxiety questionnaire, baseline measure of state anxiety and frustration, ACCE task, second measure of state anxiety and frustration, anagram task, and third measure of state anxiety and frustration.

Results and Discussion

Emotional Attention Switch Cost

The effects related to ACCE and switch costs from Experiment 1 were replicated. A multivariate approach to a repeated-measures analysis of variance (ANOVA) on RT differences between EE, NN, NE, and EN trials revealed a significant main effect, $F(3, 39) = 29.49$, $p < .0001$. Bonferroni-adjusted contrasts revealed a significant NE Switch Cost, $F(1, 41) = 11.25$, $p = .002$, $\eta^2 = .215$ and a significant EN Switch Cost, $F(1, 41) = 54.97$, $p < .0001$, $\eta^2 = .573$. These differences could not be explained by a speed-accuracy tradeoff because accuracy scores decreased when RTs slowed. A repeated-measures ANOVA revealed that switching from an emotional set to neutral set ($M = 250.30$, $SD = 218.78$) took significantly longer than switching from a neutral set to emotional set ($M = 106.56$, $SD = 205.91$), $F(1, 41) = 8.60$, $p = .006$, $\eta^2 = .173$.

Emotional Attention Switch Cost and Emotion Regulation

To test whether the anagram task induced anxiety and frustration, repeated-measures ANOVAs were run on the short test of anxiety and frustration presented just before and after the anagram task. Both anxiety and frustration increased significantly, $F(1, 41) = 19.57$, $p <.0001$, $\eta^2 = .323$; $F(1, 41) = 27.60$, $p < .0001$, $\eta^2 = .402$, respectively.

Four regressions were performed to test whether the ability to switch between mental sets uniquely predicted self-reported anxiety and frustration in response to the anagram task above and beyond trait anxiety. Neither switch cost predicted state anxiety. However, Table 2 shows that those who took longer to disengage a neutral set and re-engage an emotional set were less frustrated in response to the anagram task. This suggests that those who were able to shift from a neutral to emotional mental set more quickly were *more* frustrated. Fisher's z-transformation was used on all standardized beta coefficients from the regressions. A pair-wise comparison was performed and the NE Switch Cost coefficient predicted frustration significantly better compared to EN Switch Cost ($z = 1.91$, $p < .05$). This supports the idea that those who respond to a stressor with greater levels of frustration may not completely disengage an emotional mental set, thereby making it easier to shift to it from a neutral mental set (Winston et al., 2003; Yeung et al., 2006).

To test whether the ability to switch between emotional and neutral mental sets uniquely predicted persistence on the anagram task above and beyond trait anxiety, two regressions were performed where trait anxiety, and each type of switch cost served as predictors and the time spent on the anagram task served as the criterion variable. Table 3 shows that those with a reduced EN Switch Cost persisted significantly longer on the anagram task. Fisher's z-transformation was used on all standardized beta coefficients from the regressions. A pair-wise comparison was performed and revealed no significant difference between the coefficients for each type of switch cost. Figure 5 presents a scatterplot demonstrating that those who more efficiently disengaged an emotional set and reconfigured to a neutral set persisted longer on the anagram task.

General Discussion

Attentional deployment toward and away from emotional material is considered fundamental to emotion regulation (Gross & Thompson, 2007). While long thought to be a major mechanism of emotion regulation, Study 1 may be the first to directly link goal-directed attentional deployment to more effective emotion regulation. The results indicated that deploying visuo-spatial attention toward positive faces and away from angry faces substantially lowered frustration reactivity to a stressful anagram task. In addition, individual differences in the ability to deploy goal-directed attention toward happy faces and away from angry faces predicted actual behavior during emotion regulation. Specifically, those who were better at deploying attention to happy faces persisted longer on the stressful anagram task.

Study 1 used goal-directed attentional deployment as a bridge between anxiety-related attentional bias theory and emotion regulation theory. Regarding the attentional bias literature, the results of this study support Bar-Haim et al.'s (2007) hypothesis that an automatic threat-evaluation can be overridden. These results also support the shifted attentional account of anxiety-related attentional biases (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998). This account suggests that both high and low anxious individuals will have a bias toward highly threatening stimuli, and individual differences arise in the intensity of stimuli at which threat is perceived. All faces in this study were highly threatening or highly positive and therefore individual differences in anxiety may not strongly predict attentional processing. Importantly, these findings extend this literature by showing that deploying attention to emotional stimuli can be used as generalized mechanism for emotion regulation, irrespective of dispositional levels of anxiety. This simultaneously supports emotion regulation theory that suggests attentional deployment is a major mechanism of emotion regulation (Gross & Thompson, 2007).

These results also extend the literature on age differences in emotion regulation. While older adults appear to self-initiate an emotional regulation goal to deploy attention to positive stimuli, the results of this study indicate that younger adults can accomplish the same emotional goal and effectively regulate emotion as a consequence. Many of the previous studies investigate goal-directed emotional attention when little demand is placed on emotion regulation processes (Knight et al., 2007; Mather & Knight, 2005). It is possible that emotional regulation goals change in accordance with emotion regulation demands. This study showed that individuals are able to follow an emotional regulation goal while under stress and that this goal leads to increased regulation effectiveness on a subsequent stressor. Future studies should further investigate how different emotion regulation demands affect goal-directed emotional attention.

It is important to note that, overall, those in the goal condition who were told to deploy attention toward happy faces and away from angry faces did not persist significantly longer on the stressful anagram task. This prevents a causal interpretation of how persistence is affected by goal-directed attentional deployment. However, individual differences in the ability to deploy attention to happy faces did predict persistence on the anagram task, where those with a greater ability to deploy attention to happy faces persisted significantly longer. This provides initial evidence that individual differences in the ability to deploy attention predicts persistence on a stressful task. In addition, these findings provide evidence of convergence between experiential and behavioral domains when individuals are regulating emotion (Mauss et al., 2005).

Future studies should elucidate the mechanisms through which attentional deployment to positive stimuli leads to more effective emotion regulation. The findings in this study indicated that a general mood-induction from focusing attention on positive stimuli and away from negative stimuli could not account for the frustration reactivity differences between the conditions. An alternative explanation is that the positive attentional deployment goal carried over from the dot-probe task to the subsequent anagram task. Individuals in the goal condition may have consciously or unconsciously deployed their attention internally toward more positive thoughts, rather than being consumed by worrisome and frustrating thoughts. This may have led to decreased feelings of frustration after the subsequent anagram task. This explanation is consistent with the finding that goal-directed attentional deployment did not predict reactivity or persistence on the first anagram task prior to being given the emotional goal. This is also consistent with the aging literature that suggests young adults do not self-initiate goal-directed attentional deployment.

Another mechanism by which attentional deployment to positive stimuli leads to more effective emotion regulation could be related to affective priming. It is possible that focusing on happy faces primed other concepts related to positive mood through spreading activation (Klauer & Musch, 2003; Neely, 1991). While this spreading activation did not induce a positive mood, it may have made positive thoughts and memories more readily accessible (Forgas, 2001). Additionally, making positive concepts and thoughts more accessible could also make other emotion regulation strategies more accessible, such as cognitive reappraisal (Gross & Thompson, 2007). Consequently, those individuals focusing on happy faces experienced less frustration and persisted longer on a stressful task. While the results of this study do not fully elucidate the mechanisms of how attentional deployment leads to more effective emotion regulation, the findings do provide an important direct link between positive attentional deployment and effective emotion regulation.

The results showed that those given a goal to focus on happy faces exhibited an initial preconscious bias toward angry faces while those without this goal did not. This pattern of results may be due to an opponent process effect of a goal. This type of effect was observed by Richeson and Trawalter (2008) who gave individuals the dot-probe task that consisted of Black-White face pairs. Then, they gave some individuals the goal to avoid appearing prejudiced (i.e., look at the Black faces to avoid appearing prejudiced). These individuals demonstrated an early attentional bias that represented a reversal of their goal in that they avoided attention to Black faces. In contrast, individuals without this goal did not exhibit an early attentional bias. Late in the attentional time course, individuals in the goal condition met their goal and exhibited attentional bias toward Black faces. This opponent process effect was demonstrated in the current results in that those in the goal condition exhibited a goal reversal. Early in the attentional time course they focused on angry faces, whereas later in the time course they met their goal and focused on happy faces. Those in the no goal condition did not exhibit this reversal. This discrepancy between preconscious and conscious attentional biases could have important implications for the training of positive attentional biases (Wadlinger & Isaacowitz, 2008). By giving an individual a goal to avoid negative stimuli and focus on positive stimuli, we may paradoxically foster a preconscious threat-bias. Future studies should determine the role and the longevity of this paradoxical effect in training positive attentional biases.

By combining experimental and correlational approaches, Study 1 revealed findings that neither approach alone could uncover. The experimental approach showed that goal-directed attentional deployment to positive stimuli can serve as a generalized mechanism of emotion regulation. This causal link could not be established by using the correlational approach. However, the correlational approach showed that individual differences exist in the ability to use goal-directed attentional deployment under stress. Importantly, this approach showed that those better at using goal-directed attentional deployment under stress were also more effective emotion regulators. The experimental approach would have missed this informative finding because the approach would treat individual differences in goal-directed attentional deployment as error variance. These two findings demonstrate the explanatory power gained by combining the experimental and correlational approaches (Cronbach, 1957; Vogel & Awh, 2008).

Although speculative, these results suggest that training goal-directed attentional deployment could serve as a novel emotion regulation training technique for both nonclinical and clinical populations. MacLeod et al. (2002) trained nonclinical participants to attend to neutral words and avoid threatening words and found it predicted decreased anxiety vulnerability to a stressful task. This training appears to generalize to clinically anxious patients as well (Vasey, Hazen, & Schmidt, 2002). The results of this study indicated that frustration reactivity to a stressful task was decreased almost by a factor of three by simply attending to happy faces and avoiding angry faces. This represents a much larger impact of training than observed in the previous studies. This may indicate that encouraging individuals to rely on strategic attentional processes may be a more effective way to train better emotion regulation than relying on automatically trained attentional biases. Goal-directed attentional deployment holds considerable promise for future research into training more effective emotion regulation techniques.

Studies 2 and 3 investigated the relatively unknown processes through which emotion is regulated by attentional deployment toward and away from emotional mental representations and thought content. To examine these processes, a new measure was developed to assess one's ability to deploy attention to emotional mental representations, called attentional control capacity for emotion (ACCE). The ACCE task adapted a task switching paradigm and required participants to switch between emotional and neutral mental sets. Individual differences in ACCE were measured by the magnitude of switch cost from this emotional attention set-shifting task. This measure represents a significant shift in thinking about switch cost in that it is considered not only an executive control process, but also an important individual-difference construct in the context of emotion regulation.

In Study 2, individuals high in trait anxiety and worrisome thoughts exhibited a difficulty in switching from a neutral to an emotional set. The relationship between ACCE and trait anxiety/worry partially supported Sibrava and Borkovec's (2006) cognitive avoidance theory of anxiety. Sibrava and Borkovec's theory posits a primary source of anxiety is the constant avoidance of threatening imagery. The results showed that those high in anxiety and worry had a deficit in ability to switch from a neutral to emotional mental set. This finding is consistent with cognitive avoidance theory because it should take longer for high anxiety individuals to switch to emotional set if they are attempting to avoid attention to emotional mental representations. However, this particular switch cost could not be statistically differentiated from the other types of switch costs in its relationship to anxiety. Therefore, this explanation should be interpreted cautiously. In addition, the ACCE task did not require participants to disengage attention from threat specifically, but rather from an emotional mental set that was not valence-specific. Therefore, the current study cannot test Sibrava and Borkovec's theory directly. However, the ACCE framework provides a promising ground for future work testing a primary hypothesis in Sibrava and Borkovec's theory that worriers specifically avoid threatening mental imagery. In addition, these results provide partial support of Eysenck et al.'s (2007) hypothesis that those high in anxiety exhibit a generalized switching deficit because the switch costs were not significantly different regarding their relationship to trait anxiety.

The findings connecting ACCE and anxiety highlight a new direction for future research on anxiety. Many theories of anxiety purport that those high in anxiety have selective difficultly disengaging attention from threatening material (Bar-Haim et al., 2007; Eysenck et al., 2007; Mathews & MacLeod, 2005; Fox, Russo, Bowles, & Dutton, 2001). Future studies should test emotional attention set-shifting for threatening material specifically in high anxious individuals. While many studies have confirmed that those high in anxiety have difficultly disengaging visual attention from threatening stimuli, the same hypothesis regarding disengaging attention from a threatening mental set has yet to be tested.

The ACCE task appeared to capture a task switching ability for emotional representations specifically, as opposed to a general switching ability. General attentional control capacity, as measured by working memory capacity, did not moderate the cost of switching between emotional and neutral mental sets. The primary goal in this study was to test whether general attentional control capacity could account for switch cost in the ACCE task. However, this design does not rule out general switching ability as an explanation of switch cost in ACCE. To further establish the discriminant validity of the ACCE task, it should be compared to an identical switching task without the emotional relevance. Indeed, Johnson (in press a) designed such a task and has shown ACCE predicts emotion regulation better than general switching ability.

Study 3 supported the importance of attentional deployment in successful regulation of emotion (Gross & Thompson, 2007). This study demonstrated a convergence between experiential and behavior domains of emotion regulation. Those higher in ACCE were less frustrated and persisted longer on the anagram task (Mauss et al., 2006; Mauss et al., 2005). In the behavior domain, those that were more efficient at disengaging attention from an emotional set persisted significantly longer on the anagram task. In the experiential domain, those with higher frustration reactivity switched more efficiently from a neutral to emotional set. In contrast, in Study 2, those higher in trait anxiety exhibited the opposite trend. This discrepancy suggests that the strategy to avoid emotional stimuli could be specific to high anxiety individuals and is not an effective generalized emotion regulation strategy (Sibrava & Borkovec, 2006). Instead, it is more effective to be flexible in goal engagement, rather than maintain an avoidance goal like those high in anxiety. The relationship between ACCE and frustration reactivity suggests it is more effective to completely disengage an emotional set when this is the goal and re-engage emotion when it is the goal.

The emotional attention set-shifting task was designed to provide both a window into a mechanism of emotion regulation (i.e., attentional deployment) and a measure of individual differences in ACCE. Indeed, individual differences in ACCE were related to trait anxiety, worrisome thoughts, and general emotion regulation effectiveness. However, it is important for future research to determine whether ACCE can be manipulated to affect emotion regulation so that its causal status can be ascertained. For example, it is possible that if participants were put into an anxiety-provoking situation, anxiety and frustration could directly impact ACCE performance.

Future studies could investigate the executive processes necessary to successfully complete an emotional task switch including exogenous and endogenous processes. For example, task set reconfiguration is considered an endogenous attentional process, while the effect of proactive interference on switch cost is an exogenous process. Therefore, it is likely that switching between emotional and neutral mental sets required both endogenous and exogenous attentional processes (Johnson, in press a; Monsell, 2003; Rogers & Monsell, 1995; Rubinstein et al., 2001). Future studies could determine the degree to which emotional attention set-shifting is driven by exogenous processes and endogenous processes, just as general task switching theorists have investigated for many years (Rogers & Monsell, 1995; Verbruggen et al. 2007).

This study highlights new questions about emotion regulation. How might internally-focused and externally-focused forms of attentional control for emotional mental representations interact to affect emotion regulation? How do individuals consciously deploy attention externally to stimuli in the environment and internally to thoughts and imagery? It is possible that those who are less able to disengage their attention from emotional thoughts instead rely on deploying visual attention toward positive features of the environment, like a positive scene or happy face? The ACCE task may provide a framework with which to investigate this question because the task switching paradigm offers numerous ways to manipulate the demand on external and internal processes.

In conclusion, these studies demonstrated that both visuo-spatial attentional deployment and attentional deployment to emotional mental representations are important to an individual's ability to regulate emotion. Given the importance of attentional deployment in nonclinical anxiety, clinical anxiety, rumination, and depression, it is important to elucidate these attentional deployment mechanisms. A better understanding of these mechanisms will allow clinicians to target the cognitive processes responsible for ineffective emotion regulation and psychopathology. Determining the role of all forms of goal-directed attentional deployment provides an important avenue for discovering novel intervention and therapeutic techniques for those in need.

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Table 1.

Four Regressions With EN Switch Cost and NE Switch Cost as Predictors of Trait Anxiety and Worry.

Reg. Number	Predictor Variable	Criterion Variable	*b*	*SE b*	β
1	EN Switch Cost	Trait Anxiety	.002	.003	.06
2	NE Switch Cost	Trait Anxiety	.010	.003	.24**
3	EN Switch Cost	Worry	.007	.004	.14
4	NE Switch Cost	Worry	.009	.004	.18*

Note. For criterion variable worry, $N = 118$. For criterion variable trait anxiety data from experiments 1 and 2 were combined for an $N = 160$. Reg. = Regression.

*$p < .05$, **$p < .01$

Table 2.

Regressions With Trait Anxiety, EN Switch Cost, and NE Switch Cost as Predictors of Frustration.

Reg. Number	Variable	*b*	*SE b*	β
1	Trait Anxiety	.056	.046	.19
	EN Switch Cost	.001	.002	.09
2	Trait Anxiety	.042	.044	.14
	NE Switch Cost	-.004	.001	-.33*

Note. $N = 42$, *$p < .05$, **$p < .01$. Reg. = Regression.

Table 3.

Regressions With Trait Anxiety, EN Switch Cost, and NE Switch Cost as Predictors of Anagram Persistence Time.

Reg. Number	Variable	*b*	*SE b*	β
1	Trait Anxiety	1293	1174	.17
	EN Switch Cost	-108	38	-.41**
2	Trait Anxiety	1224	1187	.16
	NE Switch Cost	-34	44	-.12

Note. $N = 42$, *$p < .05$, **$p < .01$. Reg. = Regression.

Figure Captions

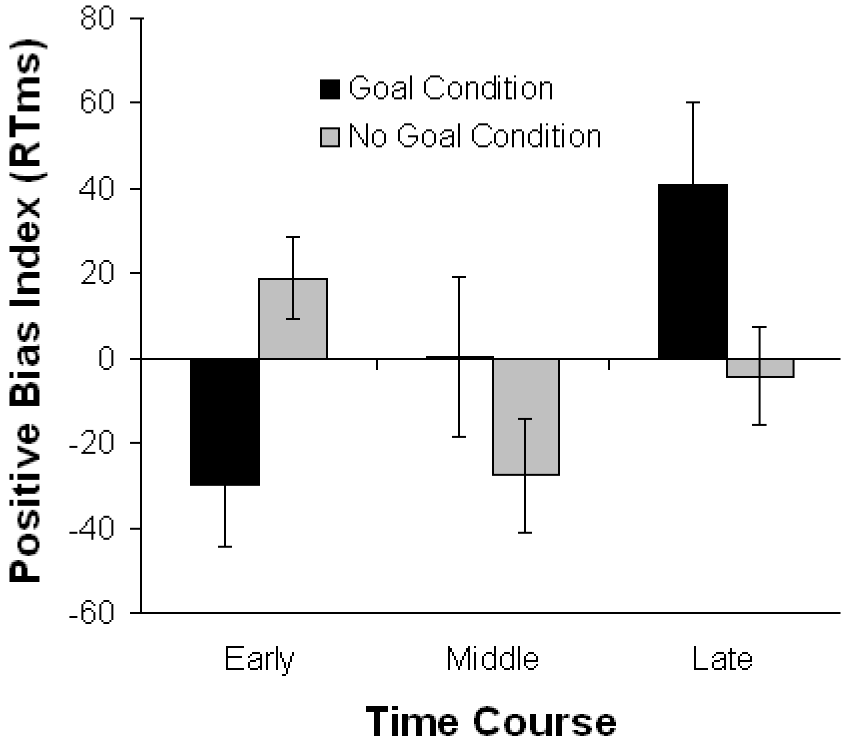
Figure 1. Results show attentional biases toward either happy or angry faces as a function of the condition and time course in attentional processing. Positive scores indicate an attentional bias toward happy faces, whereas negative scores indicate an attentional bias toward angry faces. Early = 17ms faces presentation, Middle = 500ms faces presentation, Late = 1250ms faces presentations.

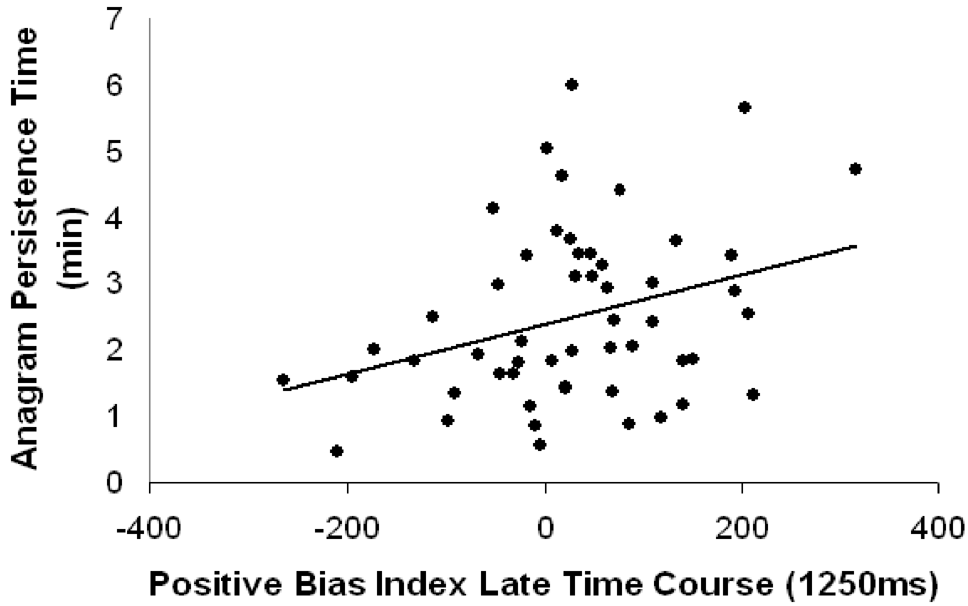
Figure 2. Results show anagram persistence time as a function of individual differences in the Positive Bias Index late in the time course of attention processing, when the faces were presented for 1250ms.

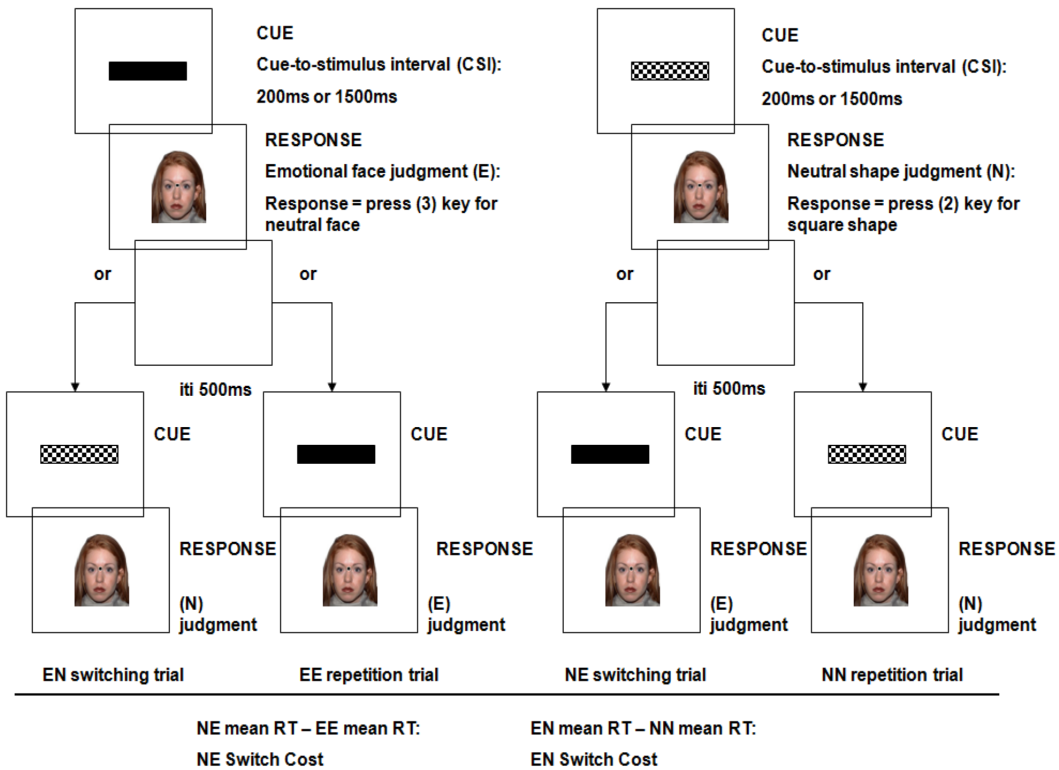
Figure 3. A schematic of the ACCE task. Each trial began with a cue that informed the participant which judgment to make, the cue remained on the screen for either 200ms or 1500ms until it was replaced by the stimulus on which the participant was to make a judgment. Then, a blank screen was presented for an iti (inter-trial interval) of 500ms and the next trial begins. The bottom section of the depiction for each task shows how each type of switch cost was calculated. RT = Reaction Time. See text for details.

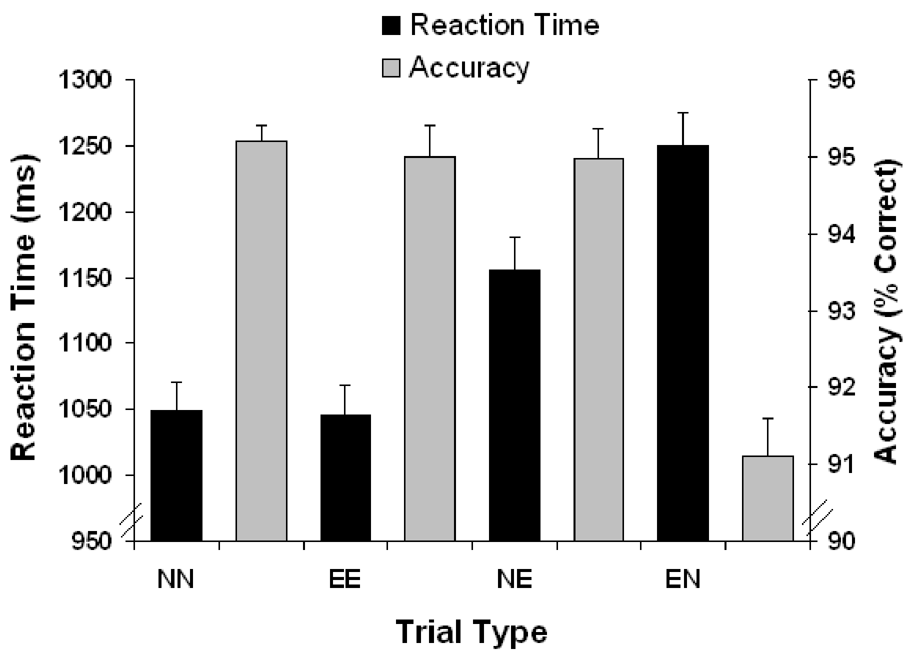
Figure 4. Results from Study 2 that show significant switch costs for both NE and EN trials and shows a significantly greater switch cost for EN trials, compared to NE trials. NN = neutral-neutral repetitions, EE = emotion-emotion repetitions, NE = neutral-emotion switches, EN = emotion-neutral switches.

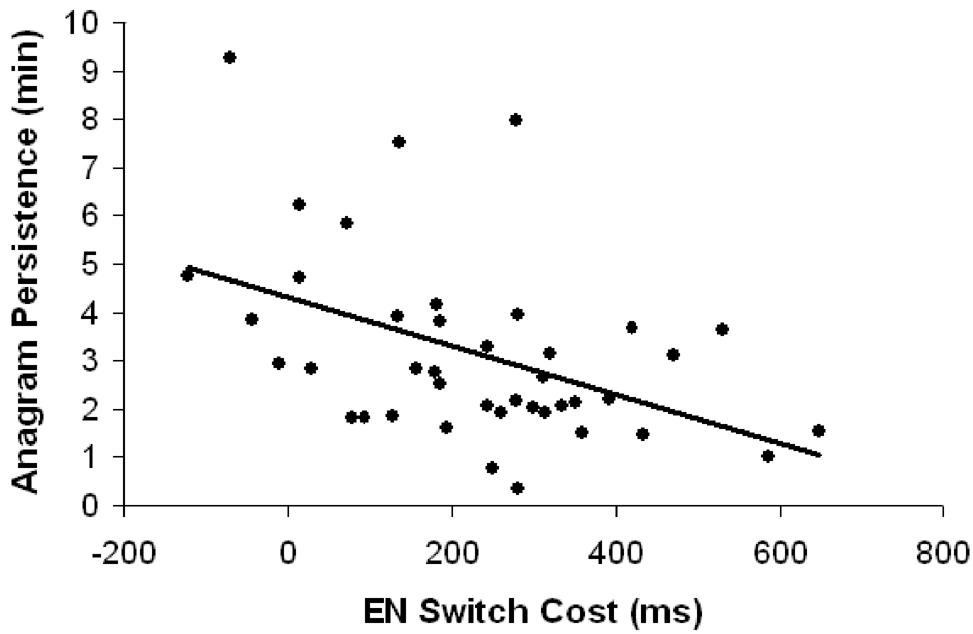
Figure 5. Results from Study 3 that show anagram persistence time as a function of EN Switch Cost.


80
60
40
20
0
-20
-40
-60
Positive Bias Index (RTms)
Goal Condition
No Goal Condition
Early
Middle
Late
Time Course


Anagram Persistence Time (min)
0
1
2
3
4
5
6
7
-400
-200
0
200
400
Positive Bias Index Late Time Course (1250ms)


CUE
Cue-to-stimulus interval (CSI):
200ms or 1500ms
RESPONSE
Emotional face judgment (E):
Response = press (3) key for
neutral face
or
or
iti 500ms
CUE
RESPONSE
(N)
judgment
CUE
RESPONSE
(E)
judgment
EN switching trial
EE repetition trial
CUE
Cue-to-stimulus interval (CSI):
200ms or 1500ms
RESPONSE
Neutral shape judgment (N):
Response = press (2) key for
square shape
or
or
iti 500ms
CUE
RESPONSE
(E)
judgment
CUE
RESPONSE
(N)
judgment
NE switching trial
NN repetition trial
NE mean RT – EE mean RT:
NE Switch Cost
EN mean RT – NN mean RT:
EN Switch Cost


Reaction Time
Accuracy
Reaction Time (ms)
1300
1250
1200
1150
1100
1050
1000
950
Accuracy (% Correct)
96
95
94
93
92
91
90
NN
EE
NE
EN
Trial Type


Anagram Persistence (min)
10
9
8
7
6
5
4
3
2
1
0
-200
0
200
400
600
800
EN Switch Cost (ms)