Emotion regulation, cognitive control, rumination and history of depression

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Abstract

Depression is a highly recurrent disorder characterized by emotion dysregulation, cognitive control impairments and ruminative response style. There are no published studies on emotion regulation in previously depressed participants and the existing data on the relationship between rumination, cognitive control and emotion regulation is mixed. There were two main aims of this study: The first was to investigate emotion regulation, cognitive control and rumination in previously depressed as compared to never depressed participants. The second was to investigate the relationship that cognitive control and rumination have to emotion regulation in all participants. Participants were 13 previously depressed and 19 never before depressed adults between the ages of 18-58 who were enrolled in an emotion regulation experiment. Negative emotions were induced by emotionally arousing pictures and the participants were instructed to down-regulate their emotional reactions, which were measured by a numerical rating scale (NRS). Cognitive control was measured by a version of the STROOP test and ruminative response style was measured by questionnaire. There were no group differences on any of the main measures, indicating that history of depression did not influence emotion regulation success, cognitive control or tendency to ruminate. Across all participants, emotion regulation was dependent upon the cognitive control measure of Switching/Cognitive flexibility. These results highlight the importance of cognitive control in emotion regulation.

“Concern should drive us into action and not into a depression. No man is free who cannot control himself.”
-- Pythagoras

“Do not brood over your past mistakes and failures as this will only fill your mind with grief, regret and depression. Do not repeat them in the future.”
-- Sivananda

Introduction

The ability to effectively regulate one's emotions is a fundamental component of mental health (Gross & Muñoz, 2006). Depression is an affective disorder wherein this vital ability is impaired (Erk et al., 2010; Denny, Silvers & Ochsner, 2009). Depression is accompanied by failed attempts at regulating negative emotions. People with depression tend to use ineffective strategies, like rumination, in an attempt to feel better, but these ineffective strategies can act to enhance negative thinking, thereby contributing to depression (Nolen-Hoeksema, 2000; Erk et al., 2010). People who are currently depressed have problems not only controlling their emotions, but also their cognition (Kaiser et al., 2002) and these problems with cognitive control might contribute to emotion regulation impairments. Depression has a high rate of recurrence and so it is of interest to investigate possible contributing factors to recurrent depression. Does the characteristic impaired emotion regulation of a depressed episode persevere even after the depressive episode has passed? If so, does it persevere because people with a history of depression carry with them trait-like ruminative thinking patterns? Or does it persevere due to impairments in cognitive control?

Theoretical and Empirical Background

Depression

Depression is a mood disorder that negatively affects ability to experience pleasure, feelings of self-worth, sleep, energy and appetite. Depression is characterized by impaired ability to manage negative emotions and impaired cognition (World Health Organization [WHO], 2012). Depression is one of the leading causes of disability in the world when considering years lived with a disability, and the 4th leading cause of global disease burden when considering the years of productive life lost due to a disability (WHO, 2012).

Recurrent Depression. Depression has a high rate of recurrence and it is for this reason that it is important to study previously depressed participants and possible contributing factors to recurrent episodes. A person has a 50% chance of recurrence after having had one episode and that risk increases to 70% and then 90% if a person has had two or three previous episodes respectively (Depression Guideline Panel, 1993). The more episodes one

experiences, the sooner, more severe and more treatment-resistant the next episode is likely to be (Keller & Bolland, 1998, Spiegel, 1996). After following patients for 15 years, an 85% recurrence rate was reported, even for people who had been depression-free for as long as 5 years (Mueller, Leon, & Keller, 1999).

Despite the fact that recurrent depression is a global disease burden, we still do not understand the factors that contribute to recurrent episodes and many research questions remain unanswered. It has been suggested that people who have been previously depressed are vulnerable to recurrent episodes because they have impaired cognitive control over their emotions and carry with them negative thinking patterns that perpetuate negative mood (Joormann, 2010). Yet, the phenomenon of recurrent depression after treatment continues. To our knowledge, emotion regulation in people with a history of depression has yet to be investigated.

State-Trait Vulnerability. Beck, in his cognitive theory of depression, suggests that people have trait-like dysfunctional attitudes and negative cognitive biases that develop in childhood and persist throughout life unless treated. He explains that these attitudes and biases contribute to the high recurrence rates in depression (Beck, Rush, Shaw, & Emery, 1979). Others suggest that these attitudes and biases are dependent on the depressed mood and so represent a state, rather than a lasting trait. After reviewing the literature, Coyne and Gotlib (1983) argue against the Beck's Trait theory and cite weaknesses in study design as hindrances to Beck's conclusions. They suggest that cognitions and attitudes are not as stable as Beck had claimed. Spurred by the conflicting arguments put forth by state and trait theorists, research began to tease apart these issues. Zuroff, Blatt, Sanislow, Bondi, & Pilkonis (1999) collected data from the Dysfunctional Attitudes Scale (DAS) at the beginning and end of a 16 week treatment as well as after an 18 month follow up. They found that attitudes were neither purely state nor purely trait dependent. They also suggest that Beck's original theory was not as much a trait theory as critics have assumed, but rather more of a state-trait theory, which suggests a vulnerability that can be triggered by stressors. Other support for a mixed state-trait model comes from Beevers and Miller (2004). In a longitudinal study, which assessed negative cognitive bias, dysfunctional attitudes and depression during hospitalization, and then after both 6 months and 1 year of treatment, negative cognition was found to have both state and trait dependent attributes (Beevers & Miller, 2004). It is likely

that there is an interaction between negative cognition and environmental stressors and that this interaction leads to depression (Ilardi & Craighead, 1999). The research on the state-trait model of depression continues and there are now both positron emission tomography (PET) and functional magnetic imaging (fMRI) studies attempting to explain this model. Numerous studies have found resting state brain activity differences in depressed participants compared to controls (Greicius et al., 2007; Videbech, 2000) and these differences have also been found in previously depressed participants during a sad mood provocation (Liotti et al., 2002) and during a tryptophan depletion (Neumeister et al., 2004). The continued abnormal brain activity patterns seen in previously depressed participants under different types of stress lends support to the idea that there are some trait-like thinking patterns that persist even in a remitted state and that can be activated under stress. We thus chose to include rumination and cognitive control as relatively stable trait predictors in our experimental paradigm on emotion regulation.

Emotion Regulation

Emotion regulation refers to the process of cognitively controlling our emotions, the attention we give to emotions and the way we interpret and experience emotions. We are able to regulate our emotions on many different levels, including psychologically (by changing the way we think about an event in order to change the way we feel), behaviorally (by choosing not to expose ourselves to an event in order to avoid feeling badly) and experientially (by choosing what aspects of an event to attend) and this ability allows us to dampen, increase or maintain the emotion we are experiencing (Gross & Muñoz, 2006).

There are different models of emotion regulation. Gross (1998) presents a model of emotion regulation that differentiates antecedent vs. response focused strategies. Antecedent focused strategies are those that are used to alter our appraisal of the emotion-eliciting stimulus before the emotion is fully activated. Response focused strategies are those that are used after the initial appraisal of the emotion-eliciting stimulus and after the emotion has been activated. Denny et al., (2009) summarize a twofold process that involves an ongoing and changing appraisal of the emotion-eliciting stimulus by means of cognitive strategies that directly regulate the appraisal process. This model emphasizes that both appraisal and regulation are intertwined in an ongoing process. These models have in common that emotion

regulation involves a form of appraisal and then regulation of that appraisal (Gross, 1998; Denny et al., 2009).

Reappraisal. Research has shown that learning more effective emotion regulatory strategies helps prevent future recurrences of depression (Hollon, DeRubeis, & Seligman, 1992). Reappraisal involves changing the way one thinks about an event with the goal of changing the way one feels. Reappraisal has proven to be an effective strategy for reducing negative affect associated with negative events. There is a wealth of multi-level research showing that when participants use reappraisal while exposed to negative stimuli, they show a decrease in negative affect, amygdala activity (activated during emotional appraisal) (Ochsner and Gross, 2005; Phillips, Ladouceur, & Drevets, 2008) as well as decrease in physiological arousal (Kim & Hamann, 2012), suggesting that reappraisal is an effective way to regulate one's emotions. When control participants reappraise negative stimuli, there is a change in the way they respond to these stimuli, even after a time delay (Walter et al., 2009), but these long lasting effects are not seen in people with depression (Erk et al. 2010).

Distancing. Distancing is a type of reappraisal that involves creating mental space between oneself and the emotional event in order to see things from a different, less self-focused perspective. For a clinical sample, distancing is a relevant strategy to test. Distancing is, according to Beck, a fundamental skill involved in cognitive behavioral therapy for depression (Beck, 1970) and cognitive behavioral therapy is currently one of the most effective treatments for depression (Dobson, 1989; Butler, Chapman, Forman & Beck, 2006). When attempting to understand and construct a model of depression and recurrent depression, it is useful to study a skill that can potentially be taught in therapy as not only a treatment for depression, but also a prevention for depression and/or recurrent episodes. Preliminary data has shown that distancing is a strategy that people can improve at over time compared to reinterpretation and that over time distancing even helps to reduce negative emotions on experimental trials in which participants were not asked to regulate their feelings (Denny, B. T., & Ochsner, K. N. Examining the temporal dynamics of emotion regulation: Evidence from longitudinal reappraisal practice. Unpublished manuscript).

Distancing has been shown to be an effective strategy for reducing negative affect during experiments that ask participants to reflect back on negative life events. In a study by

Ayduk and Kross (2008), participants were told to recall a negative event that made them angry. The participants were then randomly assigned to either a self-immersed condition or a self-distanced condition and again asked to recall the event from these perspectives. Self-assessed affect and blood pressure were measured at baseline, throughout the experiment, and in a recovery phase. Participants in the self-distanced group displayed lower negative affect and blood pressure in the second recall condition as compared to the self-immersed group. The self-distanced participants also showed lower blood pressure in the recovery phase of the experiment. In another study using the same experimental design (Kross & Ayduk, 2008), participants were instructed to recall a depression experience and rate affect intensity. Here, it was found that participants in the self-distanced group had lower levels of depressed affect in the second recall condition as compared to the self-immersed group. In a replication of the study, but with time added as factor, it was found that distancing was related to lower depressed affect when the participants returned either 1 or 7 days after the initial experiment. On these days, they were asked to recall the depression experience and rate it on affect intensity.

Moreover, Ayduk and Kross (2010) have found that the more participants use self-distancing in their day-to-day lives, the less they report repetitive and passive thinking about negative emotions (i.e. rumination). This suggests that the skill to distance oneself from negative emotions might be a protective measure against depressive affect over time.

Insights into the effectiveness of using a distancing strategy are also offered by Construal Level Theory and Construal-Level Theory of Psychological Distance (Trope & Liberman, 2003, Trope & Liberman, 2010). The theories propose that the way in which you frame your experiences in space and time will determine the quality in which you experience them. Experiments based on these theories have shown that creating mental distance helps participants to have a broader, less detailed view of events, which thereby helps them to self-regulate (Liberman & Trope, 2008). For example, Davis, Gross and Ochsner (2011) tested and confirmed that negative scenes were rated as less intense when imagined moving away from the participants, and as more intense when imagined moving toward the participants, as compared to responses to scenes that were imagined unchanged.

Emotion Regulation and Depression. Depression is characterized by emotion dysregulation (inefficient and failed attempts at emotion regulation). Studies have shown that participants with Major Depressive Disorder (MDD) self-report more difficulty in the down-regulation of negative feelings than controls (Beauregard, Paquette & Levesque, 2006) and their ability to down-regulate decreases as their symptom severity increases (Erk et al., 2010). Most studies on emotion regulation and depression are fMRI studies without self-reported regulation measures. Past research has shown that regulation-induced changes in self-report match up with regulation-induced changes in neural activity (Ochsner & Gross, 2008) in non-depressed controls. Whether or not to expect this coherence between self-report and fMRI data in depressed and previously depressed participants is a matter of uncertainty.

fMRI studies have well established the neural system involved in emotion regulation in healthy participants. When controls attempt to down-regulate their negative emotions, they show increased activation in the anterior cingulate and lateral and medial prefrontal regions and decreased activation in the amygdala and medial orbito-frontal cortex. (Ochsner, Bunge, Gross & Gabrielli, 2002; Ochsner et al., 2004). However, when depressed participants attempt to regulate, they exhibit a different pattern of activity.

MDD participants exhibit greater amygdala activation than controls while regulating (Beauregard et al., 2006). A study by Johnstone, van Reekum, Urry, Kalin & Davidson (2007) used pupil dilation as a measure of effort during emotion regulation and found that depressed participants who used more effort to regulate also had more amygdala activation. This is the opposite pattern of controls, who showed decreased amygdala activation as their regulation effort increased. Johnstone et al. (2007) also found that while control participants have left-lateralized PFC activity during down-regulation, MDD participants have bilateral PFC activity. These findings suggest that the depressed participants are trying to regulate, but their method is ineffective, as the more effort they exert, the more amygdala activation.

This extraneous recruitment of the right hemisphere during emotion regulation is consistent with a plethora of multi-level research showing that people with depression have a prefrontal laterality characterized by hyperactivity in the right PFC and hypoactivity in the left PFC (Henriques & Davidson, 1991; Grimm et al., 2007; Martinot et al., 1990; Gershon, Dannon, & Grunhaus, 2003). The Dorsolateral Prefrontal Cortex (DLPFC) is a major area

involved in the cognitive control of emotion and regulation of amygdala activity (Denny et al., 2009). MDD participants have shown hypoactivity in the left DLPFC and hyperactivity in the right DLPFC compared to controls when making emotional judgments and this hyperactivity in the right DLPFC correlated with depression severity (Grimm et al., 2008).

The effect of emotion regulation over time is also different in MDD participants. During a passive viewing task post-emotion regulation task, control participants, show a lasting effect of regulation on amygdala activity after a 15 minute delay. However, this effect is not seen in MDD participants, even if the MDD participants managed to regulate during the emotion regulation task (Erk et al., 2010).

Emotion regulation ability is tied to good mental health while dysfunctional or ineffective emotion regulation is related to mental health problems (Gross & Muñoz, 2006). The strong evidence for emotion dysregulation in depression, seen on multiple levels, paired with high recurrent rates in depression makes it important to investigate if emotion regulation is a problem that perseveres after the depressive episode is over. There are currently no known studies published on emotion regulation in previously depressed participants.

Rumination and Depression

Rumination is defined by Nolen-Hoeksema (2000) as the repetitive and passive thinking about negative emotions in an attempt to feel better with a focus on the symptoms of distress. People with depression have higher rumination scores than do controls (Nolen-Hoeksema, 2000; Ray et al., 2005). Rumination predicts depressive and subclinical depressive symptoms (Treynor, Gonzalez & Nolen-Hoeksema, 2003 Garnefski & Kraaij, 2006; Nolen-Hoeksema, 2000) as well as disgnoses of depressive disorders and severity and length of depressed mood (Nolen-Hoeksema, 2000; Nolen-Hoeksema, Marrow, & Fredrikson, 1993).

Kavanagh and Wilson (1989) gave depressed participants questionnaires that measured feeling of self-efficacy, or to what extent the participants felt they could control their mood, thoughts, ruminations and stress. They found that the extent to which pariticpants felt they could control their ruminations predicted their tendency to relapse into another depressive episode, highlighting the important role rumination plays in depression. Additional support comes from a study by Roberts, Gilboa and Gotlib (1998). They measured rumination

scores in currently depressed, previously depressed and never depressed participants and found that currently depressed and previously depressed participants reported ruminating more than the never depressed participants. There was no difference in rumination scores between the currently depressed and previously depressed participants. The authors interpret these results to mean that rumination might be a trait-marker that makes previously depressed participants more vulnerable to depression.

The strong predictive connection between rumination and depression alongside of the connection between depression and emotion dysregulation lends support to the idea that rumination might also predict regulation style and/or success. However, in an fMRI study by Ray et al., (2005) on a normal sample, rumination scores predicted the extent to which participants up- or down-regulated (activated vs. deactivated) their amygdala response while attempting to up- or down-regulate emotion, respectively. Since the amygdala is a region that is activated in response to emotional stimuli and regulated when people cognitively reappraise that stimuli, these results were interpreted to mean that the people who were high in rumination were actually better than controls at regulating, but that they did not practice this strategy in their daily lives.

So, it is possible that ruminators' extensive practice of engaging in self-reflective thought and unintentionally up-regulating their emotions, puts them in a good position to learn how to down-regulate their emotions in their daily lives or, in an experimental setting, to down-regulate when instructed. The Ray et al. (2005) study, however, found these differences only on the neuronal level and found no difference between ruminators and non-ruminators on self-report measures.

Cognitive Control and Depression

Cognitive control is a term used to describe the processes involved in the control and regulation of other cognitive processes (Fossati, Ergi & Alilaire, 2002). Cognitive control is a necessary component of good mental health and impairments are a symptom in a wide array of psychological disorders like schizophrenia (Minzenberg et al., 2009), obsessive compulsive disorder (Olley, Malhi, & Sachdev, 2007), and bipolar disorder (Daban, Sanchez-Moreno, Garcia-Amador, & Vieta, 2006). Some cognitive control processes, like selective attention, inhibition, flexibility and emotion regulation are impaired in people with MDD (Fossati et al.,

2002; Gross & Muñoz, 2006; Airaksinen, Larsson, Lundberg and Forsell, 2004; Deveney and Deldin, 2006; Ottowitz, Dougherty & Savage, 2002) and have also been shown to be impaired in people with remitted major depression (Paelecke-Habermann, Pohl & Leplow, 2005; Eliott, 2002; Paradiso, Lamberty, Garve and Robinson, 1997).

Inhibition, as traditionally thought of, is a form of cognitive control that involves the overriding of automatic responses. It has been studied extensively in its relation to depression and rumination. Current research suggests that inhibition, previously thought of as one pure process, is instead several processes that are distinct from each other. More specifically, Friedman and Miyake (2004) argue that inhibition, can be separated into distinct categories that differentiate between: 1. Prepotent Response Inhibition (to resist automatic or prepotent responses, for example, in the traditional STROOP task); 2. Resistance to Distractor Interference (to resist irrelevant external information, for example, in a priming task); and 3. Resistance to Proactive Interference (to resist memory intrusions of previously relevant information, for example, in the Switching version of the STROOP task).

Prepotent Response Inhibition. This subcategory of inhibition is the ability to resist automatic or prepotent responses. Kaiser et al. (2002) found that depressed participants, compared to not depressed controls, were impaired at inhibition in a Go/Nogo task and event-related potentials showed a different pattern of activity in the depressed group than the control group during the inhibition task. Several studies have found weaker performance overall in participants with depression on the classic STROOP task, with depressed participants taking longer time to complete and making more errors than controls (Videbech et al., 2004; Benoit et al., 1992). Lemelin et al., (1997) found that within the depressed participants, there were two subgroups; one group had problems with distractor inhibition, while the other group had problems with overall processing. Weaker performance on the STROOP has also been found in remitted depressed participants (Paelecke-Habermann et al., 2005).

Resistance to Distractor Interference. This subcategory of inhibition is the ability to resist irrelevant external information, for example, in a priming task. Problems with inhibiting irrelevant information in depression have been found in response to a variety of stimuli, from negative words, to negative faces. Joormann and colleagues found, in a series of priming studies, that people with depression and with a history of depression had problems inhibiting

negative, but not positive words (Joormann & Gotlib, 2010). Their results were replicated by Goeleven, DeRaedt, Baert, & Koster, 2006), who used a priming task that used emotional faces instead of words. Mathews and MacLeod, (2005), in a review of cognition in emotional disorders, argue that there is not enough evidence to support the idea that people with depression have trouble inhibiting information that is specifically negative. They do, however, support the idea that there is indeed a problem with inhibitory control in depression and that this problem most often arises concerning negative information, since it is this type of information that we need to inhibit more frequently in order to maintain good mental health.

A connection between inhibition of irrelevant information, emotion regulation and rumination has also been found. In a study comparing currently and previously depressed participants with never depressed controls, Joormann & Gotlib (2010) found that in the depressed group, reduced inhibition of negative material was associated with higher rumination scores. Across all participants deficiencies in cognitive control were related to the reported use of dysfunctional emotion regulation strategies, such as less reappraisal and more suppression. This relationship between rumination, emotion regulation and cognitive control has been summarized in a review paper by Joormann (2010), in which they propose that the depressive person's inability to inhibit negative material, leads to more rumination, which thereby leads to more depression. The inability to inhibit negative material is suggested not only to lead to more rumination, but to additionally block the incoming of new, mood-incongruent material, that could help to change the mood and prevent depression. The current study builds on these findings by additionally including an experimental measure of emotion regulation.

Resistance to Proactive Interference. This subcategory of inhibition is the ability to resist interference from memory of previously relevant information that is no longer relevant, for example, in task switching. Also called Switching or Cognitive Flexibility, Resistance to Proactive Interference is distinct from Resistance to Distractor Interference in that Proactive interference information is presented before the task, whereas Distractor Interference is presented during the task. People with depression have impairments on this aspect of inhibition as well.

A number of tasks have been used to investigate depression-related impairments in switching and flexibility. Impairments have been found on the Trail Making Task B in depressed participants (Airaksinen, Larsson, Lundberg & Forsell, 2004; Austin et al., 1992) as well as in previously depressed participants (Paradiso, Lamberty, Garvey & Robinson, 1997). De Lissnyder, Koster, Derakshan & Raedt (2010) found moderate to severely depressed participants performed worse than controls on the Affective Shift Task, a task that measures set shifting or switching. Impairments have also been found in switching and flexibility, as measured by The Wisconsin Card Sorting Task (WCST), in depressed participants (Merriam, Thase, Haas, Keshavan & Sweeney, 1999; Stordal et al., 2004); in depressed young adult participants (Grant, Thase & Sweeney, 2001); and in depressed geriatric participants (Kindermann et al., 2000). Depressed participants also showed an impairment of flexibility and switching in an emotional version of the WCST (Deveney & Deldin, 2006). Interestingly, flexibility and switching impairments on the WCST have been shown to be associated with measures of rumination. Davis and Nolen-Hoeksema, (2000) have shown that ruminators made more perseverative errors and had more trouble maintaining set in the WCST than non-ruminators. They associate an inflexible cognitive style to increased rumination.

Aims

There were two main aims of this study. The first was to investigate emotion regulation in previously depressed (PD) and never depressed (ND) participants. We hypothesized that the Previously Depressed participants would not be as effective at emotion regulation as the Never Depressed participants. We also wanted to investigate possible group differences in cognitive control and rumination.

The second main aim was to investigate the association between cognitive control and emotion regulation. Since inhibition and flexibility are important components in not only purely cognitive processes, but also emotional ones, we hypothesized that cognitive control performance would predict emotion regulation success. We additionally wanted to investigate if Rumination predicted emotion regulation success.

Method

Participants

Participants were 13 previously depressed (PD) female participants satisfying criteria for at least one previous episode of major depressive disorder and no current depression compared to 19 never depressed (ND) participants. The MINI International Neuropsychiatric Interview (Sheedan et al., 1998) was used for initial depression diagnosis in the previously depressed group and performed by the responsible clinicians.

All participants completed the study in compliance with REK guidelines and were reimbursed 250NOK (approximately $50 USD). Solely female participants were included because depression is more common as a diagnosis in females than in males. Another reason for only using females was to avoid complications with sex differences that might have arisen from the different ways that men and women process emotional and visual stimuli (e.g., Canli et al., 2002; Cahill et al., 2001). ND participants were recruited via posters on the University of Oslo campus and PD participants were recruited through clinics in Oslo, Trondheim and Kristiansand, where they had been treated for depression.

Procedure

The author conducted all testing sessions. First, participants and experimenter went through the informed consent procedure. The participant reviewed the consent form, had the opportunity to ask questions and express concerns, and once it was clear to the experimenter that the participant understood the session and the voluntary nature of the experiment, the participant and experimenter both signed the informed consent form.

The first phase of the experiment took place in a neuropsychological testing room either at The Center for the Study of Human Cognition in Oslo, The Coperio Center in Trondheim or Sørlandet Hospital in Kristiansand. Two subtests from the Wechsler Abbreviated Scale of Intelligence (WASI) (Similarities and Matrix Reasoning) were administered, followed by the STROOP task. The second phase of the experiment (Emotion Regulation Task and questionnaires) took place either in a neuropsychological testing room or in the Cognitive Laboratory of the Psychology Institute, Oslo. For the Emotion Regulation

task, participants sat at a computer and first read task instructions, which had details about what the task would be like and what exactly they should do when they saw the LOOK and DISTANCE instructions. Instructions were based on well-validated procedures (Ochsner et al., 2004). After participants read the instructions, the experimenter reviewed the key points and completed some practice trials together with the participant to ensure she understood the task. The participant then completed practice trials on her own, after which she began the main task. Once the task was completed, the participant filled out the questionnaires. Upon completing the session, the participant was debriefed and had a chance to ask questions and discuss her experience during the task. The participant then received a gift card that could be used at stores in the local area.

Emotion Regulation Task

The Emotion Regulation task was programmed using the E-Prime 2.0 Software (Psychology Software Tools, Pittsburgh, PA). Participants were shown negative and neutrally-valenced images on a computer screen accompanied by either a LOOK instruction or a DISTANCE instruction. All participants viewed 30 neutrally-valenced images and 60 negatively-valenced images for a total of 90 trials.

Thirty of the negative images were paired with LOOK instruction, the other 30 negative images were paired with the DISTANCE instruction and all 30 neutral images were paired with the LOOK instruction. For the LOOK trials, participants were instructed to respond naturally to the images and to let themselves really feel their natural reaction. For the DISTANCE trials, participants were instructed to regulate their emotional reaction to the images by using a distancing strategy.

Participants received detailed instructions before the task about how to view pictures with each instruction. It was made clear to participants that they should specifically use a distancing strategy and not another type of emotion regulation strategy, such as cognitive reappraisal.

After viewing each image in one of these two ways, participants then rated how negative they were feeling, by using a numeric rating scale (NRS) that ranged from 1-5 with 1 meaning “not negative at all” and 5 meaning “very negative”. Participants were instructed on

how to use the scale and told that they should rate how they feel at the very end of the trial whether or not they succeeded at following the viewing instructions.

The negative image set was compiled of 30 sad themed and 30 gory themed images in order to investigate potential differences between groups for sad themed images within the negative images. Picture type and Instruction were counterbalanced and pseudo randomized. Two versions of the experiment were used to avoid order effects.

The pictures for the emotion regulation task came from the International Affective Picture System (IAPS) (Lang et al., 1993), which is a collection of normative emotional stimuli. This picture set is designed to evoke emotions in experimental settings and is widely used internationally by emotion researchers on a variety of different populations.

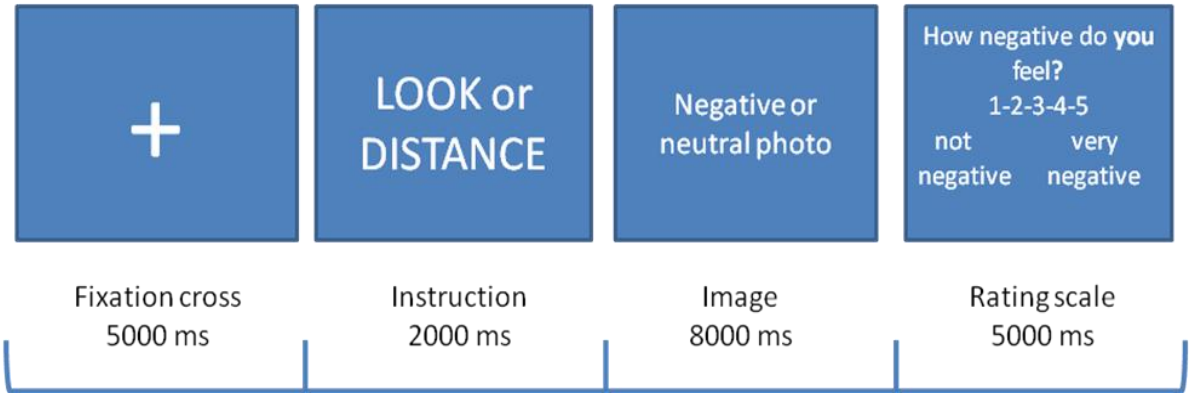

Figure 1. Timeline of one trial. Trials began with a fixation cross, followed by an instruction cue, either LOOK or DISTANCE. After the instructional cue, participants saw a negative or neutral image, which they viewed according the instructional cue. The trial ended with a rating scale on which participants rated how negatively they were feeling.

Cognitive Control Task

The STROOP task is a cognitive control task that measures response inhibition. We used the Delis Kaplan Executive Functioning System (DKEFS) Color-Word Interference Test (Delis et al., 2001), a version of the STROOP (hereafter referred to as STROOP).The test has four subsections: 1) NAMING COLORS. First the participant must simply state the ink color of a series of squares; 2) READING WORDS. Then the participant must simply read through a list of words printed in black ink and these words are names of colors; 3) INHIBITION.

Next the participant is given a list of words printed in different colors of ink and these words are names of colors, but the actual color of the ink and the printed word are incongruent, for example, the word "red" is printed in blue ink. The participant must state the color of the ink, rather than read the word, thereby inhibiting the more automatic response of reading the word. This condition measures the participant's ability to inhibit the overlearned response of reading the printed word; 4) INHIBITION/SWITCHING. Finally the participant is given a similar list to the last one, but this time some of the words have a square box around them. The participant has two tasks. As in the last task, she must name the incongruent color of the ink that the word is printed in, except when the word has a box around it, in which case she must simply read the word. This condition gives measures of both the participant's inhibition as well as cognitive flexibility.

The STROOP effect is seen in the last two conditions when the word is printed in an ink color that does not correspond the word, for example the word "red" printed in blue ink. On these incongruent trials, participants show longer reaction times and make more errors. It is a well-used and effective measure of executive function, cognitive control, selective attention and flexibility, all of which are affected by depression.

Switching / Cognitive Flexibility. The DKEFS version of the STROOP task has the special feature of the 4th subsection. This subsection is a measure of both Inhibition and Switching, and calculated contrast scores further allow for a pure measure of Switching/Cognitive Flexibility. This measure is what Friedman and Miyake (2004) call Resistance to Proactive Interference, while the classic STROOP effect or the Inhibition subsection is what they call Prepotent Response Inhibition. Test-retest reliability for the 4 subsections ranges from r = 0.62- 0.76.

Calculating Contrast Scores for Cognitive Control Task. Cognitive control scores from each condition were first transformed into age scaled scores and then three contrast scores were calculated from these scores and then scaled again. The 3 main measures used in the current study are 3 contrast scores designed to tap directly into Inhibition and Switching. A visual explanation of how the contrast scores were calculated is presented in Figure 2.

4 original conditions used in computing contrast scores

Condition 1	Condition 2	Condition 3	Condition 4
Color Naming	Word Reading	Inhibition	Inhibition/Switching

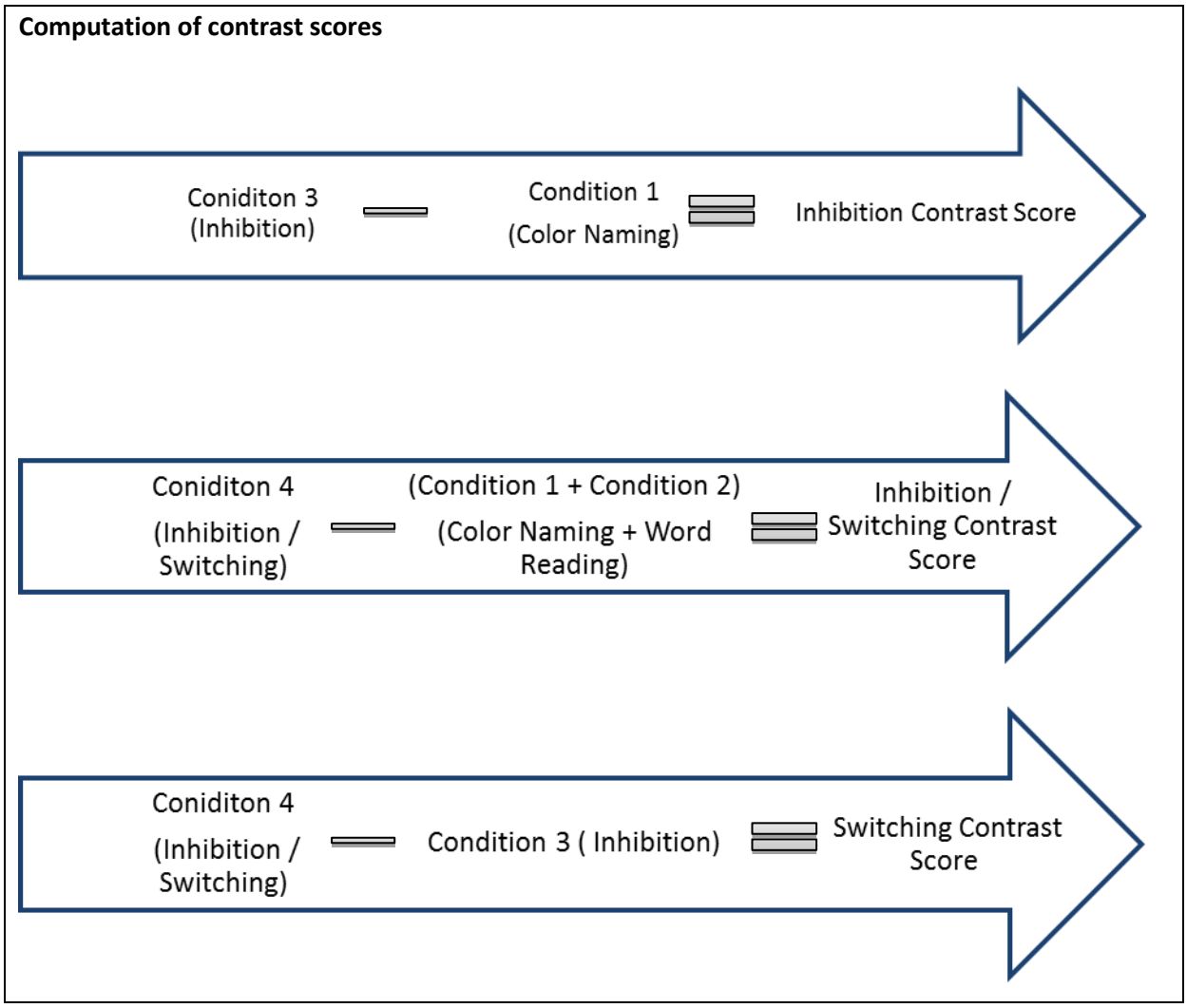

Figure 2. Visualization of contrast scores calculated from the DKEFS STROOP task. There were 3 contrast scores calculated from the 4 original conditions: 1) Inhibition, 2) Switching, and 3) Inhibition / Switching.

The conversion of scores was done in accordance with the Delis Kaplan Executive Function System Examiner's Manual (Delis et al., 2001a). After first converting raw scores from the 4 main tasks into age scaled scores, a composite score of condition 1 + condition 2

was created and age scaled. These 5 scaled scores were then used to create 3 final contrast scores, as pictured in Figure 2. These contrast scores were then scaled one last time. Table D.6. from the Examiner's Manual was used in this final scaling step and this table is included in Appendix A.

The resulting contrast scores are based upon a curve with medium scores representing optimal performance on both tasks and low and high scores representing disproportionately worse performance on either Switching, Switching/Inhibition or Color Naming + Reading. Contrast scores between 8 and 12 represent optimal performance on all tasks considered in the equation. Contrast scores below 8 reflect disproportionately worse performance on the higher level than lower level scores and contrast scores above 12 represent disproportionately worse performance on the lower level score. So, for example, a high score on the Inhibition Contrast Score indicates disproportionately better performance on Inhibition compared to color naming, while a low score on the Inhibition Contrast Score indicates disproportionately worse performance on Inhibition compared to color naming. Both high and low scores, therefore represent impaired performance on one of the measures, while medium scores represent good performance on both.

This method of calculating contrast scores has some benefits. Firstly, it allows us to look more closely at the measures of interest. The Inhibition score, for example, allows us to control for speed of color naming and look more directly at the Inhibition effect. Secondly, it allows us to access a measure of Switching, by subtracting out the Inhibition measure from the 4th condition.

Ruminative Responses Scale (RRS) Nolen-Hoeksema & Morrow, 1991

The RRS is a 22 item self-report measure of depressive rumination style that asks the participants to indicate how often they engage in behaviors such as, for example, thinking 'why do I always react this way?' or "analyze your personality and try to understand why you are depressed" by rating between 1 "almost never" to 4 "almost always". The scale has been used widely and has been updated and refined by Nolen-Hoeksema to more directly measure and predict depression change over time. The current scale includes two subscales, reflective pondering and brooding that have been shown to be unconfounded with depression in a longitudinal study by Treynor, Gonzalez, and Nolen-Hoeksema (2003). These authors also

found that the reflection subscale has been associated with more concurrent depression rates, but less depression over time, while the brooding subscale was associated with more concurrent depression and depression over time. Women score higher on the RRS than men. The RRS has a test-retest reliability of $r = 0.67$ (Treynor et al., 2003) and correlates significantly ($r = 0.62$) with use of rumination over time (Nolen-Heoeksema et al, 1990)

Beck Depression Inventory – Second Edition (BDI-II) Beck et al., 1996

The BDI is a 21 item self-report measure of depression symptomology. The scale includes 21 different groups of statements addressing different depression themes, such as sadness, suicidal thoughts, crying and self-criticism. Within each group are four different statements from which the participant must choose the one which best matches his/her feelings during the past two weeks. An example item is "Sadness: 0) I do not feel sad. 1) I feel sad much of the time. 2) I am sad all the time. 3) I am so sad or unhappy that I can't stand it." It is a widely used scale for assessing level of depression. The scale correlated positively with the Hamilton Depression Rating Scale, r = 0.71; it had a test-retest reliability of r = 0.93 after one week; and had a coefficient alpha rating of 0.91 for internal consistency (Beck et al., 1996).

Symptom Check List- 90 (SCL-90) Derogatis, Leonard, R., 1983

The SCL is a 90 item scale used to assess psychological problems and psychopathological symptoms across a broad range of areas. The items cover nine symptom dimensions and can be used to screen for existence of symptoms as well as symptom severity. It is widely used and has test-retest reliability scores between 0.68-0.90 (Derogatis, 1983, Derogatis, 2000).

Wechsler Abbreviated Scale of Intelligence-II (WASI-II), **Wechsler, 1999**

The WASI-II is a standardized measure of cognitive function made up of four subtests, two verbal tests, vocabulary and similarities and two performance tests, matrix reasoning and block design. Two or four of the subtests can be used to asses general cognitive functioning and estimate IQ scores in research samples. We used one verbal (Similarities) and one

performance (Matrix Reasoning) subtest as a measure of general cognitive function. *T* scores are reported from this measure.

Statistical Analyses

All analyses were performed in IBM SPSS Statistics 19 for Windows. Independent Sample *t*-tests were performed to investigate main effects of group. Repeated Measures ANOVA was used to investigate the effect of trial type on affective ratings. Univariate analyses of variance (ANOVA) were used with Regulation Success Score as the dependent variable together with BDI scores and MDD history as independent variables. Further ANOVAs were conducted to identify if there was a relation between basic cognition and Regulation Success Scores. All alpha levels were set to 0.05. LSD Post hoc tests were performed for significant ANOVA results. Effect sizes are reported as eta squared using Cohen's criteria. (Cohen, 1988)

Manipulation Check. A manipulation check for the Emotion Regulation Task was performed in order to confirm that the stimuli elicited enough negative emotion and that the regulation strategy of Distancing was effective at reducing negative feelings. The manipulation check tested if Emotional Reactivity and Regulation Success were significantly greater than zero. Emotional Reactivity was defined as the percent increase of reported negative feelings on LOOK NEGATIVE vs. LOOK NEUTRAL trials. The Emotional Reactivity score was calculated as ((LOOK NEGATIVE – LOOK NEUTRAL) / LOOK NEUTRAL x 100). The Regulation Success Score was defined as the percent decrease of reported negative feelings on DISTANCE NEGATIVE vs. LOOK NEGATIVE trials and was calculated as ((LOOK NEGATIVE – DISTANCE NEGATIVE) / LOOK NEGATIVE x 100).

Results

Participant characteristics

All never depressed (ND) participants scored below 14 on the BDI except for one, who had a score of 14 (classified by the BDI guide as "mild mood disturbance". Upon closer inspection of the BDI subscales by the supervisor, it was determined that the participant would not meet criteria for depression. All previously depressed (PD) participants were evaluated by their clinicians as not currently depressed. Nevertheless, 5 PD participants had

BDI scores above 15 (20, 20, 23, 15, 21), which according to the BDI guide ranges from borderline to moderate depression. Upon closer inspection of the BDI subscales by the supervisor, however, it was determined that none of these participants would meet criteria for current depression.

Demographic, Clinical and Psychometric Measures

Descriptive statistics of Demographic information along with BDI scores and SCL-90 scores were compared between the previously depressed and never depressed groups. Results from Independent Samples *t* tests are presented in Table 1. There was a significant difference between groups in Age and score on the Similarities subtest of the WASI, but both groups were above average on the WASI Similarities, which implied sufficient general cognitive functioning for participation.

Table 1 Demographic, psychometric and clinical characteristics of the two groups.

Variables	Never Depressed group (*n*=19)	Previously Depressed group (*n*=13)	*p* value
Age	24.26 (4.69)	37.69 (9.50) **	0.00
Education	1.89 (0.66)	2.08 (0.76)	0.48
WASI Similarities	65.42 (6.59)	59.77 (5.45) *	0.02
WASI MatrixReasoning	60.26 (5.29)	57.92 (12.65)	0.48
BDI final score	7.00 (4.18)	10.08 (8.44)	0.24
SCL Somatization	0.39 (0.40)	0.65 (0.52)	0.12
SCL Compulsion	0.61 (0.53)	0.75 (0.46)	0.46
SCL Interpersonal Sensitivity	0.54 (0.50)	0.47 (0.42)	0.66
SCL Depression	0.62 (0.60)	0.65 (0.53)	0.88
SCL Anxiety	0.39 (0.38)	0.39 (0.30)	0.98
SCL Anger Hostility	0.25 (0.34)	0.29 (0.33)	0.74
SCL Phobic Anxiety	0.11 (0.19)	0.12 (0.16)	0.81
SCL Paranoid Ideas	0.31 (0.37)	0.32 (0.31)	0.91
SCL Psychotisism	0.15 (0.25)	0.22 (0.24)	0.49
SCL Extra Scale	0.53 (0.45)	0.48 (0.31)	0.73
SCL Sum	37.11 (27.51)	42.00 (25.47)	0.61

*p < 0.05**, p < 0.01. Values given as Mean (Standard Deviation). WASI = Wechsler Abbreviated Scale of Intelligence; BDI = Beck Depression Inventory; SCL = Symptom Check List 90.

Emotion Regulation Task

Manipulation check on the Emotion Regulation Task. After calculating the Emotional Reactivity and Regulation Success (percent increase and decrease scores), *T* tests were performed to test that the stimuli and regulation strategy were effective. Emotional Reactivity Scores (ND group *M* = 173.0%, SD = 55.8, PD group, *M* = 178.5%, SD = 49.3) were significantly greater than zero (ND group, *t*(18) = 13.5, *p*<.001, PD group, *t*(12) = 13.1, *p* = <.001). Likewise, Regulation Success Scores (ND group, *M* = 30.6%, SD = 16.9, PD group, *M* = 25.6%, SD = 15.6) were also significantly greater than zero (ND group, *t*(18) = 7.9, *p*<.001, PD group, *t*(12) = 5.9, *p* = <.001), indicating that both groups reacted sufficiently to the negative vs. neutral stimuli and were successful at regulating on the DISTANCE vs. LOOK trials.

Previously Depressed vs. Never Depressed Participants

Previously Depressed vs. Never Depressed Emotion Regulation. A one-way repeated measures ANOVA was conducted to compare affective ratings on the different trial types (LOOK Neutral; LOOK Negative; DISTANCE Negative). There was a significant effect of trial type on affective ratings, Wilks' Lambda = 0.1, F (2 ,30) = 163.9, *p* = 0.0 meaning that participants' affective ratings were significantly different for each trial type. Independent Samples t tests revealed no group differences on affective ratings (1=not at all negative, 5=very negative); Emotional Reactivity scores; or Regulation Success scores. The Negative trials were then further divided into Sad and Gory subcategories. There were no group differences on affective ratings, Emotional Reactivity scores or Regulation Success scores for these subcategories either. Group affective ratings for the different trial types are presented in Figure 3.

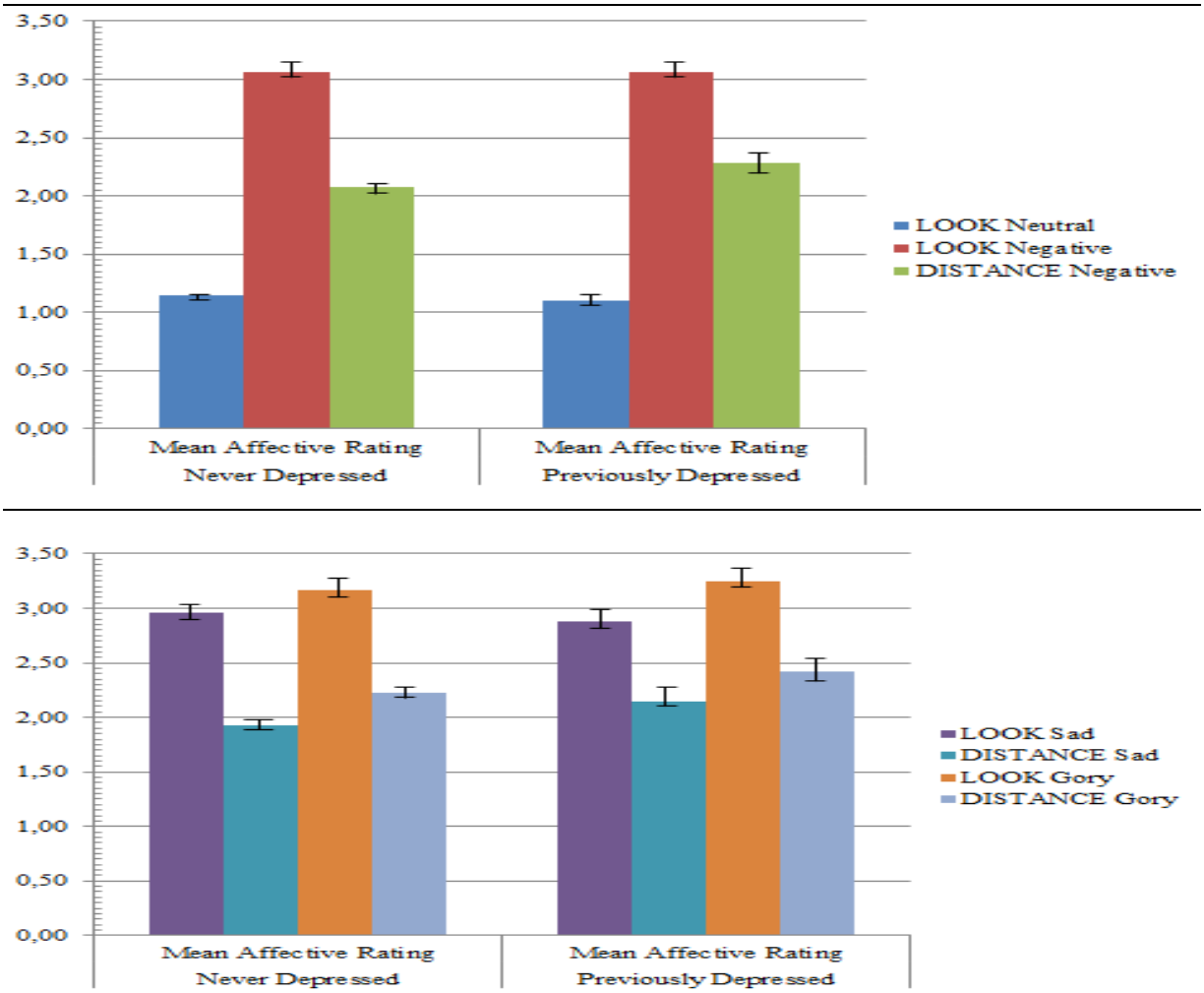

Figure 3. Emotion Regulation Task Affective Ratings for the Never Depressed group and the Previously Depressed group on LOOK Neutral, LOOK Negative and DISTANCE Negative trials and then LOOK Sad, DISTANCE Sad, LOOK Gory and DISTANCE Gory trials.

Previously Depressed vs. Never Depressed Cognitive Control. STROOP scores from each condition were first transformed into age scaled scores and then three contrast scores were calculated from the 4 main measures, color naming, reading, inhibition, inhibition/switching. The three contrast scores represented: 1) Inhibition; 2) Inhibition/Switching combined; and 3) Switching. No differences were found between the previously depressed and never depressed groups on STROOP contrast scores 1. Inhibition (ND *M* = 11.1, SD = 2.8, PD *M* = 11.9, SD = 2.2); 2. Inhibition/Switching (ND *M* = 10.1, SD

= 2.4, PD *M* = 10.8, SD = 3.4); 3. Switching (ND *M* = 9.4, SD = 1.8, PD *M* = 9.5, SD = 4.0) indicating that history of depression did not affect performance on the cognitive control task.

Previously Depressed vs. Never Depressed Rumination. No group differences were found on Rumination scores.

Whole Group Analyses

Clinical predictors of Emotion Regulation, Cognitive Control and Rumination. In order to investigate which characteristics of depression, if any, influence emotion regulation ability, cognitive control and rumination, Univariate ANOVAs were performed with age as covariate. There were no significant effects of BDI, SCL-90 or MDD history on Regulation Success, cognitive control or rumination, meaning there was no association between Regulation Success, cognitive control or rumination and either symptoms (BDI) or syndromes (MDD history) of depression.

Relationship between basic cognition and Regulation Success. Univariate ANOVAs were used to test the effects of the STROOP contrast scores, 1.Inhibition, 2. Inhibition/Switching combined and 3.Switching, on Regulation Success. There was a large significant effect of STROOP Inhibition/Switching on Regulation Success, F (2, 31) = 9.26, p = 0.00, n^2=0.39, as well as a medium-large significant effect of STROOP Switching on Regulation Success, F(2, 31) = 3.44, p = 0.05, n^2= 0.19. These results indicate that switching or mental flexibility contributes significantly to successful emotion regulation. Post hoc tests using the Fisher LSD test indicated that for the Switching contrast, there were significant differences between low and medium Switching contrast scores. For the Inhibition/Switching contrast, there were significant differences between low and medium as well as between medium and high contrast scores. Results from post-hoc tests are reported in Figure 4. Taken together, these results imply that performance on the Switching aspect of the cognitive control task has an effect on emotion regulation success. More specifically: 1. when participants had strong performance on both Inhibition/Switching and color naming + word reading, they had high regulation success; 2. when participants had strong performance on both Inhibition/Switching and Inhibition, they had high regulation success and 3. When participants had better performance on Inhibition/Switching vs. Inhibition, they had high regulation success.

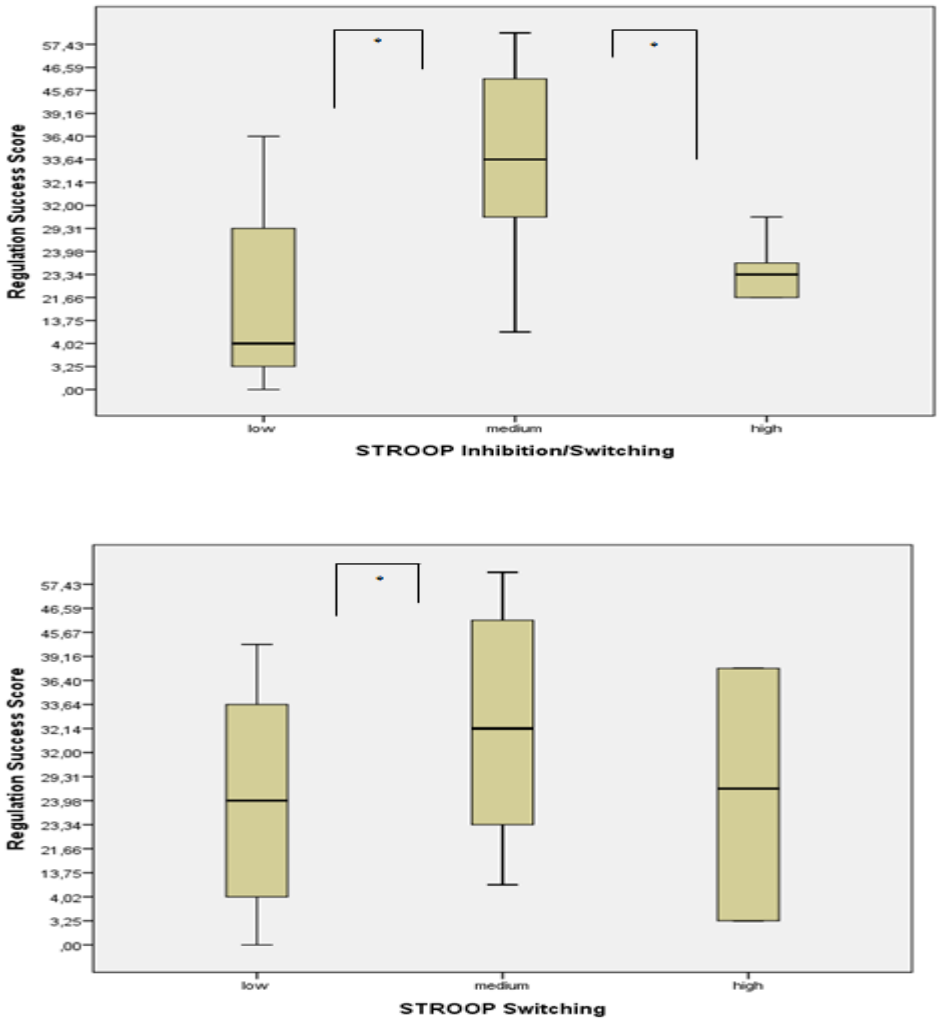

Figure 4. Post hoc tests for the Regulation Success—STROOP ANOVAs using the Fisher LSD test. STROOP contrast scores are based on a curve with medium scores representing optimal performance on both tasks and low and high scores representing disproportionately worse performance on either Switching, Switching/Inhibition or Color Naming + Reading.

* = $p < 0.05$

Emotion regulation success was dependent on both the Inhibition/Switching contrast score and the Switching contrast score. Emotion regulation success was not dependent on the pure Inhibition contrast score. Since we found no effect from Inhibition alone, we conclude

that the relationship between emotion regulation and cognitive control is driven by the measure of Switching.

None of the RRS scores significantly contributed to Regulation Success or STROOP scores.

Discussion

For all participants, Distancing significantly decreased negative affective ratings compared to the LOOK condition. We found that the previously depressed (PD) group did not differ from the never depressed (ND) group in emotion regulation, cognitive control, or rumination. While there were no group differences on these measures, across all participants, cognitive control, as measured by the STROOP Switching scores, predicted regulation success, suggesting a more general and overarching relationship between cognitive control and emotion regulation.

Are Previously Depressed participants as effective as Never Depressed participants at emotion regulation?

Emotional Reactivity scores were calculated as the percent increase in affective ratings from Neutral to Negative trials and used to ensure participants reacted significantly to the negative vs. neutral stimuli. Regulation Success Scores were calculated as the percent decrease in affective ratings from LOOK to DISTANCE trials and used to ensure that the emotion regulation strategy significantly reduced negative affective ratings compared to the LOOK trials. Both groups' Emotional Reactivity and Regulation Success change scores were significantly greater than zero, indicating that the experimental manipulation was successful.

Both groups were successful at regulating their emotions, based on the significant change in affective ratings between LOOK Negative and DISTANCE Negative trials. The emotionally arousing pictures induced negative emotions of moderate intensity (i.e. NRS = 3.1) and the size of the change in affect between trial/conditions was roughly one unit on the NRS.

The ND group was expected to regulate successfully, so their results were as expected. Emotion regulation ability in healthy controls has been demonstrated in a multitude of multi-level studies (Ochsner & Gross, 2008). The level of success in the PD group was, however, uncertain since there are no existing studies on this topic. The effective regulation in the PD group and the lack of significant difference between the groups is therefore an interesting and important initial finding.

There are 3 major points to consider in relation to the lack of group differences on the emotion regulation task. First, we must take into consideration the lack of group differences on the cognitive control and rumination measures. These results might indicate that previously depressed participants do not carry with them trait-like depressive thinking patterns. Additionally, as per our second main aim, cognitive control performance predicted emotion regulation success and so the lack of group differences in cognitive control might explain the lack of group differences in emotion regulation success.

Secondly, we must consider the type of reappraisal strategy used in this experiment. Kross & Ayduk (2009) have shown the Distancing strategy to be particularly effective for people with depressive symptoms. They pooled data from several past studies and found that not only did taking a distant perspective reduce negative affect, but that this effect increased linearly with BDI scores, meaning the higher the participant's BDI score, the stronger the effect of distancing on reducing negative affect. Although we did not find this linear trend, their results highlight the effectiveness of distancing in a clinical sample.

Thirdly, it is important to remember that the emotion regulation task is an instructed experiment, wherein the participant is given explicit instructions on when and how to regulate. An fMRI emotion regulation study by Erk et al., (2010) found that depressed participants were as successful as controls at regulating amygdala during an instructed task, but that this effect did not last in the depressed group as it did in the control group, when participants passively viewed the same pictures 15 minutes later. This finding suggests that the depressed group was only effective at changing their emotional reactions when instructed. Although we do not have data from uninstructed conditions, Erk et al.'s study points towards important differences between clinical and non-clinical samples.

Are Previously Depressed participants as effective as Never Depressed Participants at cognitive control and rumination?

Cognitive control. No group differences were found on any of the STROOP scores in our data, meaning history of MDD did not influence cognitive control performance. These results are in opposition to studies that have shown impaired STROOP performance in remitted MDD participants compared to control participants (Nakano et al., 2008; Paradiso et al., 1997), but in line with other studies, which have found no STROOP impairments in remitted MDD participants (Merens, Booij, & Van Der Does, 2008). No apparent differences in study design, age, sex, or treatment status seem to explain these conflicting results, however, these studies did differ in which version of the STROOP they used. The 2 studies that found impaired performance in remitted MDD participants (Nakano et al., 2008; Paradiso et al., 1997) used 2 different versions of Golden's STROOP Color and Word Test (1978), while the one study that did not find impaired performance in remitted depressed participants (Merens, Booij, & Van Der Does, 2008) used an unspecified version of the STROOP. Description of the tasks showed that all 3 varied slightly from each other, but shed no light on cause for the differing results.

The current results suggest that the cognitive control impairments typically seen in current depression do not persevere after the depressive episode has passed. The existing literature lends support to the idea that depression is characterized by increased rumination and inability to successfully regulate, alongside with more effort and extraneous recruitment of different brain regions during emotion regulation attempts (Nolen-Hoeksema, 2000; Ray et al., 2005; Beauregard et al., 2006; Erk et al., 2010; Johnstone et al., 2007). It follows, therefore, that in current depression, cognitive resources are more limited and control regions are overactive, which might lead to impaired cognitive control. As in the model proposed by Joormann (2010) of current depression, impaired inhibition of negative material leads to more rumination, which leads to more depression. If this model is correct, then this cycle might be dependent on deficiencies in all 3 areas at one time (deficient inhibition, rumination, depressed mood), and perhaps improvement in one area can slow the cyclic perpetuation of the depressed mood and cause a remission. Assuming this model works, cognitive control performance should be more dependent on current depression and not as much on history of

depression. The current data lends some support to Joormann's (2010) model, but without a currently depressed group, we cannot directly fit our data to this model.

Rumination. No group differences were found on RRS scores. There is a wealth of research tying RRS to current depression and Spasojevic, J. and Alloy (2001) have also found a positive association between history of depression and tendency to ruminate. Much of the research on rumination and depression has shown a strong relationship between RRS scores and depressive symptomatology (Treynor, Gonzalez & Nolen-Hoeksema, 2003; Garnefski & Kraaij, 2006; Nolen-Hoeksema, 2000). It was surprising, therefore, to also find no association between RRS and BDI or RRS and the SCL-90 Depression subscale in this sample.

In summary, past research has shown that PD participants are different from controls and similar to currently depressed participants on a number of different measures, including the way they respond to negative stimuli (Liotti et al., 2002); their negative attitudes and cognitions (Ilardi & Craighead, 1999); and their resting state brain activity (Henriques and Davidson, 1990). Results from these studies suggest that people with MDD history maintain a lasting depression-like way of thinking. However, the PD group in the current study did not differ from the ND group, indicating that the characteristic tendency to ruminate; impaired cognitive control and impaired emotion regulation seen in currently depressed participants might not be lasting trait-like cognitive impairments and might instead be more dependent on the depressed state. The inclusion of a currently depressed group in future studies would allow a more in-depth analysis of this possibility.

Whole Group Analyses

Cognitive control predicts emotion regulation success

As expected, cognitive control was related to better performance on the emotion regulation task. After collapsing across groups, we found that Emotion regulation success was dependent on both the Inhibition/Switching score and the Switching score, but not the Inhibition score. We have interpreted this to be the measure of Switching. Switching is a measure of cognitive flexibility or ability to switch from one task to another while avoiding interference from previously relevant rules.

The difference between Inhibition and Switching is a matter of the type of cognitive interference and the timing of the interference. Inhibition is the ability to resist and override the automatic response (reading the words in STROOP) and apply a new rule (name the color the words are printed in). Weaker performance on this type of Inhibition has been found in remitted depressed participants by Paelecke-Habermann et al (2005). The interference for this type of Inhibition arises during the task and the main rule of the task is to inhibit this particular type of information. Switching, on the other hand, is the ability to resist interference of previously relevant information from memory that is no longer relevant to the current task at hand. For example, in task switching, the participant learns one rule and later learns a new rule that should henceforth replace the old rule. The participant must switch attention and only apply the new rule, while inhibiting previously learned reactions. Switching is also called cognitive flexibility.

The emotion regulation task is not designed to be a measure of switching, but nonetheless requires a certain degree of switching and cognitive flexibility to follow the instructions effectively. While viewing a mixture of neutral and emotionally salient pictures, paired with a mixture of LOOK and DISTANCE trials, the participant must switch between, at one moment, allowing a natural emotional reaction to arise, to another moment, implementing a learned emotion regulation strategy. If the participant cannot adapt and switch to the new rule quickly enough, a LOOK trial followed by a DISTANCE trial might become the cause of a cognitive and emotional struggle, resulting in unsuccessful emotion regulation. This might be one reason for the positive prediction seen in the present study.

The overlap between cognitive control and emotion regulation can be understood theoretically—we are using our cognition to control our emotions—but this overlap can also be seen on a neuronal level. Emotion regulation strategies, such as reappraisal, involve the modulation of emotional appraisal systems. fMRI data has shown that emotion regulation recruits brain regions implicated in cognitive control (PFC and cingulate), while at the same time modulating brain regions involved in the processing of emotion on both low and high levels (amygdalae and orbitofrontal cortex) (Ochsner & Gross, 2004). One can thus assume that cognitive control ability, and switching, in particular, would predict success on this type of emotion regulation task.

Our data support recent evidence for a predictive connection between cognitive control and emotion regulation. Tabibnia et al. (2011) studied the association between emotion regulation and cognitive control. They used the Stop Signal Task (Logan, 1994) to measure motor inhibitory control and emotion regulation was measured by asking participants to use a reappraisal strategy in response to negative images. They found that performance on the motor inhibitory control measure predicted regulatory success on the emotion regulation task affective measures (subjective report). These results show a connection between emotion regulation and a very specific type of cognitive control.

In an fMRI experiment, Winecoff, LaBar, Cabeza, & Huettel (2011) also studied the association between emotion regulation and cognitive control. Emotion regulation was measured by asking participants to use a reappraisal strategy in response to negative images. They did not use subjective reports of affect, but rather used decreases in amygdala activation as an indicator of regulation success. A composite score of cognitive ability was calculated from performance on tasks that tested memory and executive function (reaction time, STROOP and digit span). They found that increased cognitive ability was related to decreased amygdala activation when participants tried to regulate (regulation success). Our results are in line with these results and offer a closer look at the specific cognitive control ability of Switching, rather than using a composite score.

Lastly, McRae, Jacobs, Ray, John, & Gross (2012) studied the connection between different cognitive control measures and emotion regulation. An emotion regulation task using reappraisal to negative images was used to measure regulation ability. They used a math task to test working memory, a global/local judgment task to test set shifting and the classic STROOP to test response inhibition. They found that reappraisal ability was positively related to working memory and set shifting, but not to the classic STROOP. Our results are in line with these, such that performance on the cognitive control measure of shifting (switching in the current study), but not classic inhibition were related to emotion regulation ability/success.

Rumination does not predict emotion regulation success. No relationship was found between Rumination and Emotion Regulation. Based on the existing literature, we generally think of ruminators as low in healthy emotion regulation strategies, high in depressive symptoms and low in cognitive control (Treynor, Gonzalez & Nolen-Hoeksema, 2003

Garnefski & Kraaij, 2006; Nolen-Hoeksema, 2000; Joormann & Gotlib, 2010), but there is some data that suggests that this issue is more complex than previously thought.

In a study that investigated how rumination is related to emotion regulation, Ray et al. (2005), instructed participants to regulate their emotions in response to negative images using a reappraisal strategy. They found that participants high in rumination were more effective than those low in rumination at regulating the amygdala. Since ruminators are not thought of as effective regulators, this result was a surprising one. The authors interpreted these results to mean that because ruminators have so much practice in maintaining and even up-regulating negative mood, they are quite skilled at up and down regulating when instructed. The authors suggest that during an instructed regulation task, ruminators were able up and down regulate well, but that they did not do this on their own in day-to-day life. Additionally of interest is that the results were found only on the neuronal level and not in the behavioral data. This might also indicate that ruminators' subjective reports of affective do not match up with their actual brain activity. However, further replications of this finding are needed. Our understanding of rumination and how it relates to cognitive control and emotion regulation remains unclear. The current study found no relationship in either direction between rumination and the other measures, thereby lending support to the behavioral data from Ray et al. (2005).

Study Strengths and Limitations

Sample

A limitation of the present study is the sample. Ideally, the two participant groups would be larger in size and age matched. The participants in the PD group were significantly older than the participants in the ND group and had significantly lower Similarities scores. Due to more restricted availability of the PD participants as a clinical sample, these differences were difficult to avoid within the time frame of the master's thesis. Even with the significant differences though, neither Similarities scores nor Age predicted Regulation Success, STROOP or Rumination. Also, both groups' Similarities scores were above average.

Some of the participants from the current study had been treated with cognitive therapy, while others had received electroconvulsive therapy (ECT). The expected cognitive

results of these types of therapy are not completely understood, but while cognitive therapy should ideally result in qualitative changes in cognitive style, the end result of ECT, aside from less sadness, has not been thoroughly investigated. So, it is not known how treatment type affected cognition in this sample or whether or not the participants had become more skilled in emotion regulation strategies via therapy, compared to how they were in their depressed state. Furthermore, the PD group in the current study varied in terms of their depression history. Some participants had a history of only one past episode of depression while other participants had a lifelong history of multiple episodes. These participants are expected to have different types of cognitions and as well as differences in brain activity.

The plasticity of the brain results in changes over time as a result of practiced activities (Lazar et al., 2005; Vestergaard-Poulsen et al., 2009). For example, if one type of thought pattern is used repeatedly, neuronal connections between different regions are strengthened, but after an intervention or therapy, these habitual thought patterns can be changed and the changes can be seen in brain structure and activity as well (de Lange et al., 2008; Goldapple et al., 2004; Shu et al., 2012). We would therefore expect very different thinking patterns and brain activity when comparing participants with a history of one previous depressive episode to those with a lifelong history of multiple episodes. It is the participants with a history of multiple depressive episodes that would be expected to have exaggerated trait-like cognitions and so future studies should focus on this subgroup of remitted depressed participants.

In the future, therefore, it would be wise to include more information about the PD group, for example, number of MDD episodes, type of treatment, medication status and length of time since the last episode. Also, while the control group had no history of MDD, it is possible, that due to their young mean age, they had simply not had enough time in life to become depressed. This issue would be relevant for control participants, age matched or not, but the best we can do to address the complexities of studying a clinical sample is to have a sufficient sample with a large age range.

Lastly, in addition to a previously depressed group, future investigations into possible causes of recurrent depression would benefit from also including a currently depressed group. In the current study, the previously depressed group was a relatively high functioning group, based on their WASI scores, education level and job status. The results therefore might reflect their high level of functioning and it is possible that they were a high functioning group during their depressive episodes as well. Including a currently depressed group into the

experimental design would allow any results to be more conclusive, especially within the state-trait vulnerability framework.

Emotion Regulation Task

The nature of the stimuli used in most reappraisal studies might not tap into the type of emotions that are difficult for people with depression or history of depression to regulate. Erk et al. (2010), for example, found no differences between depressed and non-depressed participants during the instructed period of an emotion regulation task. In Erk et al. (2010), depressed participants were asked to down-regulate negative emotions in response to negative images. There were no group differences between the depressed and not depressed groups on self-reported negative affect or amygdala activity during the task. It is possible that these types of negative images do not create emotions that are particularly hard for people with depression to regulate, at least when instructed. Since the self-relevance of negative stimuli and time given for self-reflection seem to be related to negative bias in depression (Bradley et al., 1998), perhaps stimuli that tapped into this vulnerability would present different results. For example, it would be interesting to investigate if group differences would arise from previously depressed participants if negative self-referential memories were used as stimuli instead of pictures (Kross, Dadvidson, Weber, & Ochsner, 2009). Using self-relevant memories as stimuli instead of pictures would allow a closer look at how people with depression or history of depression regulate in life outside of the laboratory.

The emotion regulation task is an often used and well established way to study reappraisal. The task relies on subjective reports of emotional state at the end of each trial and these subjective reports are the measure used to assess regulation success. Reliance on solely subjective reports is a weakness with any experimental study, but since subjective reports in emotion regulation studies have been found to overlap well with neuronal and physiological activity (Ochsner & Gross, 2008; Ray, McRae, Ochsner, & Gross, 2010, as cited in Silvers et al, in press), there is support for the validity of this method. In some cases, however, depressed participants self-report regulation success, but their neural activity does not indicate that they have successfully regulated (for example, continued heightened amygdala activity) (Beauregard, 2006). For this reason, it would be beneficial in the future to add another level to

the emotion regulation task, such as psychophysiological measures, fMRI or EEG, to support and enhance the findings.

These shortcomings, however, must not overshadow the clear strength of the experimental task, which is the manipulation of emotions in real time. When studying emotion, there is the ever-challenging obstacle of gaining access to the inner and very subjective world of the participant's emotional experience. The current task relies on the well-validated IAPS to elicit emotion in combination with a well-established emotion regulation paradigm to manipulate and measure emotion regulation. The experiment's strength lies in the fact that participants must attempt to regulate emotions during the task and have direct access, therefore, to their emotional experience. This method allows participants to observe and reflect upon their regulation success while they are experiencing it, rather than demanding that they think back into their memory and report how successful they think they are at regulating emotions in general.

Future Directions

Distancing

Future studies might further investigate Distancing, as an emotion regulation strategy, by comparing it to another strategy, like reinterpretation. Denny & Ochsner have shown that distancing, compared to reinterpretation, is something that people can improve at over time (Denny, B. T., & Ochsner, K. N. Examining the temporal dynamics of emotion regulation: Evidence from longitudinal reappraisal practice. Unpublished manuscript). Distancing could potentially be used as a part of therapy to improve emotion regulation in depression and future studies should therefore test for specific effects of distancing over time in depressed and previously depressed participants.

Mood Induction

Perhaps PD patients would react differently to the emotion regulation task if under stress. Existing research has investigated the interaction of stressful life events and genetic vulnerability (short allele in the serotonin transporter; Caspi et al., 2003) on depression, while yet other studies have investigated the interaction of sad mood, as a measure of life stress, and depression history on attention deployment and regional cerebral blood flow (McCabe, Gotlib

& Martin, 2000; Liotti et al., 2002). These studies have all found that stress in the form of stressful life events or sad mood induction interacts with vulnerability for depression, resulting in depression, depression-like task performance or depression-like brain activity. In line with this knowledge, future studies should try to mimic stress in the laboratory setting to see how a history of depression vulnerability interacts with mood (representing a life stressor) to determine regulation success.

Cognitive control training

This study has found that across all participants, emotion regulation success was dependent upon cognitive control. Considering this relationship between cognitive control and emotion regulation, it is worthwhile to ponder the potential usefulness of this knowledge. If deficits in emotion regulation are predicted by deficits in cognitive control, strengthening cognitive control ability could potentially strengthen emotion regulation ability as well. The phenomenon of recurrent depression highlights the importance of improved therapies, since the current therapies are often not effective at preventing relapse.

Future studies should test how cognitive control training effects emotion regulation in previously depressed and depressed participants. Existing literature shows that cognitive training for people with depression helps to reduce symptoms of depression and these effects can also be seen in fMRI data (Siegle, Ghinassi & Thase, 2007).

Siegle et al. (2007) examined the effect of a cognitive control training (CCT) program on severely depressed participants. In order to train the PFC to activate during emotional experiences and reduce automatic negative thoughts, they implemented the Paced Auditory Serial Addition Task (PASAT, Gronwall, 1977) and the Wells (2000) attention control training task (ACT). The PASAT is a task in which participants must continuously attend to a series of numbers while performing addition and the ACT involves selectively attending to different sounds in a room and switching between the sounds, thereby practicing attentional control. Before training, depressed participants performed worse than controls on these tasks, but after only 2 weeks of training, the depressed group had improved performance and better performance than controls. Most importantly, after training, depressed participants showed fewer depressive symptoms and less rumination, indicating that CCT is beneficial in treating depression.

In another study based on the same training program by the same group, Siegle et al. (2007) found effects of CCT in fMRI data from a small sample. Depressed participants showed significant changes in amygdala and DLPFC activity from pre-to post-training. During an emotion task in which participants needed to judge the personal relevance of an emotional word, they found that post-training, amygdala activity increased for positive words and decreased for negative words. During a cognitive digit span task, they found that post-training, DLPFC activity decreased for the easiest trials and increased for the most difficult trials. The resulting post-training activity patterns show that CCT affects amygdala and DLPFC activity in depressed participants and makes activity in these regions match up with that of control participants.

Since depressive symptomology and rumination can be reduced through a CCT program, a logical next step would be to test the effect of CCT on emotion regulation in depressed and previously depressed participants. As we have shown in the current study, regulation success depends on cognitive control and testing the effect of CCT on emotion regulation might allow us to better understand the interplay between cognitive control and emotion regulation.

A benefit of CCT is that the participants do not need to directly address their depressive symptoms and thought patterns, something that, as Siegle et al. (2007) point out, is a process that might be too challenging for many depressed people, especially the severely depressed. In order to do the sort of work demanded of cognitive therapy, the patient must be motivated and feel a certain amount of capability. By going at the problem via CCT, a process that does not directly involve work with the emotions and thoughts, it could give the depressed person a helpful start in the right direction. Once cognitive control has improved, the depressed person, according to the existing literature, should experience less automatic negative thinking, less depressive symptoms (Siegle et al., 2007) and might therefore find it easier to take responsibility for his/her own cognition.

Conclusion

History of depression did not influence emotion regulation success, cognitive control performance or rumination tendencies in this study. These results suggest that depression-like symptoms (impaired emotion regulation, impaired cognitive control and increased rumination) do not carry over and persevere into the remitted state and therefore might not be the cause of recurrent episodes. Across all participants, switching/cognitive flexibility predicted regulation success, meaning that the ability to control emotions is related to the ability to control cognitions. It remains a possibility that the previously depressed group is more vulnerable to relapse and possible external stressors might reignite the habitual thinking patterns from the depressed episode, but that is something that only future research can explore. The connection between cognitive control and emotion regulation contributes useful knowledge to the development of training programs and therapies for depression and possibly for preventing recurrent episodes. Future research in this field should further explore the connection between cognitive control and emotion regulation in currently depressed, previously depressed and never depressed participants on multiple levels. Emotion is a complex and at times elusive phenomenon to study. Multi-level research on emotion, therefore, is particularly vital, as the different channels of emotional response do not always cohere.

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Appendix

Table D.6. Scaled-Score Equivalents of Scaled-Score Differences by All Age Groups: Contrast Measures

Scaled Score	Inhibition vs. Color Naming	Inhibition/Switching vs. Combined Naming + Reading	Inhibition/Switching vs. Inhibition	Inhibition/Switching vs. Color Naming	Inhibition/Switching vs. Word Reading	Scaled Score
1	<−8	<−8	<−7	<−9	<−8	1
2	−8	−8	−7	−9	−8	2
3	−7	−7	−6	−8 – −7	−7	3
4	−6	−6	−5	−6	−6	4
5	−5	−5	—	−5	−5	5
6	−4	−4	−4	−4	−4	6
7	−3	−3	−3	−3	−3	7
8	−2	−2	−2	−2	−2	8
9	−1	−1	−1	−1	−1	9
10	0	0	0	0	0	10
11	1	1	1	1	1	11
12	2	2	2	2	2	12
13	3	3	3	3	3	13
14	4	4	4	4	4	14
15	5	5	—	5	5	15
16	6	6	5	6	6	16
17	7	7	6	7–8	7	17
18	8	8	7	9	8	18
19	>8	>8	>7	>9	>8	19

Table D.6. from Appendix D page 273 in The Delis Kaplan Executive Function System Examiner's Manual (Delis et al., 2001a).