Executive Function Contributions to Emotion Regulation in the Relationship Between Stress and Psychopathology in Emerging Adulthood

by

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B.A, McMaster University, 2011

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Abstract

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Prevailing theories of emotion regulation (ER) focus on the role of various aspects of cognition for successful regulation of one's emotions. In particular, research suggests that executive functions (EF) may play an important role in contributing to successful ER. Emerging adulthood can be a time of high levels of perceived stress associated with changing developmental roles, which can be a risk factor for psychopathology (e.g., depression, anxiety). Emerging adulthood is also a time during which EF comes to maturation both behaviorally and biologically. This prolonged period of development associated with EF and ER maturity may represent an increased period of vulnerability in young adults, and deficits in EF may pose a significant risk for emotion dysregulation and future psychopathology. This study aimed to investigate whether EFs played a role in ER for emerging adults. More specifically, this study examined whether EFs (including, working memory, attentional control, and inhibitory control) moderated the indirect effect of ER in the relationship between stress and psychopathology in the context of emerging adulthood. A sample of 75 undergraduate students at the University of Victoria was recruited. Participants self reported perceived levels of stress and psychopathology symptoms. Participants also completed a computerized ER task where they viewed aversive pictures and sentences on a computer screen and explicitly applied an ER strategy to reduce their negative emotions when viewing the stimuli. Tests of EF including the Go/No-Go, Number-Letter and N-Back task were also completed. Results

revealed that moderated mediation did not hold for this sample. However, working memory, attentional control, and inhibitory control moderated the relationship between ER and psychopathology. Specifically, low working memory and attentional control, and high inhibitory control moderated the relationship between cognitive reappraisal and psychopathology. For this same relationship of cognitive reappraisal to psychopathology, faster engagement in response inhibition (i.e., faster reaction times) was trending toward significant levels of psychopathology symptoms. For expressive suppression, the relationship to psychopathology was moderated by inhibitory control. ER did not mediate the relationship between stress and psychopathology symptoms across the entire sample. The results illuminate the ways in which EFs contribute to ER in the context of emerging adulthood. Implications for promoting successful ER and informing therapeutic techniques used with this critical population are discussed.

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Acknowledgments

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Dedication

To my family, friends, and partner, thank you for teaching me to go after what I am most passionate about in life. You have undoubtedly motivated me to pursue my dreams and none of this would have been possible without your love and support.

Introduction

Over the past two decades, emotion regulation (ER) has become the focus of intense research activity. At a basic level, ER involves a diverse set of control processes that work together in order to manipulate when, where and how emotions are experienced and how these emotions are expressed (Gross, 1998a; Gross & Thompson, 2007). A range of activities has been shown to support successful ER. Although great debate surrounds what can be considered to be 'successful' ER, for the purpose of this study it can be understood as an individual's ability to monitor, evaluate, and modify their emotional responses in such a way that allows them to act in accordance to their own goals and to appropriately respond to environmental demands (Gross, 1998a). Current speculations have suggested that ER processes should be, at least in part, dependent on one's cognitive resources specifically, executive functions (EF) (Schmeichel, Volokhov, & Demaree, 2008; Sheppes & Gross, 2011; 2012). Similar to emotion processes, EF can be understood as an outcome of a number of emotional and cognitive control processes. These interactions are thought to be mediated by key areas in the brain that are important in rule setting and organizational abilities/behaviors that influence one's daily activities (e.g., setting goals, planning meals, driving to work). Ultimately, the fundamental goal of EFs is to contribute to volitional, efficient, and purposeful goal directed behaviors (Garcia-Barrera, Duggan, Karr, & Reynolds, 2014). These abilities play an important role in one's capacity to engage and interact in the world (Miyake et al., 2000). Increasingly, evidence has begun to show that engaging in specific forms of ER can require significant cognitive resources and may have taxing consequences on EFs. However, the majority of

this research has studied these processes separately and as such it is not clear which EF processes contribute to or interact with ER processes. Emerging adulthood is a critical developmental period in which neural networks in the brain related to both ER and EFs are continuously developing and being refined (Lebel & Beaulieu, 2011; Passler, Issac, & Hynd, 1985; Veroude, Jolles, Croiset, & Krabbendam, 2013). It is speculated that emerging adults may be particularly susceptible to the deleterious effects of stress as a result of not having a fully developed cognitive control system (i.e., EFs) available in order to support adaptive ER (Ochsner & Gross, 2005; Opitz, Gross, & Urry, 2012). Therefore, the primary aim of this study was to investigate whether EFs played a role in ER for emerging adults and further, to examine whether neurocognitive underpinnings of emotion dysregulation (i.e. EFs) moderated the relationship between stress and psychopathology in the context of emerging adulthood. The results of the present study will help inform current investigations by identifying potential risk and resiliency factors in the onset of mental health difficulties during this critical transitional period. Furthermore, results of this study could be used to educate emerging adults in implementing adaptive ER strategies when in the midst of stress, before a clinical diagnosis is made.

Emerging Adulthood: A Time of High Stress and High Risk for Psychopathology

Emerging adulthood includes the period of development from individuals' late teens through their twenties (i.e., 18-25 years of age), whereby they are no longer considered adolescents, but have yet to obtain the independence and self-sufficiency associated with adulthood (Arnett, 2000). This critical developmental period is a time of extensive growth and change whereby individuals are at an elevated risk for

psychopathology (Chan, 2010; Olfson, Bianco, Wange, Laje, & Correll, 2014; Stawski, Siliwinski, Almeida, & Smyth, 2008; Wang & Saudino, 2011; Wittchen, Nelson, & Lachner, 1998). Critical transitions from social, occupational, and academic environments to novel contexts have been suggested to contribute to this elevation in psychopathology (Arnett, 2000). A number of significant life altering changes, such as graduating from high school, attempting new educational and occupational endeavours, departing from one's home, and becoming involved in social and intimate relationships are suggested to contribute to high stress levels for young adults (Arnett, 2007). As such, these particular changes may pose crucial vulnerability factors resulting in decline in mental health. It is this variation and insecurity in multiple aspects of one's life coupled with high emotion dysregulation that may render emerging adults vulnerable to psychopathology (e.g., mood disorders, anxiety disorders, and eating disorders) (Masten & Tellegen, 2012; O'Connor et al., 2012; Rohde, Lewinsohn, Klein, Seeley, & Gau, 2013; Schreiber, Grant, & Odlaug, 2012; Stone, Becker, Huber, & Catalano, 2012).

Psychopathology has been commonly viewed as a result of chronic emotion dysregulation (Aldao, Nolen-Hoeksema, & Schweizer, 2010; Mennin & Farach, 2007). Theoretical models have provided evidence supporting this underlying assumption, indicating that emotion dysregulation plays a critical role in the development and maintenance of psychopathology (Berenbaum, Raghavan, Le, Vernon, & Gomez, 2003; Mennin & Farach, 2007; Moore, Zoellner, & Mollenholt, 2008). For instance, emotion dysregulation is a component of several models of specific psychopathologies, including major depressive disorder (MDD; Nolen-Hoeksema, Wisco, & Lyuomirsky, 2008; Rottenberg, Gross, & Gotlib, 2005), bipolar disorder (Johnson, 2005; Lewinsohn, Klein,

& Seeley, 2000), generalized anxiety disorder (GAD; Mennin, Holoway, Fresco, Moore, & Heimberg, 2007), social anxiety disorder (SAD; Kashdan & Breen, 2008), eating disorders (Bydlowski et al., 2005; Clyne & Blampied, 2004), and substance-related disorders (Fox, Axelrod, Paliwal, Sleeper, & Sinha, 2007; Sher & Grekin, 2007). Individuals who cannot effectively manage their emotional responses to everyday events are more likely to experience longer and more severe periods of distress that may evolve into recurrent mental health difficulties (Nolen-Hoeksema et al., 2008). Thus, it is not surprising that prolonged or chronic emotion dysregulation leads to subsequent psychopathology (Campbell-Sills & Barlow, 2007; Mennin et al., 2007).

A significant occurrence of emotion dysregulation and the onset of various mental health disorders commonly occur during this critical developmental period of emerging adulthood. Earlier onset of these disorders is often associated with more debilitating trajectories and poorer prognosis than those with later onset in life (Statistics Canada, 2003). Furthermore, chronic stress and psychopathology during emerging adulthood is associated with far-reaching consequences including other health and developmental concerns, notably with educational achievements (Fry & Liem, 2011; Sheidow, McCart, Zajac, & Davis, 2012). According to the 2006 Census outlined by the Public Health Agency of Canada, prevalence rates of psychopathology in young adults are considerably larger compared to any other age group. Prevalence rates for mood disorders in this population are suggested to range from 3.5%-6.9%, anxiety disorders from 3.8%-7.8%, eating disorders from 1.5% to over 3%, and substance abuse from 6%-27% (Statistics Canada, 2009). These findings are consistent with current insights demonstrating that emerging adults have the highest incidence and cumulative prevalence of

psychopathology of any age group (Rohde et al., 2013), with overall incidence rates for mental health diagnoses ranging from as low as 8% to as high as 57% (Patel, Flisher, Hetrick, & McGorry, 2007). Internalizing disorders are among the most common psychiatric difficulties experienced in this population including increased negative mood, feelings of loneliness, and heightened anxiety (Hankin et al., 1998; Tanner et al., 2007).

Although major transitions in young adulthood may be deleterious to some individuals, they may act as positive turning points for others (Burt & Paysnick, 2012; Diener & Larson, 1993; Gore, Aseltine, Colten, & Lin, 1997). Interpersonal relationships and social support networks have often been considered critical protective factors during this developmental period (Burns & Machin, 2013). Additionally, access to stable resources, and adaptive ER strategies are associated with better outcomes for young adults (Gross & John, 2003; John & Gross, 2004). For instance, the ability to engage in goal-directed behaviors while experiencing negative emotions has not only been associated with greater emotional stability in adulthood, but has also been found to aid in reducing or managing the level of stress one experiences (Brose, Scheibe, & Schmiedek, 2012). Below an integrative paradigm that links genetics, neurobiological, psychological, and environmental factors is examined.

The high prevalence of psychopathology in emerging adulthood can be best understood by considering the diathesis-stress paradigm. This model holds that some individuals due to a diathesis, or pre-existing vulnerability in their make-up (e.g., behavioral/temperamental, physiological or genetic in origin) are more likely to be affected by an environmental stressor (Monroe & Simons, 1991). In the context of the diathesis-stress model, it has been posited that ER difficulties are one example of a

diathesis that in combination with stress leads to psychopathology. This becomes increasingly obvious when considering evidence from both human and animal models. Specifically, it is widely established that exposure to stress releases stress hormones, including corticosteroids and glucocorticoids (see Lupien, McEwen, Gunnar, & Heim, 2009 for a review) which are thought to cause damaging and suppressive effects on neurogenesis (Gould & Tanapat, 1999), that is, the production of new neurons in the brain. Research suggests that these newly generated cells are continuously produced and mature into functional neurons throughout the life span (van Praag et al., 2002), and ultimately perform the role of supporting lifelong adaptation by allowing organisms to deal with levels of novelty and complexity throughout life (Penzes, Cahill, Jones, VanLeeuwen, & Woolfrey, 2011). It is suggested that healthy neuronal turnover supports a very high level of plasticity in the brain (Bardi. True, Franssen, Kaufman, Rzucidlo, & Lambert, 2012; Gould & Tanapat, 1999; Schmidt-Hieber, Jonas, & Bischofberger, 2004). Emotion dysregulation in interaction with high stress poses a significant risk for emerging adults in terms of experiencing mental health difficulties, given the high plasticity of the brain during this transitional developmental period. Emerging adulthood is a time of high stress, in combination with immature cognitive control networks, places this population at a vulnerable place in terms of developing psychopathology. For example, high stress during this developmental period may negatively impact the integrity of a young persons brain and may increase vulnerability in terms of adapting to new environmental demands (e.g., attending a new school, leaving home) and regulating stress (e.g., balancing academics and social activities and managing homework). Therefore, emotion dysregulation and stress can be understood as being partially

independent yet reciprocally influential (Gross, 2002). Emerging adulthood may act as a sensitive period in which individuals may experience brain-based changes as a result of high stress without the proper resources to protect themselves (i.e., adaptive ER strategies).

Stress hormones have not only been found to slow the production of neurons in the brain (Czeh et al., 2002), but have also been found to be involved in the hypothalamic-pituitary-adrenal (HPA) axis response to stress (Aimone, Deng, & Gage, 2010; Lupien & Lepage, 2001). The key function of the HPA axis is to act as the body's first line defense to stress, with the stress hormone cortisol playing a key role (Herman & Cullinan, 1997). Abnormal HPA function has been implicated in psychopathology and conceptualized in part as an inappropriate, often prolonged, response to stress (Lopez-Duran et al. 2009). Environmental stress is a strong modulator of neurogenesis as discussed above, yet prolonged stress has been found to cause more extensive neuropathology in critical brain regions including the hippocampus, prefrontal cortex (PFC), and anterior cingulate cortex (ACC) regions (Goto, Yang & Otani, 2010; Gould & Tanapat, 1999; MacLullich et al., 2006). These are brain regions implicated in ER processes. Support for these findings come from a large number of studies with laboratory animals that have indicated that exposure to stress or stress hormones is commonly associated with detrimental effects on hippocampal integrity including a loss of hippocampal neurons (Sapolsky, Krey, & McEwen, 1985; Snyder & Cameron, 2012; Kerr, Campbell, Applegate, Brodish, & Landfied, 1991), inhibition of cell proliferation (Gould, Woolley, Cameron, Daniels, & McEwen, 1991; Tanapat, Galea, & Gould 1998) a decrease in dendritic branching (Wooley, Gould, & McEwen, 1990; Watanabe, Gould,

& McEwen, 1992), and ACC integrity including reductions in ACC grey matter volume, loss of synaptic spine density, and decreased dendritic length of neurons (Ansell, Rando, Tuit, Guarnaccia, & Sinha, 2012; Kassem et al., 2012; Papagni et al., 2011). Similarly, deleterious effects of stress on the PFC have been differentially implicated in various psychiatric disorders whereby disruptions in synaptic plasticity in this region is commonly associated with debilitating cognitive deficits marking these disorders (e.g., depression, anxiety, and substance abuse) (Goto, Yang & Otani, 2010). The diathesis-stress model as introduced at the beginning of this section, posits that chronic stress sets up a biological vulnerability (e.g., dysregulation of HPA axis) to poor ER and subsequent psychopathology. It is suggested that neurogenesis deficits consequent to prolonged exposure to stress, coupled with dysregulation of the HPA axis, may leave young adults vulnerable to considerable emotion dysregulation and future mental health difficulties.

It is important to note for the purpose of this study that suppressed neurogenesis has been associated with various cognitive deficits including a decreased ability to cope with stress (Marin et al., 2011; Papez, 1937; Revest et al., 2009; Sapolsky, 2000). This is suggested to be due in part to disturbed functioning in critical brain regions implicated in ER processes and connections with other important networks in the brain (e.g., hippocampal, PFC, and ACC) (Gould & Tanapat, 1999), as well as regulation of the HPA axis. Thus, deficits in these critical structures are thought to lead to maladaptive responses to the external environment and negatively impact one's cognitive abilities. Therefore, stress-induced changes or disruptions of new neurons in critical brain regions may ultimately contribute to young adults' vulnerability in dealing with and regulating levels of emotional stress throughout life. For instance, when considering poor cognitive

outcomes as a result of chronic stress and biological vulnerability, recent research has found that higher levels of cortisol were associated with poorer cognitive ability and decreased performance on measures of EF (Stawski, Almeida, Lachman, Tun, Rosnick & Seeman, 2011). This is likely due to the toxic effects of stress on neuronal production (Teicher, Tomoda, & Anderson, 2006). These findings are consistent with previous research and are suggested to account for why substantial impairments on complex cognitive processes such as ER are consequently seen (Pechtel & Pizzagalli, 2011). There is an underlying assumption that cognitive abilities, namely EFs, are important predictors of HPA function, with relatively healthier levels of cortisol being associated with higher levels of EFs (Applehans & Leucken, 2006; Stawski, Almeida, Lachman, Tun & Rosnick, 2010). Moreover, it has been suggested that individuals possessing critical components of EF may be better at tempering their reactions to stressful experiences which in turn leads them to have relatively healthier profiles of HPA axis function (Stawski et al., 2011).

Emotion Regulation: An Overview

As noted above, within the context of the diathesis-stress model of psychopathology, emotion dysregulation presents as one important diathesis to be considered. But what is ER, and how can this construct be best conceptualized? ER encompasses a heterogeneous set of processes by which emotions are themselves regulated. ER involves a wide array of activities that allow an individual to monitor, evaluate, and modify both the nature and the course of an emotional response in accordance to one's own goals, and in a way to appropriately respond to environmental demands (Gross, 1998a). Various aspects of cognition have been suggested to contribute

to successful ER and as such have become the focus of prevailing ER theories (Ochsner & Gross, 2008; Sheppes & Levin, 2013). For instance, the ability to flexibly choose between ER strategies in a manner that is adaptive to differing situational demands, and in accordance to one's own goals and restraints is critical (Kashdan & Rottenberg, 2010; Troy & Mauss, 2011; for reviews). Ultimately there is this constant competition between emotion generation and ER processes for dominance over one's behaviors (Gross, Sheppes, & Urry, 2011a,b). The underlying ability to engage in specific ER strategies is suggested to result in a differential cost-benefit trade-off or interaction between emotion and cognition processes (Sheppes & Gross, 2011, 2012). In the following section one of the most sound and well-respected models of ER will be examined. This model effectively focuses on this interaction between emotion and cognition and demonstrates how cognitive abilities interact with and contribute to ER processes.

The process model view of ER as proposed by Gross (1998) distinguishes specific points during the emotion generative process at which emotions may be regulated. The underlying notion of this model rests on the fact that it distinguishes five ER processes on a temporal dimension that indicates when each one is deployed. Below is a brief explanation of each of the five stages (see Figure 1.).

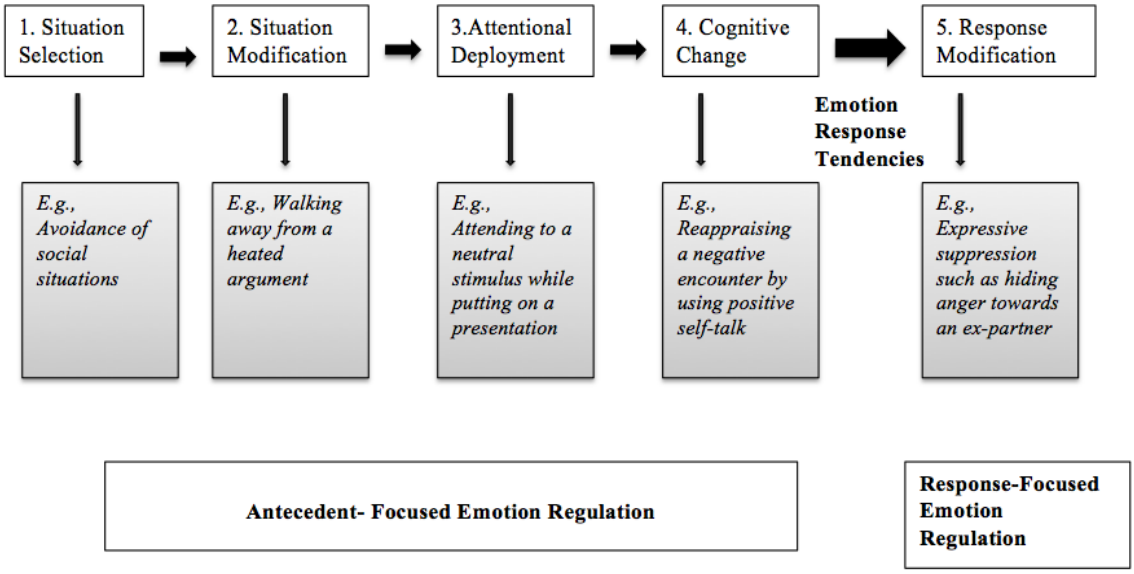


Figure 1. The process model of emotion regulation. Adapted from "Emotion Regulation: Conceptual Foundations," by J. J. Gross and R. A. Thompson, in J. J. Gross (Ed.), *Handbook of Emotion Regulation* (p. 10), 2007, New York, NY: Guilford Press. Copyright 2007 by Guilford Press.

Situation selection, the first family of regulatory processes, represents an individual's tendency to either approach or avoid certain people, places, or activities so as to regulate their emotions. This first step in the model highlights the idea that there are times when an individual can avert the emotion altogether, even before the emotion has started. Individuals can choose which situations to expose themselves to, leading them to have certain emotions they would like to have while avoiding those that they would not. Situation selection is a way of intervening before emotions start. The second stage of regulatory processes, **situation modification**, includes those strategies that are utilized once an individual selects a situation; the emotional impact associated with that particular situation is then modified. In the third family of regulatory processes, **attentional deployment** is emphasized. Situations have many different aspects, and attentional

deployment can be used to pick particular aspects to focus on. Once an individual is in a situation and attending to it in certain ways, they can influence how they are attending to that situation as a way of modifying their emotions. For example, one can shift his or her attention with the goal of modifying the emotions he or she is experiencing. For example, attending to a non-threatening stimulus during a presentation (e.g., maintaining focus on a friend) may be an effective ER strategy to reduce anxiety. However, it is important to note that for some individuals this ability to effectively control one's attention may be difficult. Individuals with anxiety and depression are often associated with rigid and impaired attentional control, and often perseverate on anxiety provoking stimuli, as well as mood congruent information in the environment (Austin, Mitchell, & Goodwin, 2001; Han et al., 2014), which contribute to their negative emotions. Once a particular aspect of a situation is focused on many possible meanings may be attached. Individuals possess the ability to change their cognition or interpretation of that aspect in order to regulate their emotions; this represents the fourth family of regulatory processes referred to as, **cognitive change**. Once an individual finds him or herself in a situation that is eliciting an emotional response, they attend to certain aspects of the environment in certain ways and try to modify the way they are thinking about the situation in order to alter the emotion itself. One form of cognitive change includes cognitive reappraisal, which involves the construing of a potentially emotion-eliciting situation in a way that reformulates the meaning of a situation, thereby changing its emotional impact (Gross & Thompson, 2007; Lazarus & Alfter, 1964). It is important to note that cognitive reappraisal includes challenging how one thinks about a situation in order to decrease its emotional impact (Gross, 2001). Thus, the focus is on decreasing the experience and

behavioral expression of emotion. One form or method of using cognitive reappraisal include strategies such as self-talk. Self-talk consists of dialogue through which an individual interprets, regulates, and changes evaluations of their emotions (Hackfort & Schwnekmezger, 1993). As a method of cognitive reappraisal, self-talk is commonly used as a way of modifying the how a particular situation is interpreted and in turn, modifying the emotion itself (Hardy, 2006). Encoding information in one's mind through the use of this strategy (e.g., engaging in thoughts or subvocal self-talk statements) leads a person to behave in correspondence to his or her expectations of what consequences will follow from particular actions (Houghton, Wu, Godwin, Neck, & Manz, 2012). For instance, through the use of constructive self-talk, an individual can become motivated to act in ways that positively influence his or her future whereas negative self-talk can be detrimental and may lead to negative experiences such as experiencing increased negative emotions. Finally through **response modification**, the fifth family of regulatory processes, the individual attempts to influence his or her emotion response tendencies once the emotions have already been elicited. Response modification may influence physiological, experiential, or behavioral responses relatively directly. Expressive suppression is one form of response modification, which focuses on decreasing negative, rather than increasing positive, expressive behavior and may also involve altering one's experience or physiology (Gross, 2002). Thus, the ability to actively inhibit or down regulate expressive behaviors is pertinent to the ability to modify one's response once an their emotions have already been elicited. Of note, the goal of expressive suppression is to decease the behavioral expression of emotions (i.e., put on a 'poker face') however this ER technique does not necessarily decrease the actual felt experience of emotion (Gross,

2001). Taken together, these five families of regulatory processes take advantage of the idea that as an individual processes information in a manner that causes them to feel particular emotions, they can ultimately intervene at any point during the emotion process. Although each stage of this model is thought to represent distinct ER processes, there is an underlying commonality of all five stages, which is the prominent role of cognition (Hofmann, Schmeichel, & Baddeley, 2012; McRae, Jacobs, Ray, John, & Gross, 2012b; Mueller, 2011); specifically, the ability to continuously monitor, evaluate, and utilize cognitive control processes necessary for effective ER. This will be further explored later in this review in the context of EFs.

Emotions are generated in various ways ranging from automatic reactions to stimuli in the environment (e.g., reacting to a spider) to conclusions drawn from social interactions or interpersonal relationships (e.g., pursuing a romantic relationship). At a basic level, emotions are generated when an external or internal event signals to an individual that something important may be at stake (Gross, 2002). When attended to and evaluated in certain ways, emotion cues trigger a coordinated set of responses that involve experiential, behavioral, and physiological systems. Once these emotion responses arise, they may be modulated, thereby shaping the individual's observable responses – what is meant by the process of ER. As noted in the model outlined in Figure 1, the five types of regulatory strategies can be conceptualized under two different approaches in the context of Gross's process model (2007): antecedent-focused and response-focused ER. These two types of ER strategies can be differentiated based on the point in time in which they are enacted relative to the onset of the emotion to be regulated (Gross, 1998a). **Antecedent-focused** strategies refer to those strategies an individual

engages in before his or her emotional response has become fully activated; they include situation selection, situation modification, attentional deployment, and cognitive change (see Figure 1.). Individuals often engage in or utilize this type of strategy (e.g., cognitive reappraisal) before they make changes to their behavior and/or physiological responding. As an example consider the following: during a work meeting a colleague makes an inappropriate remark towards a fellow co-worker; the co-worker might cognitively re-evaluate the comment (e.g. as a sign that the colleague may be having a bad day) and thereby alter the entire emotion trajectory, feeling sympathy for the colleague rather than anger. The goal of such antecedent-focused strategies is the modification of future emotional responses. On the other hand, **response-focused** strategies reflect those utilized once an emotion is already underway, or after the response tendencies have already been generated. Referring back to the previous example, during the same meeting the same colleague makes another inappropriate comment; in this case, the co-worker might try to appear unbothered or hurt by the comment, despite underlying feelings of anger and frustration. Therefore, the aim of such response-focused strategies is the management of existing or current emotions and includes response modification (Gross & John, 2003).

Research on the development of ER has concentrated on infancy and early childhood to the relative neglect of other periods of the lifespan, including emerging adulthood. However, these studies have consistently demonstrated that ER is a life-span developmental process that is complex in nature. In early life, studies emphasize the role of caregivers in regulating infant and young children's negative emotions (e.g., self-comforting strategies, help seeking, and physical soothing) (Stifter & Braungart, 1995).

Early in life, infants have very limited capacity to regulate their emotions and are ultimately dependent on their caregivers to meet their goals. Caregivers play a critical role in socializing young children's emotions, which influence the development of children's independent ability to regulate their own emotions (Kopp, 1989). Prevailing views suggest that the development of ER changes from being socially regulated to being self-regulated over the course of childhood (Sameroff, 2010) as a child's reliance on others lessens over time (Calkins, 2009). Moreover, there is evidence to suggest that children develop ER alongside the development of self-talk (Barrett, 2009; Thompson, 1994; 2011), an ability that facilitates effective use of ER strategies such as cognitive reappraisal (Gross, 2001). Aspects of cognition are evidently developing alongside ER strategies and as such, enable individuals to engage in adaptive ER over the life span (Thompson, Virmani, Waters, Raikes & Meyer, 2013). Furthermore, early developmental advances illustrate how pervasively emotion interacts with cognition in its progress from simple preverbal or self-talk strategies, to more sophisticated self-awareness and more complex ER strategies (Barrett, 2009; Izard, 2007). Thus, the acquisition of adaptive ER skills and strategies is considered a critical achievement of early childhood (Bronson, 2000; Posner & Rothbart, 2000). As ER continues to develop across the lifespan, there are interrelated biological and social changes taking place in adolescence that afford new challenges and opportunities for this population to experience and regulate emotions (Giedd, 2004). Moreover, adolescence marks a complex and unique period in the development of ER that often places an emphasis on social groups and peer acceptance (Guyer, Caouette, Lee, & Ruiz, 2014). Many of the neural and cognitive systems thought to underlie the regulation of emotion appear to mature throughout the adolescent period

into young adulthood (Spear, 2000). In addition, differential social experiences with peers have been suggested to have important effects on adolescent ER (Dahl, 2004; Scherf, Behrmann, & Dalh, 2011). For instance, sensitivities to certain types of interactions (e.g., peer evaluations) affect the emotional lives of adolescents and during this developmental period it may be more challenging to engage in certain adaptive ER strategies. Learning to regulate emotions, which start to become more intense in adolescence (Larson & Lampman-Petraitis, 1989), is a challenging developmental task (Dahl & Gunner, 2009; Forbes & Dahl, 2010). The transition from adolescence to young adulthood marks another important developmental period, which is often not studied directly. Emerging adulthood is a time of dramatic cognitive, emotional, behavioral, and social changes (Arnett, 2000). In the cognitive domain, brain development is still underway particularly in the circuitry of critical brain regions including the PFC, which supports ER processes. In the social arena, young adults are commonly transitioning into more autonomous and adult-like social roles, carrying more responsibility, expectations about their independence, and ability to control their own emotions (Arnett, 2000; Fuligni & Pedersen, 2002). Importantly, this period of rapid and complex change toward adult levels of emotional and social competence also represents an interval of vulnerability. That is, young adulthood is a period during which we see an emergence of many psychological problems (Stawski et al., 2008) that may be linked to neural changes taking place, particularly in terms of the networks that process cognitive and emotional information (Wahlstrom, White & Luciana, 2010). Regardless of developmental stage, social context plays an important role in the development of ER (English & Carstensen, 2014). For instance, even as the capacity for self-regulation develops, social relationships

continue to play a large and significant regulatory role throughout the lifespan influencing the development of ER. Taken together, the lifespan development of emotional processes is associated with age related changes in the regulation of emotions that parallel biological and cognitive maturation. Brain maturation and patterns of neurological functioning related to emotional processes continue to develop throughout young adulthood (Cunningham, Bhattacharya, & Benes, 2002), yet very little research has directly focused on this population. As such, it is important that processes of emotion management are directly studied during the transition to adulthood.

Neural & neurocognitive underpinnings of emotion regulation. Investigations of the neuroanatomical underpinnings of ER consistently suggest that ER cannot be traced to a single brain system, and is instead the product of multiple neural systems that interconnect with complex areas in the brain (Ochsner, Silvers, & Buhle, 2012; Zhang, Guo, Zhang, & Luo, 2013). Much of this current research has relied on functional neuroimaging methodologies, typically examining regulation of emotional responses to emotion-evoking images or films, or down-regulation of anticipatory anxiety.

Regardless of the type of ER mechanism or the specific paradigms used, most studies examining ER networks have shown prefrontal activation, often involving the dorsolateral (DLPFC), dorsomedial (DMPFC) and orbitofrontal cortex (OFC) including the ventromedial prefrontal cortex (VPFC), and the anterior cingulate cortex (ACC; primarily dorsal ACC) (Etkin, Egner, & Kalisch, 2011; Ochsner & Gross, 2008). Incidentally, these are structures associated with the neural basis of EF, as will be discussed in the subsequent section. In general, the strength of prefrontal (primarily OFC and medial PFC) and dorsal ACC activation correlates with decreases or increases in

amygdala activation, depending on whether the goal of participants' regulatory strategy was to decrease or increase (respectively) a given emotional experience (Giuliani, Drabant, & Gross, 2011; Goldin et al., 2008; Ochsner, Bunge, Gross & Gabrieli, 2002; Phillips et al, 2008; Ray & Zald, 2012; Phan et al., 2005; Urry et al., 2006). These patterns of coactivation demonstrate that the PFC exerts some degree of control over the emotional trigger during antecedent response stages, thereby also up- or down- regulating one's emotional responses (Goldin et al., 2008; Gross, 2002). All of the above brain regions have been commonly pointed out as important composites of the neural circuit underlying ER processes in both previous structural and/or functional imaging studies as well as in recent research (Ochsner & Gross 2005; Goldin et al., 2008; Welborn et al., 2009; Giuliani et al., 2011; Giuliani, Drabant, Bhatnagar, & Gross, 2011; Kühn, Gallinat, & Brass, 2011).

When examining the neural underpinnings of cognitive reappraisal and expressive suppression explicitly, there are differences that emerge in the brain structures that are recruited for these processes. For instance, a recent study by Hermann and colleagues (2013) indicated that habitual engagement in cognitive reappraisal was associated with enhanced amygdala volumes, whereas habitual use of expressive suppression was associated with larger dmPFC gray matter volume. Speculations have been made to make sense of these novel findings suggesting a use-dependent brain plasticity hypothesis (Hermann, Bieber, Keck, Vaitl, & Stark, 2013). It is suggested that habitual use of these particular ER strategies may be associated with frequent activation of the associated brain regions mentioned above, leading to greater efficiency (Giuliani et al., 2011) and changes in volume.

As previously noted, structures implicated in ER are also known to play a prominent role in EF, suggesting that these processes may be, in fact, interconnected and mutually influential. In the following section, conceptualizations of EFs will be examined with the primary goal of better understanding what is meant by EF and to identify its associated substrates.

Current Conceptualizations of Executive Functions

The topic of EF has been of great debate over the last few decades. Various influential models and theories of EF have been proposed in an effort to integrate the control processes of the frontal lobe into a coherent framework. These conceptualizations have stemmed primarily from three areas of research including psychometric approaches (e.g., statistical analyses of neuropsychological questionnaires and self-report measures) (Burgess et al., 2006; Miyake et al., 2000; Salthouse, Atkinson & Berish, 2003), clinically based models focused on identified patient groups (Mateer 1999; Norman & Shallice, 1986), and models with a neural basis of conceptualization (Fuster, 1985; Levine, Turner, & Stuss, 2008; Miller & Cohen, 2001). However, despite this progress, there is much that remains elusive and not consistently agreed upon. Ultimately these are questions regarding the organization of EF and their roles in complex cognition, which remain unanswered.

Controversies surrounding EFs have largely been fuelled by the debate as to whether EFs can be described as a "unitary" or "diverse" construct, an idea originally proposed by Tueber (1972). It has recently been argued that EF represents both a "unitary" and "diverse" construct (Miyake et al., 2000; Miyake & Friedman, 2012). Different EFs have been shown to correlate with one another, thus tapping some common

underlying ability (unity), but they also show some separability (diversity). Therefore, the purpose of this section is not to provide an exhaustive overview of EFs but rather, to provide insight into current understandings. Specifically, the goals of this section are: (1) to address current conceptualizations of EF; (2) examine the neural bases of EF; and (3) investigate developmental aspects of EF, in particular, how the brain is changing in emerging adulthood. In doing so the relationship between ER and EF processes are emphasized.

One of the most widely cited approaches to EF identifies three fundamental components including (a) shifting between tasks or mental sets (shifting), (b) updating and monitoring of working memory representations (updating), and (c) inhibition of dominant or prepotent responses (inhibition) (Miyake et al., 2000). These lower order and more circumscribed EFs are implicated in the performance of complex, conventional EF processes and tasks including reasoning, problem solving, and planning (Collins & Koechlin, 2012, Lunt et al., 2012). Below each EF as proposed by Miyake and colleagues (2000) are discussed.

'Shifting' represents the ability to alternate between tasks or mental sets with flexibility (Anderson, 2002). For example, when an individual is dealing with a difficult task and is unable to solve the problem at hand, they may be able to think of a new way of addressing the problem that was not considered before and flexibly shift to a new approach. In contrast, an individual with poor shifting abilities may perseverate on certain aspects in the environment or may have greater rigidity in their thinking. For example an individual may have greater rigidity or inflexibility in their thinking and may not be able to shift to a new perspective or problem solving strategy. Thus, they may perseverate or

consistently try to solve the problem 'sticking' with their initial unsuccessful strategy. From these examples it is easy to acknowledge the importance that this fundamental EF has in various complex processes, including problem solving situations, planning and decision making. Moreover, 'shifting' enables individuals to flexibly adjust to changing demands or new priorities, take on new perspectives, and explore new environments. Thus the ability to shift back and forth between multiple tasks, operations, or mental sets (Monsell, 1996) is an important aspect of executive control (i.e., higher order EF) (Norman & Shallice, 1986) and deficits in this area can have a significant impact across many fundamental domains.

The second core EF includes updating and monitoring of working memory. 'Updating' refers to the ability to monitor the relevance of external information and tie that information to the task at hand by updating the content of working memory (Miyake et al., 2000). Research suggests that this updating process may involve "temporal tagging" to keep track of which information is old and no longer relevant (Jonides & Smith, 1997). Another central aspect of this updating function is the active engagement required rather than a passive storage of information over time. It goes beyond the simple maintenance of task-relevant information in that it requires an individual to actively manipulate the contents of working memory (Lehto, 1996; Morris & Jones, 1990). This lower order EF (i.e., 'updating of working memory') is critical for making sense of information in the environment unfolding over time. For instance, being able to hold information in mind and mentally work with it, relating it to whatever information comes later in the day is a critical component that supports activities of daily living.

Lastly, inhibition represents the ability to suppress or hold back outgoing automatic and/or dominant responses (Friedman et al., 2008; Miyake et al., 2000). The conception of inhibition is multifaceted, however, for the purpose of this study inhibition refers to the deliberate, controlled suppression of prepotent responses. Inhibitory control is critical in a number of higher order EFs and plays a role in many aspects of one's life. For example, inhibitory control facilitates one's ability to selectively attend to and focus on what is relevant and suppress attention to other stimuli in the environment. This may be especially useful in social, academic, and occupational settings, whereby one often needs to attend to a specific task at hand rather than being distracted by others in the environment. One may also voluntarily inhibit certain stimuli and attend to others based on a larger goal or intention. For example, an individual may exert self-regulatory efforts in order to resist the temptation of eating all of the cookies out of the cookie jar. Inhibiting or controlling the dominant response of automatically eating all the cookies may aid the individual in exerting self-control (i.e., higher order EF) in order to attain the larger goal (i.e., healthy lifestyle). Immature inhibitory control in young adults may increase the likelihood of engaging in risky and reckless behaviors (Magar, Phillips, & Hosie, 2008; Schreiber et al., 2012; Spear, 2000).

It is important to note that the three above-mentioned EFs (i.e., shifting, updating and inhibition) are not mutually exclusive, but rather these EFs can be understood as sharing some common underlying ability (unity), while at the same time each encompassing their own unique processes (diversity) (Fisk & Sharp, 2004; Miyake et al., 2000). This conceptualization is the most widely accepted approach to understanding EF in current literature and thus, will be used as the focus in the present study. Below the

proposed neural substrates of EFs are examined as well as the evolution of EF over the life span with a particular focus on emerging adulthood.

Neural substrates of executive functions. Traditionally, EFs have been exclusively related to the PFC, with frontal lobe function and EFs often considered as synonymous. More recently however, it has been shown that brain damage distant from the frontal lobes (e.g., Schmahmann & Sherman, 1998), such as damage to subcortical structures or interruption of connections between frontal and non-frontal areas, may also impair EFs (Alvarez & Emory, 2006; Baddeley, 1998; Heyder, Suchan, & Daum, 2004; Miller & Cohen, 2001; Royall et al., 2002; Stuss & Alexander, 2000; Stuss & Levine, 2002). Thus, the underlying neural basis of EF has evolved and current views hold that EFs are associated with different regions of the frontal lobes (Stuss & Alexander 2000; Stuss & Levine; Koechlin, Corrado, Pietrini, & Grafman, 2000), as well as distributed over a wide cerebral network including subcortical structures and thalamic pathways (Lewis, Dove, Robbins, Barker, & Owen, 2004; Monchi, Petrides, Strafella, Worsley, & Doyon, 2006).

At a basic level, there are three main distinct, parallel, frontal-subcortical circuits that are thought to be differentially important in supporting EF: the DLPFC circuit, the OFC circuit (involving VM-PFC) and the ACC circuit (see Alvarez & Emory, 2006 for a review). These regions can be best understood as functioning within circuits given their complexity and interconnections among other brain areas. The DLPFC is an area that is highly interconnected primarily with posterior areas of the cortex such as the parietal and temporal lobes. This circuit plays an important role in supporting self-regulation, responding to external information, integrating and organizing incoming and outgoing

information from various areas in the brain, as well as supporting working memory. Conversely, the OFC has connections with lower-level brain systems, most notably the limbic system. This circuit is important in regulating affect and decision-making by integrating emotional and limbic information into behavioral responses (Alvarez & Emory, 2006). This structure is also largely involved in the appraisal of various stimuli (Ochsner & Gross, 2005 for a review) in self-regulation by processing pertinent information, and integrating this information to inform behavior (Bradshaw, 2001). The ACC circuit plays a critical role in emotion-cognition interactions including error monitoring/correction and behavioral motivation (Allman, Hakeem, Erwin, Nimchinsky, & Hof, 2001; Alvarez & Emory, 2006; Schackman, Salomons, Slagter, Winter, & Davidson, 2011). The ACC is also suggested to be involved in assessing the salience of emotional information and the regulation of emotional responses (Etkin et al., 2011; Kober et al., 2008; Pavlovic, Pavlovic, & Lavkovic, 2009). For instance, the ACC has been associated with mood regulation because of its close connectivity to limbic regions (Soares & Mann, 1997). Traditionally, theories have viewed the ACC from a segregationist view separating cognition and emotion (Bush, Luu, & Posner, 2000). However, more recently researchers have provided evidence in support of the view that all subregions of the ACC including dorsal, rostral, subcallosal, and subgenual regions (McCormick et al., 2006) work together to process incoming information (Shackman et al., 2011). Research suggests that the proliferation and maturation of spindle-shaped neurons in the ACC largely depend on early life experience including factors such as enrichment or stressors (Allman et al., 2001; Tanti et al., 2013; van Praag, Kempermann & Gage, 2000). As such, this critical window of development has the ability to

significantly impact an individual throughout their life (Allman et al., 2001). It is therefore likely that the development of the ACC following birth has evolved in order to aid individuals in coping with the complex challenges, including high stress, presented in their environment (Pavlovic et al., 2009).

Table 1.

Summary of Brain Regions Implicated in Emotion Regulation and Executive Functions

Brain Region	**Emotion Regulation**	**Executive Function**
Prefrontal Cortex (PFC): including dorsolateral PFC, ventromedial PFC, and orbitofrontal cortex (OFC)	Kühn et al., 2011; Ochsner & Gross, 2005; Ohira et al., 2006	Cummings, 1995; Duke & Kaszniak, 2000; Sbordone, 2000; Stuss & Benson, 1984
Anterior Cingulate Cortex	Etkin et al., 2011; Phan et al., 2005; Urry et al., 2006	Cohen, Botvinick, & Carter, 2000; Dove, Pollmann, Schubert, Wiggins, & von Cramon, 2000; Ochsner et al., 2001; Smith & Jonides, 1999
Subcortical and Thalamic Pathways	Kober et al., 2008; Ochsner & Gross, 2005; 2008; Ochsner et al., 2004; Phan et al., 2005; Phelps, 2006	Lewis, Dove, Robbins, Barker, & Owen, 2004; Monchi, Petrides, Strafella, Worsley, & Doyon, 2006

Note. Many brain regions implicated in ER and EF processes are overlapping. Although there are inconsistencies that still exist in current research, this table provides an overview of the main regions most commonly implicated in each.

Evolution of executive functions over the life span. The maturation of the PFC has been linked to the development of EFs and is associated with a prolonged period of maturation (Anderson, Northam, Hendy, & Wrenall, 2001) with the PFC being one of the last brain regions to mature (Gogtay et al., 2004). The maturation of prefrontal regions has been suggested to enable and interact with important new cognitive forms of ER (Casey et al., 2010; McRae et al., 2012a). Broadly speaking, EFs are thought to unfold

and mature from around two years of age until late adolescence (Best & Miller, 2010), however, less is known about the development and maturation of EFs in emerging adulthood. Traditionally it has been accepted that adolescence marks the developmental stage that is largely associated with the maturation of new neurons in the PFC, including the reduction of synaptic density. However, recent research suggests that this synaptic pruning does not end in adolescence but instead continues into early adulthood (Petanjek et al., 2011). Synaptic pruning has been shown to continue beyond adolescence and throughout the third decade of life before full maturation (Petanjek et al., 2011). Thus, it is likely that given the long phase of PFC development, this structure may be especially vulnerable to environmental influences during emerging adulthood (e.g., high stress). As a result, the development of cognitive and emotional capacities in emerging adults may also be similarly vulnerable. However, literature on EFs in this population is limited and findings are often contradictory and/or non-universal. This critical developmental period (ages 18-25) is often not directly studied, at least not to the extent of pediatric and older adult populations. From the limited research that is available, it is suggested that EF abilities have unique developmental trajectories with certain EF components not reaching adult competency until late adolescence or early adulthood (Passler et al., 1985). For instance, EF abilities including the ability to inhibit overlearned behavior develop earlier in life whereas cognitive flexibility or shifting between mental sets has a much longer developmental trajectory (Davidson, Amso, Anderson & Diamond, 2006; Jurado & Rosseli, 2007). The transition from adolescence into young adulthood is a developmental period that is often one of increased vulnerability and adjustment as a result of continual brain development. This is a developmental period that is largely associated with activity

and growth in brain regions and systems, particularly those that are key to the regulation of behavior and emotion, and to the perception and evaluation of risk and reward. EFs are thought to mature throughout adolescence and into young adulthood, contributing to a more fully conscious, self-directed, and self-regulating mind (Donald, 2001; Keating, Lerner, & Steinberg, 2004). Much of the brain maturation is focused on specific developments in the PFC, but with equal importance on linkages to the whole brain (Donald, 2001, Luna et al., 2001, Newman & Grace, 1999). These complex processes of assembly are supported by increased rapid connectivity and synaptic pruning in various brain areas, especially in frontal areas that are crucial to EF (Giedd et al., 1999; Paus et al., 1999; Sowell, Delis, Stiles, & Jernigan, 2001; Sowell, Trauner, Gamst, & Jernigan, 2002; Steingard et al., 2002). These significant improvements and growth in multiple regions of the brain, including the PFC, are associated with improvement in various components of EF. For instance, as adolescents continue to develop they engage in more abstract thinking, self-regulation, and have better coordination of affect and cognition (Eisenberg, Morris, McDaniel, & Spinrad, 2009; Keating et al., 2004). Interestingly, these changes in brain structure and function have also been linked to functioning in the ventromedial PFC, namely the regulation of risk and reward. This is in line with research demonstrating improved connectivity between regions of the PFC and several areas of the limbic system, a restructuring that further affects the ways in which individuals evaluate and respond to risk and reward (Martin et al., 2002; Spear, 2000). There are social and emotional factors that are particularly salient in adolescence including the susceptibility to peer influence or impulse control that impact EFs and commonly lead to differences in adolescent decision-making (Gardner & Steinberg, 2005; Steinberg, 2005). For example,

increased risk taking behaviors in adolescents is suggested to be a function of both maturing EFs (e.g., immature impulse control) as well as heightened inclination to seek rewards during this developmental period. Because full maturation of EFs occurs later in life, this creates a period of heightened vulnerability (e.g., to risk-taking during adolescence) (Steinberg, 2008; 2010). The prolonged period of developmental reorganization in the PFC extends into young adulthood (Pentanjek et al., 2011). Given the current lack of research examining this critical period explicitly, future research is warranted to better understand how the continual development of EFs in young adulthood may be impacted by not only the environment, but also by cognitive and emotional capacities as they continue to mature. Together, this research highlights not only the influence of developing EFs, but also the interaction between cognitive and emotional control processes; that is, the influence of the context and other factors including social and emotional factors (Eisenberg et al., 2009). Therefore, these studies indicate that patterns of EF development in emerging adulthood, vary both as a function of the context under consideration and the emotional and social context in which the reasoning occurs. In the following section, several ways in which EF and ER may be intricately linked is examined and a necessarily selective review of recent research that has supported these connections is provided.

Executive Functioning and Emotion Regulation: Review of Current Evidence

EFs may be recruited at any given time in order to support or facilitate an individual's ER. Although there is general agreement on these speculations, very few studies have specifically examined which EFs play an important role in one's ability to regulate their emotions. For instance, it is unclear whether these processes can be studied

separately, whether EFs contribute to ER or, whether ER is merely an outcome of various EF abilities. In line with these controversies rests the fundamental difficulties in studying these complex constructs (i.e., EF and ER) that have yet to be consistently operationally defined or agreed upon in the literature. However, research in this area has recently flourished in an effort to fill some of these gaps. There is a growing body of research that suggests ER involves a number of EF processes including the initial activation of a goal, the ability to continually update these goals in working memory (i.e., 'updating'), the ability to shift attention to pertinent information in the environment (i.e., 'shifting'), and the ability to simultaneously and actively inhibit irrelevant information that does not contribute to the goal at hand (i.e., 'inhibiting') (Berkman & Lieberman, 2009; Gross, Richards & John, 2006; Gross & Thompson, 2007; MacLeod & Bucks, 2011; Ochsner & Gross, 2008; Thompson, 2011). It is suggested that cognitive and emotional control processes continuously interact in order to allow individuals to engage in purposeful, and efficient goal directed behaviors that allow them to adaptively and flexibly cope with their emotions over time. As one can imagine, depending on the individual, the situation at hand, and the particular context, the ultimate 'goal' can be quite different in any given moment.

Prevailing theories suggest that some of the variation observed in emotionality over development may be due to the maturation of various cognitive abilities that can be applied to ER (Dahl, 2003; Luna, 2009; Steinberg, 2005). For instance, a recent study by McRae and colleagues (2012a) reported a quadratic relationship between reappraisal ability and age over time. These findings suggest that cognitive reappraisal may develop later in life as an individual begins to develop the cognitive control processes (i.e., EFs)

necessary to support this particular strategy. In line with these results, findings also indicated a linear relationship between age and activation in brain regions thought to subserve ER processes, including amygdala-frontal connectivity and the PFC. These findings show support for the idea that areas in the brain associated with emotional control processes which are also brain structures commonly implicated in EF processes (i.e., PFC), have yet to fully develop in emerging adults. As such, it is suggested that young adults may not be normally recruiting such brain regions implicated in EF processes to aid in ER and as a result, may be more susceptible to experiencing stress and emotional dysregulation during this developmental period. To date, cognitive and emotional skills have largely been studied separately, which has not allowed this theory to be tested. Assessing the role of cognition in successful ER requires measuring not just individual differences in how one reacts to situations and regulates their emotions, but also examining whether specific EFs moderate the relationship between stress and psychopathology via ER.

Strategy specific networks for ER including the relationship between cognitive aspects of EFs and ER have been examined. Some of these studies have assessed EFs through cognitive measures such as those that have measured cognitive flexibility (e.g., Wisconsin card sort) (Berg, 1948; Fisk & Sharp, 2004), the inhibition of unwanted responses (e.g., go/no-go task), attention and impulsivity (e.g., continuous performance task), planning (Shallice, 1982), and problem solving. Studies examining responses to self-report and/or neuropsychological questionnaires have also been commonly used (Gyurak, Goodkind, Kramer, Miller, & Levenson, 2012; Scheibe & Blanchard-Fields, 2009; Schreiber et al., 2012).

Although there is limited research directly examining how EFs impact ER abilities, there is some research to suggest that an important link between these two processes may exist. Current speculations suggest that flexibly shifting between mental sets (i.e., attentional control) may be an important cognitive ability related to successful ER (Johnson 2009a; McRae et al., 2012b). At a general level, being able to flexibly shift between more than one mental set may be important in one's ability to successfully regulate their emotions. Attentional control is suggested to be important for supporting ER as it enables individuals to focus on goal relevant information and ignore goal irrelevant information (Ochsner & Gross, 2005). Although these speculations have been made there is very little research directly examining this relationship. From the research that is available there seems to be age-related decrements in task-switching performance found in early adulthood, increasing significantly from age 18 to age 40 (Kray & Lindenberger, 2000; Reimers & Maylor, 2005). It is suggested that this observed pattern of age-related decline in shifting abilities might reflect an inability to simultaneously maintain two or more task sets (Verhaeghen & Cerella, 2002). But what does this mean in terms of ER? Given that these findings suggest that switch costs generally start to increase in early adulthood (Reimers & Maylor, 2005), this may consequently pose challenges for these individuals in terms of flexibly being able to regulate their emotions. For instance, young adults may not be able to flexibly shift between mental sets and engage in adaptive ER strategies within changing contexts. Various internalizing disorders including depression and anxiety have been found to be associated with significant emotion dysregulation and set-shifting decrements (Mocan, Stanciu, & Visu-Petra, 2014; Whitmer & Banich, 2007). Thus, shifting abilities may play an important

role in supporting emotional control processes. When these shifting abilities are not available, an individual may be more vulnerable to experiencing emotional dysregulation and psychopathology. On the other hand, there is growing evidence that supports the idea that shifting skills may not always be associated with adaptive outcome (Friedman et al., 2007; Friedman, Miyake, Robinson, & Hewitt, 2011) It may be that over time as individuals age they may begin to prioritize accuracy over speed thus accounting for the increase set-shifting costs. Future research is required in order to understand this relationship further.

Concerning working memory abilities, higher working memory has been associated with successful ER including both expressive suppression and cognitive reappraisal (McRae et al., 2012b; Schmeichel et al., 2008; Opitz, Lee, Gross, & Urry, 2014). Working memory is thought to assist ER processes by enabling the storage and manipulation of perceptual and contextual information. Moreover, working memory capacity facilitates one's ability to actively maintain and manipulate information in the service of one's particular goal (i.e., adaptive ER) (Baddeley, 1986; Norman & Shallice, 1986). Furthermore, working memory supports continuous cognitive restructuring, and one's ability to generate alternative strategies in various situations. For example, individuals may engage in a number of different techniques of cognitive reappraisal including self-talk strategies, and more online problem solving strategies (for instance through verbal mediation) in order to successfully regulate their emotions.

Lastly, regarding inhibitory control, research has shown that the ability to inhibit overt emotional displays is related to EF (Schmeichel et al., 2008). Difficulties inhibiting salient but irrelevant thoughts can reduce the use of more effective ER strategies and/or

render these strategies less effective. In line with this research, greater emotion dysregulation has been linked with reduced inhibitory control and greater impulsivity in young adults (Schreiber et al., 2012). Understanding the association among inhibition and the use and effectiveness of ER strategies has been difficult given that few studies so far have investigated this relationship. However, there is research to suggest that inhibition deficits are commonly related to increased rumination (Davis & Nolen-Hoeksema, 2000; Joormann & Gotlib, 2008; Joormann, 2010). Interestingly, in a recent study conducted by Joormann and Gotlib (2010), an inability to inhibit the processing of negative material was related to an increased likelihood of rumination and a decreased likelihood of utilizing cognitive reappraisal, in both healthy and depressed participants. Thus, it is possible that inhibitory control is important in facilitating the use of adaptive ER strategies.

The results of these studies generally suggest that there are significant links between EFs and ER; however, reliable and consistent reports of specific EFs pertinent to this relationship remain elusive. To date there have been very few reports directly examining this relationship (Malooly, Genet, & Siemer, 2013; McRae et al., 2012b; Opitz et al., 2014; Salas, Gross, & Turnbull, 2014; Schmeichel et al., 2008). Limitations from these studies including study design and nature of the analyses leaves open the question of whether EFs play a unique role in contributing to successful ER and as such, future research is vital.

Cognitive reappraisal vs. expressive suppression. The relationship between EF and ER is further highlighted when considering the two most prominent ER strategies: cognitive reappraisal (antecedent-focused) and expressive suppression (response-focused)

(Gross, 2002). These processes have been suggested to not only be independent of each other (Moore, Coellner & Mollenhold, 2008), but also differentially related to cognition (Gross, 2002). Expressive suppression involves increasing efforts to actively inhibit outward emotional expressions as they arise in response to emotion-inducing stimuli, whereas cognitive reappraisal involves early selection and implementation of a cognitive strategy that diminishes emotion without the need for sustained effort over time (Goldin et al., 2008). Expressive suppression strategies include self-monitoring and self-corrective action throughout an emotional event and requires continual cognitive resources, whereas cognitive reappraisal evoked earlier on in the emotion generative process typically does not require this same level of continual self-regulatory effort (Gross, 2002). In the context of the process model view of ER, it is suggested that antecedent-focused strategies (i.e., cognitive reappraisal) are thought to be generally more effective than response-focused strategies (i.e., expressive suppression). This is because antecedent-focused strategies divert the emotional trajectory earlier on in the emotion generation process, before emotional response are fully developed, whereas response-focused strategies which intervene later on, must overcome significant interrelated and complex emotion processes (Gross, 2001). Cognitively, suppression has been associated with greater resource depletion and high levels of cognitive effort (Johns, Inzlicht, & Schmader, 2008; Richards, 2004) ultimately requiring an individual to sustain effort in inhibiting outward emotional expressions against underlying feelings of distress. For instance, research suggests cognitive costs of suppression include the depletion of attentional resources, impairing subsequent cognitive performance (e.g., on memory tasks) as well as, lower levels of responsiveness in social interactions (Butler et al., 2003;

Richards & Gross, 1999). Despite the significant cognitive costs of utilizing expressive suppression, research suggests that young adults often engage in this type of ER, especially in high stress situations (Gross, Richards & John, 2006).

Differences in the networks associated with these different types of ER strategies have also been discussed in current research (Etkin et al., 2011). According to the process model view of ER there is evidence to suggest that EF abilities are relevant to strategies at both the antecedent-focused stage, which include situation selection, situation modification, attentional deployment, and cognitive change and the response-focused stage which includes response modification as described previously (see Figure 2) (Goldin et al., 2008; Hofmann, Schmeichel, Friese, & Baddeley, 2011). These strategies are thought to draw on a number of cognitive processes that support self-regulatory functions (Ochsner & Gross, 2008; Urry et al., 2006). The most commonly studied exemplar is cognitive reappraisal, which involves reinterpreting the meaning of a stimulus, including one's personal connection to it, in order to change one's emotional response (Sheppes & Levin, 2013). Cognitive reappraisal is suggested to recruit executive cognitive control processes such as attentional control processes (Malooly et al., 2013) and working memory (McRae et al. 2012b; Opitz et al., 2014; Schmeichel et al., 2008) which are associated with diverse structures in the brain including medial, dorsolateral, and ventrolateral PFC and dorsal ACC (Ochsner & Gross, 2008; Phan et al., 2005; Urry et al., 2006). Inhibition has also been suggested to play an important role in reappraisal ability early on the ER process (Salas et al., 2014). Cognitive reappraisal modulates ongoing emotion experience and has been consistently shown to effectively down-regulate emotional experience and behavior (Ochsner & Gross, 2005; 2008).

Interestingly, there is evidence to suggest that children develop ER alongside the development of self-talk (Barrett, 2009; Thompson, 1994; 2011), an ability that facilitates effective cognitive reappraisal. Thus, aspects of cognition are evidently developing alongside ER strategies and thus enable individuals to engage in adaptive ER over the life span. Furthermore, early developmental advances illustrate how pervasively emotion interacts with cognition in its progress from simple preverbal or self-talk strategies, to more sophisticated self-awareness and ER strategies (Barrett, 2009; Izard, 2007). Engaging in cognitive reappraisal strategies over the long term is associated with enhanced control of emotion, interpersonal functioning, and psychological well-being (Gross & John, 2003; Nezlek & Kuppens, 2008; Vrticka, Sander, & Vuilleumier, 2011).

On the other hand, expressive suppression is focused on inhibiting behaviors associated with emotional responding (e.g., facial expressions, verbal comments, gestures). Expressive suppression is implemented following emotion generation and produces decreased expressive behavior, typically with little or no change in ongoing emotion experience (Gross, 2002). Expressive suppression is commonly associated with late frontal engagement (Ochsner & Gross, 2008), and has been shown to rely primarily on the ventrolateral PFC (Ohira et al., 2006). Recent research also highlights the role of the dorsomedial PFC in the voluntary inhibition of actions (Kühn et al., 2011). Much less research has been done examining the cognitive resources implicated in expressive suppression techniques. However, one study conducted by Schmeichel and colleagues (2008) found that suppression ability was related to working memory capacity. Over the long term, frequent use of suppression has been found to result in diminished control of

emotion, interpersonal functioning, and well being, as well as greater depressive symptomatology (Gross & John, 2003).

Despite traditional claims that these two ER strategies may be distinctly and differentially related to cognitive control processes, current evidence does not clearly support these claims. There seems to be a lot of inconsistencies in the literature pertaining to the relationship between ER and EF processes. Thus, the relationship between ER and EF has implications that reach beyond what is clear in current research. In particular, an increasing amount of evidence suggests that the simple act of engaging in some form of ER can have taxing consequences on EF, and vice versa (Beilock & Carr, 2005; Shamosh & Gray, 2007). This has been an emerging debate in ER research, namely this idea of an emotion-cognition trade off. More specifically, understanding the differential impact of EFs on various ER strategies in diverse situations, whereby antecedent-focused ER strategies (i.e., cognitive reappraisal) may be more effective compared to response-focused ER strategies (i.e., expressive suppression) may suffice. For instance, recent research indicates that reappraisal techniques are more effective in academic settings whereas expressive suppression techniques in similar settings have been found to be associated with working memory deficits leading to academic performance decrements in young adults (Johns et al., 2008). Furthermore, research indicates that emotional suppression decreases the amount of remembered material on a number of cognitive tasks (Egloff, Chmukle, Burns, & Schwerdtfeger, 2006; Jing & Jiameia, 2007; Richards & Gross, 2006), which may prove especially maladaptive for emerging adults in academic settings or social interactions. Similarly, the act of exaggerating or suppressing emotional facial expressions has been found to deplete executive resources (Bardeen, Stevens,

Murdock, & Christine Lovejoy, 2013; Schmeichel, 2007). Thus, the relationship between ER and EF remain unclear and further research is necessary in order to identify which lower order EFs may be important in supporting successful ER.

Limitations of the Current Literature

Overall it is evident that emerging adulthood is a time of high stress and high risk for psychopathology. Emerging adults have the highest incidence and cumulative prevalence of psychopathology compared to other age groups, yet are often not exclusively studied. In this review a wealth of evidence indicating that ER heavily relies on EF processes such as shifting, updating, and inhibition was examined. Neuroimaging studies as demonstrated in this paper provide strong evidence for the implications of the frontal lobes including the PFC, and the ACC in EFs. Throughout this review on the effects of stress on the integrity of the brain, it is evident that the maturation of the frontal lobes involves a number of dynamic processes controlled by both biological factors and responses to environmental stimuli. The balance of positive and negative influences on neuronal growth and connectivity has also been shown to play a vital role for the maturation of the frontal lobes including the PFC, and the ACC. This proves to be necessary for the development of the complex circuitry needed for healthy cognitive functioning, namely EF and ER processes. Given that there is a growing body of evidence consistently indicating the deleterious effects of stress on cognition, EF contributions to ER holds critical implications for emerging adults. Specifically, it is crucial to identify ER strategies that may help emerging adults reduce or protect themselves against stress, and further prevent the exacerbation of mental health difficulties in this population. Furthermore, throughout this review substantial evidence

has been provided indicating that individual differences in EF play a central role in ER. For instance, EFs such as working memory capacity, attentional control, and inhibitory functions seem to have a significant role in impacting when and which ER strategies are employed in various situations (Malooly et al., 2013; McRae et al., 2012b; Opitz et al., 2014; Salas, Gross, Rafal, Viñas-Guasch, & Turnbull, 2013; 2014; Schmeichel et al., 2008). However, the specificity of this relationship remains unclear, as there are a number of inconsistencies that exist in current research. Current directions in psychological science are beginning to acknowledge the nature and organization of individual differences in EF (Miyake & Friedman, 2012); however, the understanding of how these processes interact with ER is lacking in emerging adults. A better understanding of this relationship will aid in facilitating early intervention and education regarding optimal ER strategy use which may prove particularly valuable to young adults who are challenged with high levels of stress in their daily lives.

In summary, neuropsychological theory and research has important contributions for understanding ER through the conceptualization and investigation of EFs. Despite the significant advances in these areas, many questions remain unanswered. Specifically, whether EFs play a role in ER for emerging adults and whether EFs moderate the relationship between high stress and psychopathology in this population. By examining this relationship we can begin to provide emerging adults with the tools and knowledge necessary to adaptively regulate their emotions and interact in the world around them. Therefore, understanding the differential impact of distinct EF abilities on ER may affect clinical practice and research.

Aims of the Present Study

The aim of this study was to investigate the relationship between EF, ER, stress, and psychopathology in the context of emerging adulthood. Moreover, the present study considered a population that is hypothesized to have high stress. Accordingly, the proposed research project had two primary aims: (1) to determine whether EF played a role in ER for emerging adults and (2) to determine whether neurocognitive underpinnings of emotion dysregulation (i.e. EF) moderated the association between stress and psychopathology as mediated by ER (see Figure 2.).

In particular, the goal of this study was to examine how various lifestyle and cognitive factors (e.g., stress, depression, anxiety) affect one's ability to successfully regulate their emotions given that these influences are major contributing factors to the pathogenesis of various psychological disorders. Furthermore, ER and EF abilities may be critical to recovery from such psychopathology (Berking & Wupperman, 2012). As such, the present study examined how an individual's ER was related to EF (specifically, working memory, attentional control, and inhibitory control) and measures of stress, and psychopathology. This study examined how well both male and female undergraduate students at the University of Victoria performed on a task of ER as a function of their scores on several neuropsychological inventories for stress, depression, and anxiety, as well as performance on a range of cognitive tasks of EF. This study was guided by the following hypothesis: it was predicted that EFs (i.e., working memory, attentional control, and inhibition) would moderate the indirect effect of ER in the relationship between stress and psychopathology. In order to demonstrate this effect it was expected that the following criteria were met: (i) high stress would be significantly associated with

greater emotion dysregulation, (ii) emotion dysregulation would be significantly related to psychopathology; (iii) ER would mediate the relationship between stress and psychopathology; (iv) EFs would moderate the indirect effect of stress and psychopathology. As such, the mediation relations of ER in the relationship between stress and psychopathology would be contingent on the level of EF.

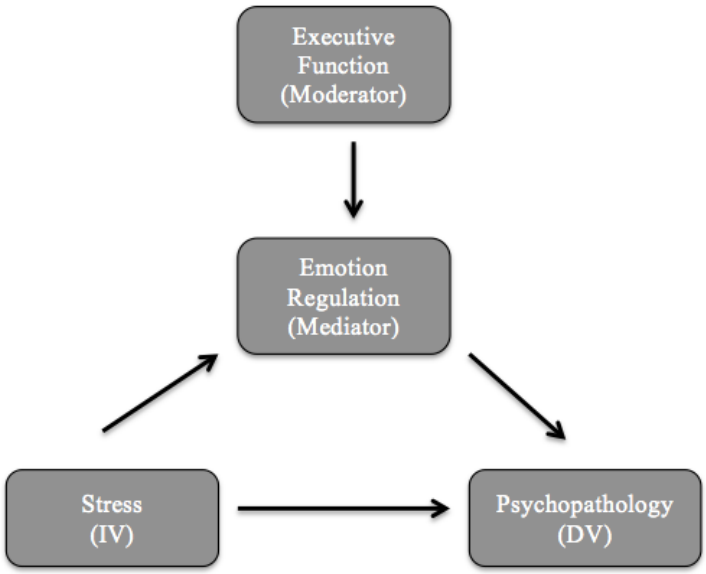


Figure 2. Moderated mediation model.

Method

Participants

A total of 75 (17 males, 58 females) participated in this study. All participants were undergraduates at the University of Victoria between the ages of 19 and 25, who had normal or corrected-to-normal vision and could speak and understand English (needed for testing). Participants were recruited from the University of Victoria Psychology participant pool and received course credit as compensation.

Measures

Participants completed five self-report questionnaires including the Beck Depression Inventory-II (BDI-II), The Beck Anxiety Inventory (BAI), Cohen's Perceived Stress Scale (PSS), and the Demographic and Life Stress Questionnaire.

Depressive symptoms. The *Beck Depression Inventory-II* (BDI-II) (Beck, Steer & Brown, 1996) was used to assess participant's mood state and depressive symptoms during the past week, where each response was rated on a 4-point scale from 0 to 3 (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). The BDI-II contains 21 multiple-choice questions that describe cognitive and somatic symptoms of depression in adolescents and adults. Scores are summed to calculate the overall BDI-II score, where higher scores are indicative of higher levels of depression (ranging from 0-63). The BDI-II has been shown to have high internal consistency, concurrent validity and strong construct validity.

Anxiety levels. The *Beck Anxiety Inventory* (BAI) is a 21-item self-report questionnaire that was used to examine levels of anxiety in this study. Participants were asked to rate various measures of their anxiety levels within the past week, each on a 4-

point scale (Beck, Epstein, Brown, & Steer, 1988). The BAI has been shown to have high internal consistency and test-retest reliability.

Perceived stress. Participant's levels of perceived stress was measured using the *Cohen's Perceived Stress Scale* (PSS). This measure consists of 10 multiple choice questions that asks participants to rate various measures of their perceived stress level within the past month, using a 5-point scale (Cohen, Kamarck, & Memelstain, 1983). This questionnaire was used to assess the degree to which situations in one's life were appraised as stressful (e.g., "In the last month, how often have you felt nervous and "stressed"?) The PSS has adequate reliability, validity and internal consistency (Hewitt, Flett, & Mosher, 1992).

Trait emotion regulation. Participants completed the *Emotion Regulation Questionnaire* (ERQ; Gross & John, 2003), which assesses the typical use of emotion suppression (4 items, e.g., "I keep my emotions to myself") versus cognitive reappraisal (6 items, e.g., "When I want to feel less negative emotion, I change the way I'm thinking about the situation"). Each item is rated on a scale from 1 (*strongly disagree*) to 7 *(strongly agree)*, and subscales are summed with higher scores indicating more use of the strategy. This scale has been shown to possess good psychometric properties including high internal consistency and test-retest reliability for both subscales (Gross & John, 2003).

The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004) was used to assess ER. This 36-item, self-report questionnaire is designed to assess multiple aspects of emotion dysregulation. The DERS consists of six subscales including Nonacceptance of Emotional Responses (nonacceptance), Engaging in Goal-Directed Behavior (goals),

Impulse Control Difficulties (impulse), Lack of Emotional Awareness (awareness), Limited Access to Emotion Regulation Strategies (strategies), and Lack of Emotional Clarity (clarity). Problems in any of these areas would be indicative of ER difficulties. The DERS is a multidimensional measure of ER, with established reliability and validity (Gratz & Roemer, 2004; Ehring, Fischer, Schnulle, Boserling, & Tuschen-Caffier, 2008).

Executive functions. Participants completed the *Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A)* (Roth, Isquith, Gerard & Gioia, 2005), which is a self-report measure used to assess impairment in EF and self-regulation in adults. This measure is a standardized self- and informant report measure developed to assess the everyday behavioral manifestations of adults; (ages 18-90 years) executive control functions. For the purpose of this study the self-report was solely used given that this is a sample of healthy adults. This measure includes nine non-overlapping clinical scales corresponding to common theoretically and empirically derived domains of EF that together tap emotional, behavioral, and metacognitive skills. The BRIEF-A contains 75 items and yields an overall score (Global Executive Composite), which is a composite of two index scores (Behavioral Regulation Index (BRI), and the Metacognitive Index (MI)). The BRI consists of four scales (Inhibit, Shift, Emotional Control, and Self-Monitor), and the MI is comprised of five scales (Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials). The BRIEF-A has been shown to have good reliability, validity, and clinical utility as a sensitive measure of executive functioning (Roth et al., 2005). Standard scores were calculated for each of the clinical scales, indices, and for the summary composite. T scores were based on comparison to the normative sample comprised of 1050 self- and 1200 informant reports,

with higher scores reflecting greater difficulties experienced by the individual. The BRIEF-A also includes three validity scales: Negativity, Infrequency, and Inconsistency.

Cognitive tests. Participants completed three subtests from a theoretical and evidence-based model of EF (Garcia-Barrera, Frazer, & Areshenkoff, 2012; Miyake et al., 2000) including the Go/No-Go paradigm, the N-Back task, and the Number Letter task. These three cognitive tasks were programmed in MATLAB (R) version 7.10.0. (The MathWorks Inc, Natick, MA) using the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997; Kleiner, Brainard, & Pelli, 2007. All three tasks are challenging and were used in the present study as cognitive measures of EF.

Inhibition: The Go/No-Go paradigm (Donders, 1868/1969) was used to measure inhibition of a prepotent response. Participants were required to respond to visual stimuli (i.e. a single letter appearing in the middle of the computer screen) by pressing the spacebar as quickly as possible. The first task block only consisted of these 'go' trials, which allowed participants to develop a prepotent response tendency to press the spacebar. In a second trial block, participants were again instructed to press the spacebar as quickly as possible whenever a letter appeared; however, they needed to withhold their response if the letter 'J' appeared (the 'no-go' stimulus). These no-go stimuli were randomly presented among go stimuli, although much less frequently. As a result, inhibitory control required participants to not respond according to the prepotent tendency (i.e. to press the spacebar for letters). Due to the additional inhibitory control requirements recruited on no-go trials, it was expected that participants would make more errors in response to the rarer no-go stimuli- indicating inhibitory control failures. Approximately twenty percent of the trials were no-goal trials. The performance measure

used on this task was Mathew's Correlation Coefficient (MCC) (Mathews, 1975). The MCC was used because it is the best single number assessment for accuracy in classification tasks like in the Go/No-Go task. It ultimately represents a proportional accuracy of participant's performance on the Go/No-Go task (i.e., participants general accuracy) and a gauge of inhibitory control performance. Average difference in reaction times (RT) between the two trials was also obtained as a crude measure of the cost of participants' inhibition.

Working memory. The N-Back task was used as a measure of working memory. There were three different memory-load (n) conditions: a 1-back condition (i.e. respond with the 'yes' key whenever the current letter is the same as the letter presented 1 trial back; e.g., (L-L), followed by a 2-back condition and a 3-back condition. The MCC was also used in this task and represented a proportional accuracy of participants' performance on the N-back task (i.e., general accuracy) and a gauge of working memory performance.

Attentional control. The Number-Letter task (Rogers & Monsell, 1995) was used to indicate attentional control, which was also implemented by Miyake and colleagues (2000) to indicate 'Switching'. On this task, participants were shown a number-letter pairing (e.g., 4A), which appeared in one of four quadrants on the computer screen. When the stimulus appeared in either of the bottom two quadrants, participants were instructed to respond by indicating whether the number was even or odd; when the stimulus appeared in either of the top two quadrants, participants were instructed to respond by indicating whether the letter was a vowel or a consonant. Thus, participants were required to switch their attention back and forth between the number and letter

components of the stimuli, and respond accordingly. Responses were made according to key presses on the keyboard (i.e. press the letter 'A' to indicate even numbers or vowels; press the letter 'L' to indicate odd numbers or consonants). This task consisted of three trial blocks. In the first trial block, all stimuli were presented in the bottom two quadrants. Similarly, in the second trial block, all stimuli were presented in the top two quadrants. In the third block, the stimuli were presented in all four quadrants; rotating in a clockwise direction to ensure that an equal number of 'switch' and 'non-switch' trials occurred. 'Switch costs' were derived by subtracting reaction time on switch trials from non-switch trials. An average of these switch costs was used as an indicator of attentional control.

Emotion regulation paradigm. The ER paradigm utilized in this study is a paradigm employed in recent research (McRae et al., 2012b; McRae, Misra, Prasad, Pereira, & Gross, 2011;Vanderhasselt, Kühn, & De Raedt, 2012), and has been refined for the purpose of this study. Participants were shown a series of aversive pictures from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1997) and linguistic stimuli which were intended to generate temporary negative emotions (e.g., negative sentences such as "Her son is in the burning building.") (McRae et al., 2011). The stimuli set consisted of 45 negative pictures of the IAPS (Lang et al., 1997) and 45 negative sentences. Each stimuli was shown only once for each participant. Participants were instructed to 'suppress', 'reappraise' or 'appraise' their emotions in response to aversive stimuli and provided a relative rating of their negative affect based on the application of the explicit ER strategy. All stimuli were generated by Acer Aspire 5741 laptop and were displayed on a 15.6-inch screen by means of E-Prime 2.0 software

(Schneider, Eschman, & Zuccolotto, 2002). Testing was done in a small quiet testing room, free of any distractions (e.g., windows or other visual distractions).

Task training. To standardize how participants applied the different instructions (appraise/suppress/reappraise), they were intensely trained for +/- 20 minutes beforehand. The training instructions used in this study are those employed in previous research conducted by Vanderhasselt and colleagues (2012). The decision to utilize this ER paradigm as presented by Vanderhasselt et al. (2012) was made in order to replicate previous findings. The number of practice trials differed between participants depending on when they achieved a minimum level of understanding or proficiency in suppression, reappraisal, and appraisal.

Participants were also trained to enhance preparatory control supporting the specific strategy they were instructed to employ. During the preparation phase, participants were told that an unpleasant, affect-laden stimulus (picture or sentence) would appear in all trials. For the cognitive reappraisal and suppression instruction this mindset of control to down-regulate and maintain control over the expression of their feelings respectively was carefully trained. It was crucial to run through the practice block successfully (see Figure 3. for specific training instructions).

The same person instructed and trained all participants to adequately prepare for and apply reappraisal, suppression, and appraisal strategies. During the practice phase, participants were asked to verbally state what they were thinking during the preparation (cue) and picture/sentence (target) phase. This way, the preparation and actual target phase was standardized over all participants. Participants were asked to use the ER strategies as they were being taught, and otherwise report this at the end of the trial. For

all the stimuli, participants were told not to look away and to concentrate on the stimuli during the time it was projected on the computer screen. During the practice phase, participants first received a couple of examples to illustrate the reappraisal instruction (e.g. how to generate reinterpretations). Subsequently, participants were asked to verbally state what they were thinking during the preparation (cue) and picture/sentence (target) phase.

Task Training Instructions		
Suppress	**Reappraise**	**Appraise**
Instruction: "This means that you should suppress your emotional response. You may not feel anything. One way to do this is to keep your face motionless so that someone who can see your face can not infer what you feel at that moment. Try not to feel and show no emotional facial expression."	*Instruction*: "This means that you should apply a strategy to reduce your negative emotions elicited by the unpleasant picture or sentence. Reinterpret the unpleasant picture or sentence (change meaning) so that it no longer elicits negative feelings. Do so by thinking about the picture or sentence in a less negative way so that your negative emotions are reduced."	*Instructions*: "This means that you will experience the emotion as elicited by the picture or sentence. Look carefully at the stimuli without trying to change your emotion. Experience your emotions as they are provoked, try not to change."
Goal: Suppress displaying negative feelings elicited by the aversive stimuli	*Goal*: Down-regulate negative feelings elicited by the negative image or sentence and decrease emotional reactivity	*Goal*: Do nothing; respond naturally to the aversive stimuli and do not apply any explicit ER strategy

Figure 3. Training instructions for the ER task.

Task. During the ER paradigm (see Figure 4.) participants were cued to suppress, reappraise and appraise a series of 90 randomly intermixed trials in 3 blocks. The order of the instructions was randomized between blocks and for each participant. Each trial started with a fixation cross (0-1.5s, jitter in steps of 500 ms) followed by a cue word (suppress, reappraise or appraise). This cue word appeared centrally on the screen for 3 s, after which a blank screen was presented (1-9s, jitter in steps of 500 ms and mean

duration of 4.5 ms). This cue-offset time enabled participants to prepare for the instructed ER strategy. Subsequently, a negative, high arousing image or sentence appeared centrally for 10 s. Although the image or sentence remained on the screen, participants performed the ER or appraisal specified by the prior instructional cue. Then, a rating scale appeared immediately after presentation of the stimuli. Participants provided a relative rating of their negative affect indicating how successful they were based on the application of the explicit ER strategy to control their negative emotions ("How successfully were you able to reappraise/suppress/appraise your negative feelings elicited by the picture/sentence?"). A Likert scale allowed participants to rate how successful they were in regulating or appraising their negative emotions (1=not at all to 4=very good) following the presentation of each aversive stimulus. Successful ER was indexed as a mean rating of >3 on a Likert scale from 1-4, which suggests that participants were able to regulate their emotions elicited by the stimuli presented (i.e., ER success indexed by down regulation of negative emotion). Successful cognitive reappraisal implies that the participants were able to down-regulate negative feelings, whereas successful expressive suppression implies that participants were able to not show their feelings on an outward level. All together, the success rating is indicative of an evaluation of 'relative negative affect' based on the application of an explicit ER strategy. Finally, the word 'RELAX' appeared on the screen for 4s, which allowed participants to relax until the presentation of the next trial. The above-mentioned ER paradigm is that of Vanderhasselt and colleagues (2012) with the addition of negative sentences as stimuli to be appraised.

Figure 4. Emotion regulation task refined from Vanderhasselt, M. A., Kühn, S., & De Raedt, R. (2012). 'Put on your poker face': neural systems supporting the anticipation for expressive suppression and cognitive reappraisal. *Social Cognitive and Affective Neuroscience.*

Procedure

The Research Ethics Review Board at the University of Victoria approved the experimental protocol for this study. The procedures were explained and informed consent was obtained from the participants. In order to ensure confidentiality, data for each participant were stored anonymously, and was coded by the participant's randomly assigned identification number. Prior to the experiment, participants were also asked to fill out a record of participation, which required their name, date, and contact information.

This study consisted of one session lasting approximately 2 hours. The procedures were explained and informed consent was obtained before the session began. Participants

were first asked to complete six self-report questionnaires of stress, depression, anxiety, EFs and a demographic and life-stress. Participants then began computerized testing of working memory, set shifting (i.e., attentional control), and inhibitory control. All instructions were presented on a computer screen. Participants notified the experimenter when they were finished this phase of testing. Lastly, participants began the training phase of the ER task for approximately +/- 20 minutes (see *Figure 3.* for more information on the training phase instructions). The number of practice trials differed between participants depending on when they achieved a minimum level of understanding or proficiency in suppression, reappraisal, and appraisal (the primary investigator trained all the participants). After successfully completing the training phase, participants began the test phase of the ER task. In each phase of the test, instructions were displayed on the computer screen and the experimenter sat quietly outside of the testing room. When participants were finished the computerized testing they notified the experimenter and this marked the completion of the experiment. All testing was done in Dr. Smart's laboratory at the University of Victoria.

Results

Descriptive Statistics

Seventy-five undergraduate students at the University of Victoria (77.3% females) participated in this experiment. On average, participants were 20.76 years old (SD=1.7). The ethnic composition of this sample included 2.7% African American, 10.7% Asian, 77.3% Caucasian, 4% Indian and 5.3% other. Descriptive statistics associated with self-report and cognitive measures can be found in Table 2.

Table 2.

	M	*SD*	*Range*
Self-Report			
BDI-II	12.11	8.90	0-42
BAI	12.48	9.05	0-50
Psychopathology	24.58	16.83	0-92
PSS	19.56	6.43	5-35
ERQ- Reappraisal	5.02	.94	2.33-6.83
ERQ- Suppression	3.30	1.15	1-6.25
DERS	78.68	18.29	46-129
BRIEF-A	115.19	24.88	74-193
ER Task			
Cognitive Reappraisal	6.33	.95	1-8
Expressive Suppression	6.21	.96	1-8
EF Tasks			
N-Back	.62	.18	-.05-.93
Letter/Number	.54	.36	-.11-1.70
Go/No-Go	.73	.17	-.09-.94

Note. The BDI-II= Beck Depression Inventory-II, BAI= Beck Anxiety Inventory, PSS= Cohen's Perceived Stress Scale, ERQ= Emotion Regulation Questionnaire, DERS= Difficulties in Emotion Regulation Scale, BRIEF-A= Behavioral Rating Inventory of Executive Function- Adult Version. Clinical Cut-off scores for the BDI-II are as follows: 0-13 Minimal, 14-19 Mild, 20-28 Moderate, 29-63 Severe (Beck et al., 1996); and for the BAI: 0-7 Minimal, 8-15 Mild, 16-25 Moderate, >26 Severe (Beck et al., 1988).

In order to test whether executive functions (EF) played a role in emotion regulation (ER) for emerging adults, each ER strategy was examined separately (i.e., cognitive reappraisal and expressive suppression) and likewise, each EF was also assessed (i.e., shifting, updating of working memory and inhibition). These analyses were run in order to determine whether these three lower order EFs played a differential role in participants' ER abilities. More specifically, it was hypothesized that EFs would moderate the influence of stress on psychopathology via ER for emerging adults (i.e., moderated mediation). In this study, psychopathology represents a composite score of both participants' level of anxiety and depression based on standardized clinical self-report measures (i.e., participants' BDI-II and BAI scores). In this study we gave participants various self-report measures in order to examine symptoms of psychopathology, stress, ER, and EF. However, self-report measures will not be the focus of this thesis document as it was decided the focus of this document would be on task-task relationships. Our decision was based on what we know about the common method of variance bias, and how this may impact the relationship between variables measured by the same method. Thus, the focus on a subsequent paper will include the self-report measures and we will focus here on the ER and EF computerized tasks.

First, in order to conduct moderated mediation analyses, a median split based on participants' EF scores was used to categorize participants as being either above or below sample median on the three tasks of EF (i.e., N-Back, Letter-Number and Go/No-Go). Next, the mediation hypothesis was tested using each ER strategy separately (i.e., Cognitive Reappraisal/Expressive Suppression). In order to test for mediator effects three conditions must initially be met (Barron & Kenny, 1986). First it needs to be shown that

the independent variable (Stress) is related to the dependent variable (Psychopathology). Second, the independent variable needs to be shown to be related to the mediator (Cognitive Reappraisal/Expressive Suppression). Third, it needs to be shown that the mediator is related to the dependent variable. Finally, in order to establish the mediator relationship, if the initial three conditions hold in the predicted direction, it needs to be shown that the effect of the independent variable on the dependent variable is either completely (full mediator) or substantially reduced (partial mediator) when controlling for the mediating variable (Barron & Kenny, 1986) whereas, the mediator needs to remain significant. Perfect mediation can be shown if the independent variable has no effect when the mediator is controlled. For moderated mediation, the above-mentioned pattern should hold for one level of the moderator variable, but not for the other one.

Tests of Moderation and Mediation

Analysis one: The relationship of working memory and emotion regulation. Hypothesis 1a predicted that working memory would moderate the influence of stress on psychopathology via cognitive reappraisal.

Moderated mediation for cognitive reappraisal. First in order to conduct moderated mediation and examine the role of working memory on ER, a median split based on participant's scores on the N-Back task was used. Participants were categorized as being either above or below sample median on the N-Back task (Moderator variable) using Mathew's Correlation Coefficient (MCC= .6400). MCC is an efficient measure of the quality of binary classifications, which takes into account true and false positives and negatives (i.e., correctly/incorrectly identifying correct/incorrect targets on the N-back) (Mathews, 1975). It is computed by calculating the correlation coefficient between the

observed and predicted binary classifications, ultimately producing a value between -1 and +1. A coefficient of +1 represents a perfect prediction, whereas 0 represents a prediction no better than random, and -1 indicates a total disagreement between prediction and observation. The MCC was used because it is the best single number assessment for accuracy in classification tasks like in the N-back task. It ultimately represents a proportional accuracy of participant's performance on the N-back task (i.e., participants general accuracy) and a gauge of working memory performance. Thus, poor accuracy was indexed by performance below the median whereas better performance (i.e., better accuracy) was indexed by performance above the median. Next, the three conditions required to test for mediator effects were examined. For these data, the three conditions were not met. The IV and the Mediator were not significantly correlated for either level of the moderator (Low:

$\boldsymbol{r = -.113, t\big((37)\big) = -.680, p = .501; High: r = -.150, t((36)) = -.896\ p = .376}$) indicating that a meditational model could not possibly fit for either group. Thus, moderated mediation could not be assessed in this model.

Simple moderation for cognitive reappraisal. Given that moderated mediation did not hold, separate levels of the moderator variable were then examined. Results indicated that for both groups Stress was related to Psychopathology. However, for Cognitive Reappraisal, the relationship to Psychopathology was significant for those below the median split on the N-Back but was not significant for those above the split. Thus, results indicated that the relationship between Cognitive Reappraisal and Psychopathology was moderated by working memory as indexed by performance on the N-Back task as shown in Table 3. The interaction between Cognitive Reappraisal and

Psychopathology for both those above and below the median split on a task of working are shown in Figure 5a.

Hypothesis 1b predicted that working memory would moderate the influence of stress on psychopathology via expressive suppression.

Moderated mediation for expressive suppression. For these data the three initial conditions that test for mediator effects were not met. The IV (Stress) and the Mediator (Cognitive Reappraisal) were not significantly correlated for either level of the moderator (Low: $\boldsymbol{r = .098, t((37)) = .589, p = .559}$; $\boldsymbol{High: r = -.090, t((36)) = -.534, p = .597}$), indicating that a meditational model could not possibly fit for either group. Thus, moderated mediation was not concluded in this model.

Simple moderation for expressive suppression. Given that moderated mediation did not hold, separate levels of the moderator variable (i.e., the impact of working memory) were then analyzed. For Expressive Suppression, the relationship to Psychopathology was not significant for either group as shown in Table 3. Therefore, results indicated that working memory did not moderate the relationship between Expressive Suppression and Psychopathology for this sample. The interaction between Expressive Suppression and Psychopathology for those above and below the median split on a task of working memory is shown in Figure 5b.

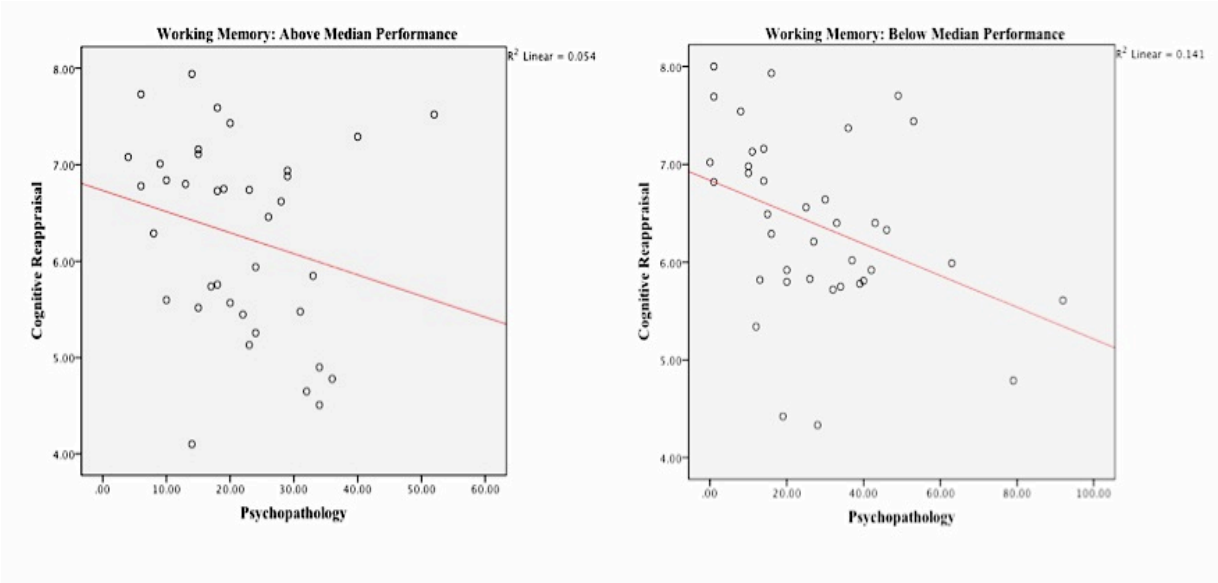
Table 3

Regression Analysis to Test for Moderation

Working Memory				
	Cognitive Reappraisal		Expressive Suppression	
	Beta	P value	Beta	P value
Low (N=38)				
Stress→ Psychopathology	.707	**.000**	.707	**.000**
ER→ Psychopathology	-.375	**.020**	-.234	.157
High (N=37)				
Stress→ Psychopathology	.479	**.003**	.479	**.003**
ER→ Psychopathology	-.232	.167	-.256	.127

Note. ER= Emotion Regulation
*$p < .05$

a)



b)

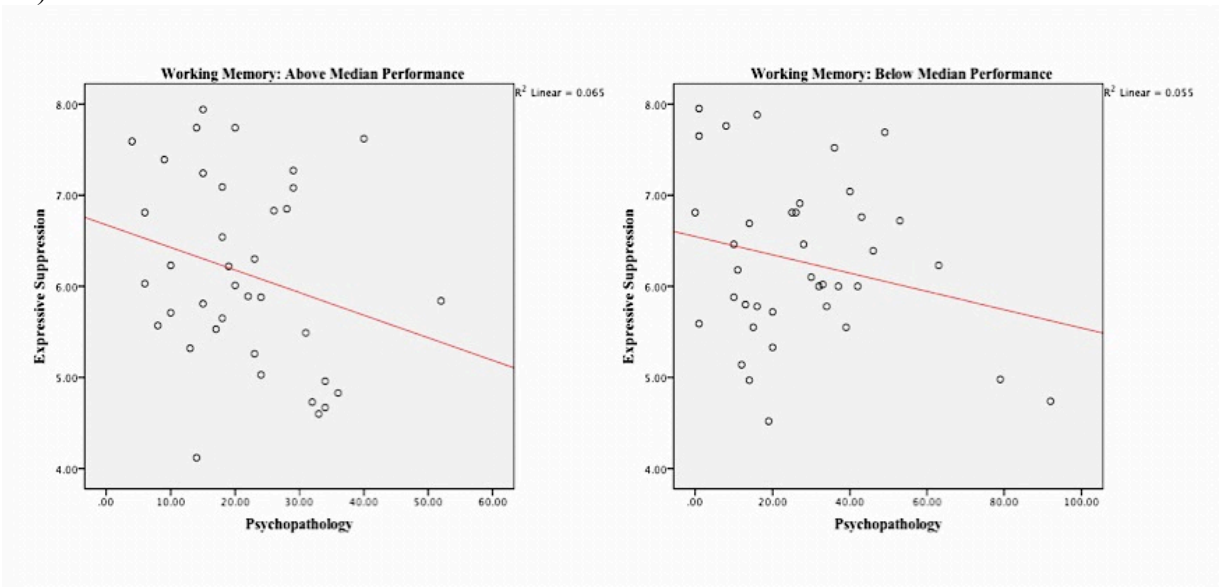


Figure 5. a) The interaction between cognitive reappraisal ability and symptoms of psychopathology, as a function of being either above or below median performance on a task of working memory. b) The interaction between expressive suppression and symptoms of psychopathology, as a function of being either above or below median performance on a task of working memory.

Analysis two: The relationship of attentional control and emotion regulation. Hypothesis 2a predicted that attentional control would moderate the influence of stress on psychopathology via cognitive reappraisal.

Moderated mediation for cognitive reappraisal. First, a median split on the Number-Letter task (a task of attentional control) was used to categorize participants as being either above or below sample median, which was .4600. Next, the three initial conditions that test for mediator effects were examined. For these data, the three conditions were not met. The IV (Stress) and the mediator (Cognitive Reappraisal) were not significantly correlated for either level of the moderator (Low: r = -.209, t ((38)) = -1.302, p = .201; High: r = -.209, t ((35))= -.281, p = .781) indicating that a mediational model could not fit for either group and therefore, moderated mediation was not concluded in this model.

Simple moderation for cognitive reappraisal. Given that moderated mediation did not hold, separate levels of the moderator variable were then examined. Results indicated that Stress was related to Psychopathology for both groups. However, for Cognitive Reappraisal, the relationship to Psychopathology was significant for those below the median on the Number-Letter task and not for those above the median (see Table 4). Therefore, results indicate that the relationship between Cognitive Reappraisal and Psychopathology was moderated by attentional control. The interaction between Cognitive Reappraisal and Psychopathology for those above and below the median on a task of attentional control is shown in Figure 6a.

Hypothesis 2b predicted that attentional control would moderate the influence of stress on psychopathology via expressive suppression.

Moderated mediation for expressive suppression. For these data the three initial conditions that test for mediator effects were not met. The IV (Stress) and the mediator (Expressive Suppression) were not significantly correlated for either level of the moderator (Low: r = .004, t ((38)) = .024, p = .981; High: r = .023, t ((35)) = .134, p = .894). Thus, results indicated that a meditational model could not possibly fit for either group and therefore, moderated mediation was also not concluded.

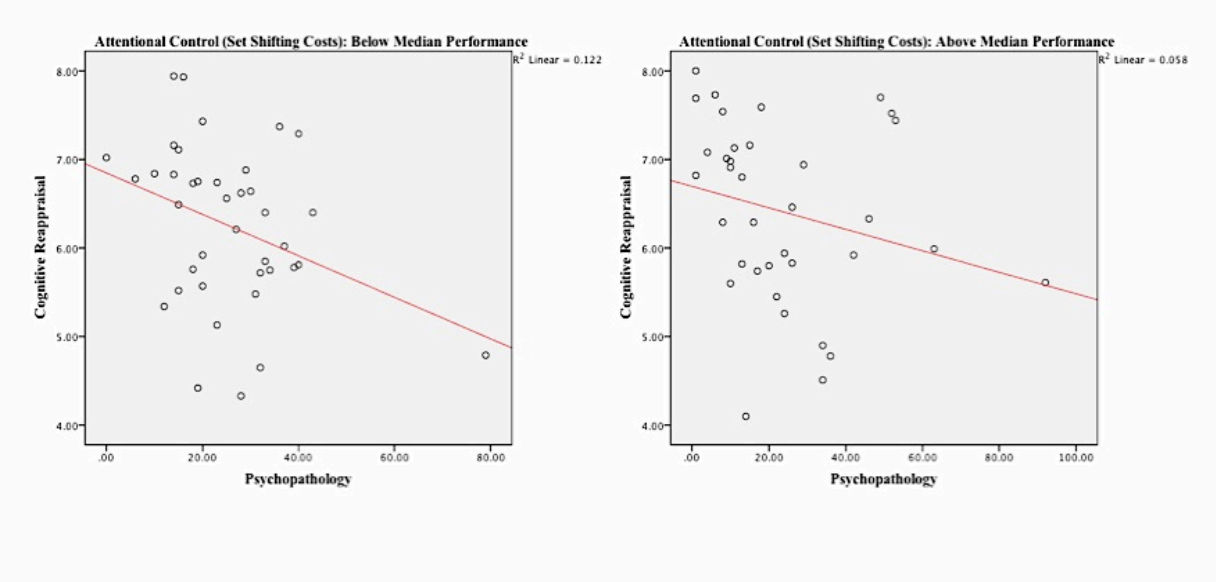
Simple moderation for expressive suppression. Given that moderated mediation did not hold, separate levels of the moderator variable were then examined. For Expressive Suppression, the relationship to Psychopathology was not significant for either group (see Table 4). Therefore, results indicated that attentional control did not moderate the relationship between Expressive Suppression and Psychopathology for this sample of emerging adults. The interaction between Expressive Suppression and Psychopathology for those above and below the median on a task of attentional control is shown in Figure 6b.

Table 4
Regression Analysis to Test for Moderation

Attentional Control				
	Cognitive Reappraisal		Expressive Suppression	
	Beta	P value	Beta	P value
Low (N=39)				
Stress→ Psychopathology	.680	**.000**	.680	**.000**
ER→ Psychopathology	-.350	**.029**	-.132	.423
High (N=36)				
Stress→ Psychopathology	.606	**.000**	.606	**.000**
ER→ Psychopathology	-.242	.156	-.268	.115

Note. ER= Emotion Regulation.
*$p < .05$

a)



b)

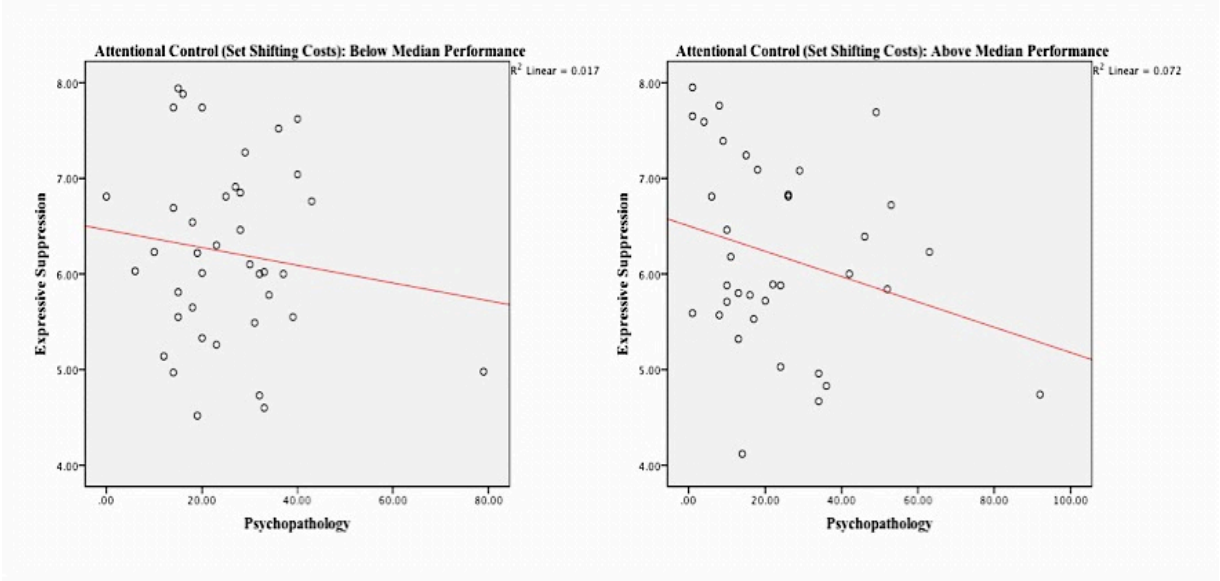


Figure 6. a) The interaction between cognitive reappraisal and symptoms of psychopathology, as a function of being either above or below median performance on a task of attentional control. b) The interaction between expressive suppression and symptoms of psychopathology, as a function of being either above or below median performance on a task of attentional control.

Analysis three: The relationship of inhibitory control and emotion regulation.

Hypothesis 3a predicted that inhibitory control would moderate the influence

of stress on psychopathology via cognitive reappraisal. It is important to note that inhibitory control was examined in two separate analyses: the first (i.e., part one) inhibitory control represents an index of overall general accuracy; and the second (i.e., part two) inhibitory control represents participants' reaction time.

Part one: Moderated mediation for cognitive reappraisal. Participants were categorized as being either above or below sample median on a task of inhibitory control namely, the Go/No-Go task (Moderator variable) that was .7500. The MCC was again used in this analysis representing participants' general accuracy on the Go/No-Go task (i.e., a gauge of inhibitory control performance). Thus, poor accuracy was indexed by performance below the median on the Go/No-Go task whereas; those participants scoring above the median represented better accuracy. The initial conditions required to test for mediation were not met. The IV (Stress) and the Mediator (Cognitive Reappraisal) were not significantly correlated for either level of the moderator (Low: $\boldsymbol{r = -.054, t\big((37)\big) = -.322, p = .749; High: r = -.213, t((36)) = -1.29, p = .206}$) indicating that a meditational model could not possibly fit for either group. Thus, moderated mediation could not be assessed in this model.

Part one: Simple moderation for cognitive reappraisal. Given that moderated mediation did not hold, separate levels of the moderator variable were then examined. Results indicated that for both groups Stress was related to Psychopathology. However, for Cognitive Reappraisal, the relationship to Psychopathology was significant for those above the median split on the Go/No-Go task, but was not significant for those below the relationship as shown in Table 5. Thus, results indicated that the relationship between Cognitive Reappraisal and Psychopathology was moderated by inhibitory control as

indexed by general accuracy on the Go/No-Go task. The interaction between Cognitive Reappraisal and Psychopathology for those above and below the median on a task of inhibitory control (general accuracy) is shown in Figure 7a.

These analyses were also run using the average difference in reaction times (RT) (Block 2- Block 1 RT) on the Go/No-Go task as the moderator variable (i.e., an index of inhibitory control). This score was used to categorize participants as being either above or below sample median, which was .6400.

Part two: Moderated mediation for cognitive reappraisal. The three initial conditions for mediation were not met for this model. The IV (Stress) and the Mediator (Cognitive Reappraisal) were not significantly related for either group (Low: $\boldsymbol{\beta}$= -.089, $\boldsymbol{t((38)) = -.545}$, p= .589, High: $\boldsymbol{\beta}$ = -.159, $\boldsymbol{t((35)) = -.938}$, p=. 355) indicating that a meditational model could not possibly fit for either group. Thus, moderated mediation could not be assessed in this model.

Part two: Simple moderation for cognitive reappraisal. Given that the moderated mediation model did not hold, separate levels of the moderator variable were then examined. Results indicated that for both groups Stress was significantly related to Psychopathology. For Cognitive Reappraisal, the relationship to Psychopathology was not significant for either group. Therefore, the difference in reaction times on the Go/No-Go task did not moderate this relationship however, was trending for those participants below the median (see Table 5). The interaction between Cognitive Reappraisal and Psychopathology for those above and below the median on a task of inhibitory control (reaction time) is shown in Figure 8a.

Hypothesis 3b predicted that inhibitory control would moderate the influence of stress on psychopathology via expressive suppression. Similar to cognitive reappraisal, both indices of inhibitory control were examined (i.e., see part one and two below).

Part one: Moderated mediation for expressive suppression. For these data the three initial conditions that test for mediator effects were not all met thus moderated mediation could not be concluded. The IV (Stress) and the Mediator (Expressive Suppression) were not significantly correlated for either level of the moderator (Low:

$\boldsymbol{r = .103, t((37)) = .621, p = .538; High: r = -.067, t((36)) = -.398, p = .693}$), indicating that a meditational model could not possibly fit for either group.

Part one: Simple moderation for expressive suppression. Given that moderated mediation did not hold in this sample, the separate levels of the moderator variable were then examined. For Expressive Suppression, the relationship to Psychopathology was not significant for either group. Thus, results indicated that the relationship between Expressive Suppression and Psychopathology was not moderated by inhibitory control as indexed by general accuracy on the Go/No-Go task as shown in Table 5. The interaction between Expressive Suppression and Psychopathology for those above and below the median on a task of inhibitory control (general accuracy) is shown in Figure 7b.

Again, these analyses were also run using the average difference in reaction times (Block 2- Bock 1 RT) on the Go/No-Go task as the moderator variable. This score was used as a crude measure of the cost of participants' inhibition and thus, participants were categorized as being either above or below sample median, which was .6400.

Part two: Moderated mediation for expressive suppression. Moderated mediation was not supported in this model, as the three initial conditions for mediation were not met. The IV (Stress) and the Mediator (Expressive Suppression) were not significantly related for either group (Low $\boldsymbol{\beta}$= .159, $\boldsymbol{t((38)) = .934}$, p= .356, High: $\boldsymbol{\beta}$ = -.144, $\boldsymbol{t((35)) = -.846}$, p=. 403). Therefore, results indicated that moderated mediation could not be concluded.

Part two: Simple moderation for expressive suppression. Given that moderated mediation did not hold in this sample, separate levels of the moderator variable were then examined. Results indicated that for Expressive Suppression, the relationship to

Psychopathology was significant for those above the median split, but not for those below. Therefore, the relationship between Expressive Suppression and Psychopathology was moderated by inhibitory control as indexed by difference in reaction times on the Go/No-Go task (see Table 6). The interaction between Expressive Suppression and Psychopathology for those above and below the median on a task of inhibitory control (reaction time) is shown in Figure 8b.

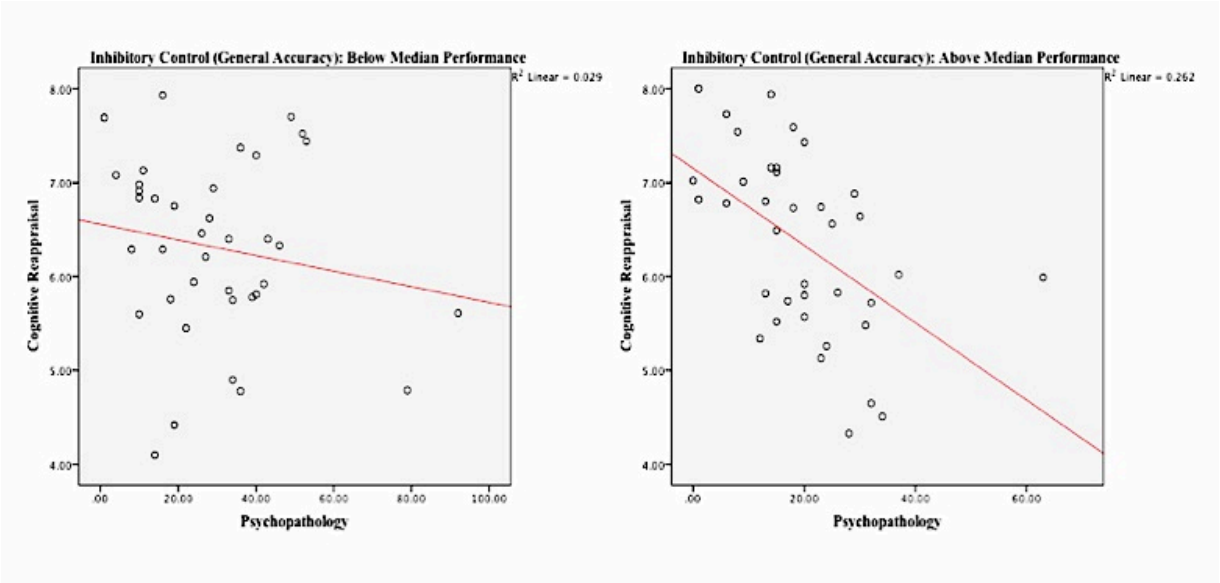
Table 5

Regression Analysis to Test for Moderation

Inhibitory Control (General Accuracy)				
	Cognitive Reappraisal		Expressive Suppression	
	Beta	P value	Beta	P value
Low (N=38)				
Stress→ Psychopathology	.626	**.000**	.626	**.000**
ER→ Psychopathology	-.171	.306	-.158	.342
High (N=37)				
Stress→ Psychopathology	.534	**.001**	.534	**.001**
ER→ Psychopathology	-.512	**.001**	-.282	.091

Note. ER= Emotion Regulation
*p = < .05

a)



b)

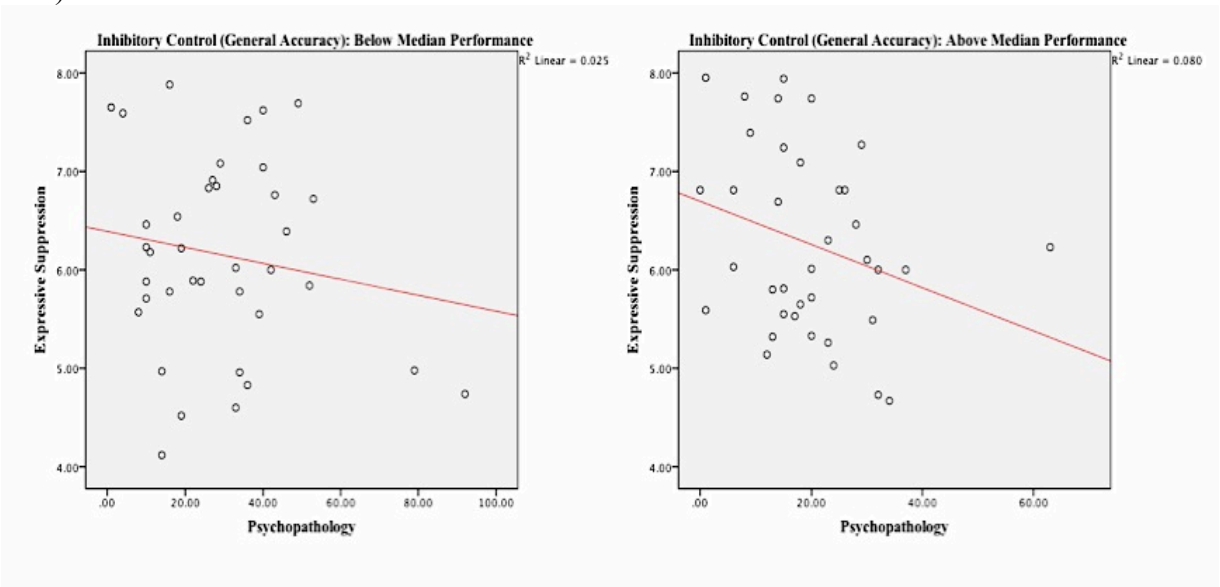


Figure 7. a) The interaction between cognitive reappraisal and symptoms of psychopathology, as a function of being either above or below median performance on a task of inhibitory control (overall general accuracy). b) The interaction between expressive suppression and symptoms of psychopathology, as a function of being either above or below median performance on a task of inhibitory control (overall general accuracy).

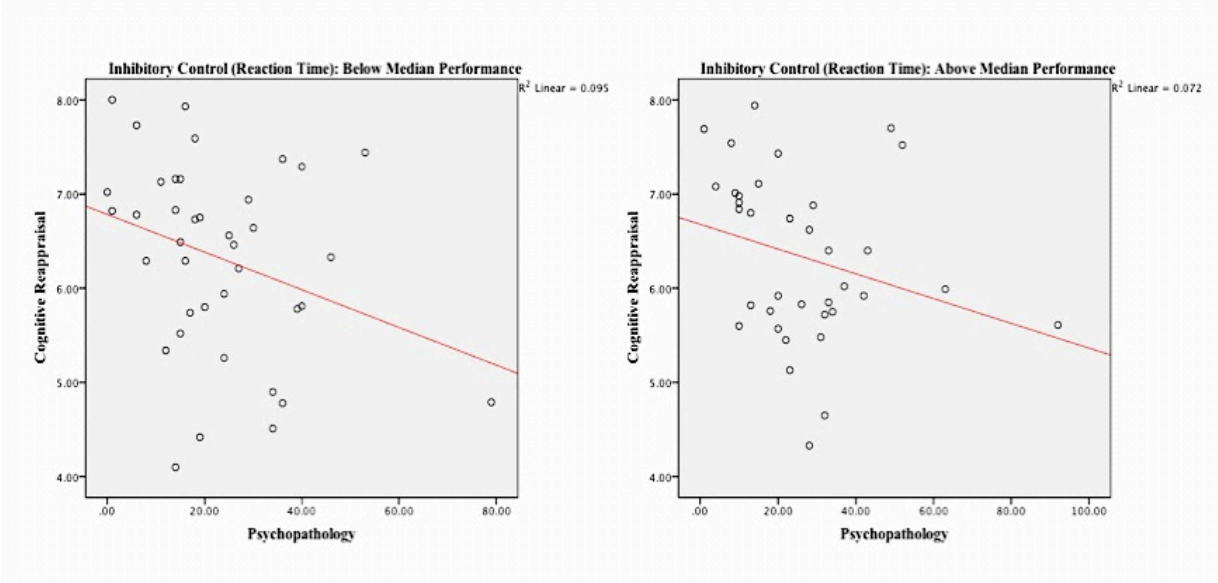
Table 6

Regression Analysis to Test for Moderation

Inhibitory Control (Reaction Time)				
	Cognitive Reappraisal		Expressive Suppression	
	Beta	P value	Beta	P value
Low (N=39)				
Stress→ Psychopathology	.662	**.000**	.662	**.000**
ER→ Psychopathology	-.309	.056	-.070	.673
High (N=36)				
Stress→ Psychopathology	.610	**.000**	.610	**.000**
ER→ Psychopathology	-.268	.114	-.374	**.024**

Note. ER= Emotion Regulation
*p = < .05

a)



b)

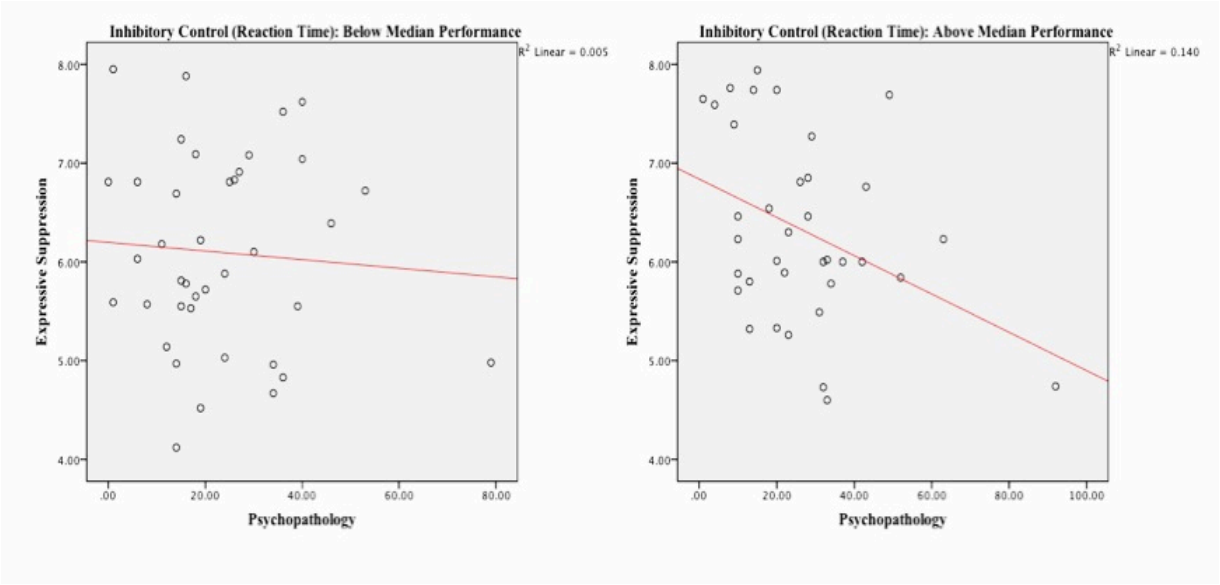


Figure 8. a) The interaction between cognitive reappraisal and symptoms of psychopathology, as a function of being either above or below median performance on a task of inhibitory control (reaction time). b) The interaction between expressive suppression and symptoms of psychopathology, as a function of being either above or below median performance on a task of inhibitory control (reaction time).

Analysis four. Examining the role of emotion regulation in the relationship between stress and psychopathology.

Simple mediation for entire sample. Lastly given that moderated mediation did not hold in any of the predicted models, the entire sample was analyzed to see if a main effect of mediation occurred. Cognitive Reappraisal and Expressive Suppression were examined as separate mediator variables. Results from these analyses indicated that for the entire sample, mediation did not hold as shown in Table 7. For Cognitive Reappraisal, the mediator pathways one and three were significant, however pathway two was not. Thus the criteria for mediation analyses were not met. Second, concerning Expressive

Suppression, results indicated that although pathway one was met, two and three were not. Therefore, results indicated that mediation was also not supported.

Table 7

Regression Analysis to Test for Mediation for the Entire Sample

Cognitive Reappraisal (N=75)		
	Beta	P value
1. Stress→ Psychopathology	.640	**.000**
2. Stress→ Reappraisal	-.120	.306
3. Block 1: Reappraisal→ Psychopathology	-.284	**.013**
Block 2: Stress→ Psychopathology	.605	**.000**

Expressive Suppression (N=75)		
	Beta	P value
1. Stress→ Psychopathology	.640	**.000**
2. Stress→ Suppression	**.014**	.904
3. Block 1: Suppression→ Psychopathology	-.207	.074
Block 2: Stress→ Psychopathology	.633	**.000**

*Note: *p* = <. 05

Discussion

The present study focused on the specific contributions of executive functions (EF) (i.e., working memory, attentional control, and inhibitory control) to emotion regulation (ER) (i.e., cognitive reappraisal and expressive suppression) in the relationship between stress and psychopathology in the context of emerging adulthood. Specifically, it was hypothesized that EF would moderate the association between stress and psychopathology as mediated by ER. Although we did not observe moderated mediation in any of the analyses, interesting findings related to separate levels of the moderator variable (i.e., EFs) were found. Specifically, two sets of key findings were obtained.

First, for cognitive reappraisal, the relationship to psychopathology was moderated by both working memory and attentional control. Thus, more cognitive reappraisal was associated with less psychopathology and this was facilitated by higher working memory and attentional control. These findings are consistent with previous research highlighting the role of working memory and attentional control as important EFs necessary to support cognitive reappraisal (McRae et al., 2012b; Opitz et al., 2014; Schmeichel et al., 2008). Our findings are also in accordance with the process model view of ER (Gross & Thompson, 2007). For working memory, it is suggested that this component of EF has an important role keeping in mind recently generated new interpretations of a negative event, maintaining that interpretation, and simultaneously monitoring its success over time (Gross, 2013). Thus, when working memory is low, one is more likely to experience difficulties reappraising their negative emotions and as a result more susceptible to symptoms of psychopathology as evidenced in our study. Therefore, our findings indicate that effective cognitive reappraisal may depend on a

person's ability to override (automatic) interpretation biases (e.g., negative thoughts/feelings) that lead to unwanted appraisals of the emotion eliciting cues. The ability to replace automatic appraisals with alternative evaluations of a negative situation (e.g., in a more positive way) requires the updating of working memory.

We also observed a relationship between cognitive reappraisal and attentional control as indexed by reaction time costs on a set-shifting task. For cognitive reappraisal, the relationship to psychopathology was moderated by attentional control for the low attentional control group in our sample. Given that cognitive reappraisal involves the manipulation of attentional focus (i.e., shifting between mental sets) (Malooly et al., 2013; McRae et al., 2012b), it is possible that attention deficits may have a negative impact on cognitive reappraisal as evidenced in the present study. Deficits in attentional control may lead to difficulties attending to and processing new information, thereby hindering the use of more adaptive strategies. For example, the young adults in the low attentional control group may not have been able to redirect their attention to reappraising the negative event in a more positive way as a result of not being able to fully disengage from their self-focused negative thoughts. As previously reported in the literature (McRae et al., 2012b), it may seem counterintuitive that cognitive reappraisal would be positively related to costs of set-shifting, as smaller costs are typically interpreted as more skillful performance (Malooly et al., 2013). However, there is growing evidence that shifting skills may not always be associated with adaptive outcome measures (Friedman et al., 2007; Friedman et al., 2011; McRae et al., 2012b) and this is consistent with our study. For example, in order to switch quickly an individual may focus his or her attention rather shallowly, making him or her agile in focusing on something else more efficiently.

However, sometimes a deep attentional focus may be more adaptive and appropriate. For instance, if an individual is pondering a difficult problem, it may be beneficial that he or she is not quickly roused out of that mode of thinking and remain focused on it. In our study, greater shift costs were positively related to cognitive reappraisal and healthier outcomes (i.e., fewer symptoms of psychopathology). Therefore, we interpret performance on the shifting task to reflect the implementation of a cautious strategy, prioritizing accuracy over speed. Those participants in the low attentional control group may have responded faster, but they may not have taken the time necessary to appropriately shift their attention, disengage from emotional aspects of the stimulus, and successfully regulate their negative emotions. Although participants in the high group were associated with greater set-shifting costs (i.e., took a longer time) it is likely that they maintained a deeper attentional focus, responding more efficiently rather than quickly. Research suggests that this speed-accuracy trade off (i.e., cognitive efficiency) as it relates to ER, can be impacted by various factors including personality (Phillips & Rabbitt, 1995; Revelle, 1987). For example, impulsivity, neuroticism, and perfectionism are three dimensions of personality that have strong effects upon the efficiency of cognitive performance. These three dimensions are suggested to impact resource trade-offs (i.e., speed-accuracy) and are associated with stylistic differences. Ultimately, these differences are thought to have important effects upon behavior. Regarding impulsivity, research suggests that less impulsive people are less biased toward speed and slower to initiate tasks; however, once they start a task they are able to persist for long periods of time (i.e., prioritizing accuracy over speed) (Revelle, 1987). The opposite is true for more impulsive people who are usually more biased towards speed, and fast to initiate tasks;

however, they tend not to be as persistent as less impulsive people (i.e., prioritizing speed over accuracy). Although, this lack of persistence can be attributed partly to arousal states (Bowyer et al., 1983), this also represents the stylistic nature of impulsive individuals. Another example includes trait anxiety, which is closely related to the personality dimension of neuroticism. Research suggests that anxious people often prefer to be accurate rather than fast. That is, higher levels of anxiety are thought to impair processing efficiency more than performance effectiveness (Derakshen & Eysenck, 2009). For instance, highly anxious individuals often require more time to complete a task, but are able to compensate by expending additional effort (Eysenck & Calvo, 1992). Therefore, their efficiency is often poor (i.e., investing more effort and time for task completion), but they are able to perform accurately (Stoeber & Eismann, 2007). Lastly, research examining the influence of perfectionism on cognitive efficiency demonstrates that high levels of perfectionism are commonly associated with lower efficiency (Ishida, 2005; Stoeber & Eysenck, 2008) as perfectionistic individuals tend to be more cautious and conservative in their performance. These findings demonstrate that individual differences may impact response style at a trait level, and suggests that differences in this speed-accuracy trade-off may impact ER processes in young adults. These are important factors that should be considered when understanding how EFs including attentional control may impact an individuals ability to regulate their emotions.

We also found that inhibitory control as indexed by participants' general accuracy moderated the relationship of cognitive reappraisal to psychopathology for those in the high inhibitory control group (i.e., greater inhibitory control was associated with greater symptoms of psychopathology). This was a surprising finding given that until recently,

there was no association that had been reported for inhibition and cognitive reappraisal despite it being a key theoretical aspect of this ER strategy (e.g., to detach from the negative emotional experience). To date, there are two studies that examined the role of inhibition and cognitive reappraisal, which identified a positive role for inhibitory control in early stages of cognitive reappraisal (Salas et al., 2013; 2014). We have replicated and extended this effect in the present study. We found that individuals' with high inhibitory control were positively associated with symptoms of psychopathology. Our findings are consistent with recent research highlighting the role of inhibition in the early stages of cognitive reappraisal, a time in which inhibiting irrelevant, negatively valenced information while pursuing a goal is crucial. However, we extend previous research findings and argue that when inhibitory control becomes rigid and is extended past the initial stages of cognitive reappraisal it may become inflexible and prevent the successful reappraisal of the negative event. In our study, this rigidity or inflexibility may have blocked participants' adaptive action (i.e., reinterpreting the situation), and it may have limited their ability to respond appropriately. Although research suggests that high levels of inhibitory control may provide relief in the short-term, there are various long-term consequences including impaired efficiency of cognitive processing and increased symptoms of psychopathology (Gross & Levenson, 1997; Gross, 1998a). Thus, inhibiting the outward expression of negative emotion may be adaptive in some circumstances such as situations of high emotional intensity; however, inhibition alone fails to provide relief from the subjective experience of negative emotion. Therefore, our study suggests that having the ability to inhibit emotional content may be important in the early stages of cognitive reappraisal in allowing an individual to look at a negative situation from

another perspective and make room to reappraise in a more positive light. There is evidence to suggest that when inhibition is impaired, the initial stage of cognitive reappraisal is not well supported and individuals take a longer time to generate reappraisals of their emotions (Salas et a., 2013). Therefore, it is possible that those participants' who focused too heavily on inhibiting the salience of their automatic negative emotions past the initial stages of cognitive reappraisal were not able to flexibly switch to reappraising the negative stimulus. They may have focused their cognitive resources on the initial inhibition of their automatic negative emotions too rigidly, leaving few resources to support the reappraisal of the negative event.

Interestingly for this same relationship of cognitive reappraisal to psychopathology, we found that inhibitory control as indexed by participants' reaction time (i.e., ignoring general accuracy) was trending for those in the low group. Thus, those participants with lower reaction times (i.e., faster engagement in response inhibition) were trending towards greater symptoms of psychopathology. It is possible that these individuals when placed in a stressful situation immediately resort to the inhibition of their initial negative emotions before taking the time to effectively monitor and evaluate the situation at hand. This more impulsive engagement in response inhibition was trending toward greater psychopathology, which highlights the idea that being faster does not necessarily mean 'better'. These findings have important implications for understanding the cognitive components and affective outcomes of cognitive reappraisal.

Concerning our second key finding, we found that the relationship of expressive suppression to psychopathology was moderated by inhibitory control (reaction time) for those in the high inhibitory control group. Ignoring accuracy, participants' in the high

group represent poorer performers (i.e., needing more time). Thus, a positive relationship between inhibitory control and psychopathology was found (i.e., greater time taken for inhibition was associated with greater symptoms of psychopathology). To our knowledge there has only been one study directly examining the impact of EFs on expressive suppression (Schmeichel et al., 2008) as the majority of ER research has concentrated on antecedent-focused ER strategies (e.g., cognitive reappraisal). However, from neuroimaging research there is evidence to suggest that expressive suppression is commonly associated with regions in the brain important in the voluntary inhibition of actions including regions of the PFC (Kühn et al., 2011; Ochsner & Gross, 2008). Our findings are in line with this evidence and indicate a role of inhibitory control in supporting expressive suppression as an ER technique. We found that there was a relationship between those individuals' who took longer to assess the situation and inhibit their prepotent response were associated with greater symptoms of psychopathology. Our findings are consistent with previous research, which consistently reports detrimental effects of inhibitory control in down-regulating negative emotions, and associations with poor mental health outcomes (Gross, 1998a; Gross & John, 2003; John & Gross, 2004). Flexible employment of inhibitory control may be more optimal in ER situations and may involve not only the suppression of a dominant response (e.g., automatic negative thoughts/emotions), but also the activation of a more adaptive response. Moreover, flexible inhibitory control may involve an alteration between initiating and inhibiting a prepotent response according to the goal and situation at hand. Although rigid employment of inhibitory control over experiencing and expressing emotion may at first be adaptive, or provide short-term relief, research consistently indicates that inflexible

inhibition impairs cognitive processing and one's ability to successfully adjust to changing situations (Gross & Levenson, 1997).

It is important to note that our findings highlight the complexity of ER processes, and show that these methods of ER represent dynamic and interacting processes rather than separate categories of ER. In order to adapt to dynamic and changing situational demands, it is likely that individuals must be able to flexibly utilize adaptive ER strategies relevant to the particular goal at hand. These choices are an integral part of daily life; little is known about this seemingly fine line between the use of cognitive reappraisal and expressive suppression. It seems obvious that there is some sort of middle ground between these two perspectives. Rigidly engaging in one ER strategy over the other across all situations and goals is not beneficial, and such inflexible patterns of ER are associated with various psychological disorders (Kashdan & Rottenberg, 2010; Rottenberg et al., 2005). Although traditional approaches to the study of ER have constituted an important first step in our understanding of the affective disturbances that characterize psychopathology, there are important questions that remain. Important next steps include better understanding what is going on as a dynamic process in each individual. From our study it is evident that there is some overlap in the components of EFs that are implemented in both cognitive reappraisal and expressive suppression. Thus, our findings propose a dynamic understanding of these two ER strategies. Traditional theories including the process model view of ER have highlighted that differences in these approaches largely stem from the temporal order in which they are employed, including early implementation and later maintenance stages (Gross, 1998aa). Despite the few studies that have examined temporal sequence of ER strategies (Paul, Simon,

Kniesche, Kathmann, & Endrass, 2013; Schnofelder, Kanske, Heissler, & Wessa, 2013), much of the research in this area has examined ER strategies in isolation. As such, questions still remain regarding the interplay between different types of strategies such as cognitive reappraisal and expressive suppression, and when these strategies may be most beneficial. For instance, recent research indicated that expressive suppression was used at an antecedent stage and this was associated with reductions in self-reported negative affect (Paul et al., 2013). Thus, growing evidence suggests that expressive suppression may be used preventatively to disrupt the emotion-generative process from the very beginning instead of targeting the emotional response itself. Taken together, the above-mentioned research highlights the complexities of ER as a, multi-step cognitive process (Ochsner & Gross, 2008) and provides an avenue for future research.

The two sets of key findings from the present study indicate that EFs ultimately play a role in ER for emerging adults and we see that this differs depending on the type of ER strategy employed. Our study further demonstrates the divergent impact of differing forms of ER including cognitive reappraisal and expressive suppression, yet we also see this seemingly fine line between the cognitive resources involved in employing these two ER techniques. Below we discuss how our findings may inform ER for emerging adults and how this might relate to the efficacy of utilizing different types of therapeutic strategies with this population.

Emerging Adults and Developing Executive Functions

In the current study, we wanted to know which of several EF components (specifically, working memory, attentional control, and inhibitory control) were empirically related to both cognitive reappraisal and expressive suppression in the

relationship between stress and psychopathology for emerging adults. To date, there have only been four studies that have directly examined the contributions of EF to cognitive reappraisal (Malooly et al., 2013; McRae et al., 2012b; Opitz et al., 2014; Schmeichel et al., 2008) and only one study examining this relationship as it pertains to expressive suppression (Schmeichel et al., 2008). Our study provides convergent support for the role of working memory capacity, attentional control, and inhibitory control as resources for successful cognitive reappraisal and inhibitory control as a resource for successful expressive suppression. Our findings are informative when considering the trajectory of the field of ER. Traditionally, ER research has largely been centered on the dichotomy between "adaptive" and "maladaptive" forms of ER and the relationship to various forms of psychopathology (Aldao et al., 2010; Aldao & Nolen-Hoeksema, 2012). There have been significant contributions from the first generation of studies and even more so now with the rapid growth of the second generation of studies. However, inconsistencies in the formerly vague maladaptive/adaptive label given to different strategies and the EF components that are thought to support these strategies have emerged. In the present study we found that EFs play a role in ER for emerging adults. More specifically, we found that different types of ER strategies (i.e., cognitive reappraisal and expressive suppression) were associated with different components of EFs (i.e., three lower order EFs, including working memory, attentional control, and inhibitory control), yet also some overlap, and varying degrees of psychopathology symptoms. Therefore, our study shows support for the notion that healthy adaptation may be the result of flexibly utilizing ER strategies to adjust to different situational demands (Bonanno, 2005; Kashdan & Rottenberg, 2010; Troy & Mauss, 2011), rather than rigidly employing only 'adaptive'

strategies (i.e., cognitive reappraisal) while avoiding 'maladaptive' strategies (i.e., expressive suppression). EFs support the deployment of various ER strategies in novel and non-routine situations; therefore, always using the same strategies is inherently maladaptive and suggests some cognitive rigidity (Gross & Munoz, 1995). Our findings highlight the dynamic interplay between ER and EF processes suggesting that these processes are constantly being updated and refined to match not only the individuals' goals but also the changing situational demands.

Given the importance of successful ER for overall well-being and mental health (Berking & Wupperman, 2012), it is critical that we begin to identify mechanisms that promote successful ER. In general, successful ER includes the ability to monitor, evaluate, and modify the nature and course of an emotional response in order to pursue one's goals and appropriately respond to environmental demands (Gross, 1998a). However, efficient ER also requires that a person has the underlying ability to implement a particular strategy (i.e., cognitive resources) (Joormann & Siemer, 2011). This is especially true for emerging adults. Emerging adulthood is the time during which EFs come to maturation, both behaviorally and biologically (Huzinga, Dolan, & van der Molen, 2006; Luna, 2009; McRae et al., 2012a; Steinberg, 2005; Stuss, 1992). It is speculated that emerging adults may be particularly susceptible to developing psychopathology symptoms as a result of not having a fully developed cognitive control system (i.e., EFs) available in order to support adaptive ER strategies. Given that EF processes play a critical role in moderating the ability to deploy ER strategies, efforts need to focus on promoting or enhancing EFs in young adults. Common methods that can

be used to target and improve EF processes namely, working memory, attentional control, and inhibitory control, in young adults are discussed below.

With regards to working memory, there is a growing body of research that suggests training can induce improvements in performance in non-trained tasks that rely on working memory (Klingberg, 2010; Li et al., 2008; Morrison & Chein, 2011; Westerberg & Klingberg, 2007). A recent example of this is a study conducted by Schweizer and colleagues (2013), who found that short term working memory training led to improvements in ER. These results are consistent with research on training induced plasticity in the intraparietal-prefontal network, which are brain regions implicated in working memory (McNab & Klingberg, 2007; Olesen, Westerberg, & Klingberg, 2003; Todd & Marois, 2004; Vogel & Machizawa, 2004). Thus, various studies have observed training effects suggesting that working memory training can be used as a remediating intervention for individuals for whom low working memory capacity is a limiting factor in everyday life. It is important to note however, that these effects include near-transfer effects only, meaning that they only extend to similar tasks of working memory capacity (Melby-Lervåg & Hulme, 2013). Enhancing working memory through training underlines the potential relevance for such training for ER processes, given that working memory plays a critical role in regulating emotions, as discussed in this review. Moreover, near transfer effects provides evidence that working memory capacity can be increased. Therefore, working memory training could help facilitate the use of effective strategies including cognitive reappraisal among young adults. Common methods to target working memory include teaching strategies such as rehearsal, chunking, and various meta-cognitive strategies (Abikoff & Gittelman, 1985; Butterfield, Wambold, &

Belmont, 1973). These are examples of explicit conscious strategies that can be applied to improve working memory. Computerized training of working memory has also been employed (Klingberg, Forssberg, & Westerberg, 2002; Klingberg et al., 2005) as a way of promoting working memory capacity. This type of training often involves repeated performance on working memory tasks, with feedback and rewards. Although the duration of training varies across studies, in younger adults, extensive daily practice (for approximately 30-45 minutes a day) over weeks has been found to be most beneficial (Dahlin, Stigsdotter-Neely, Larsson, Backman, & Nyberg, 2008; Jaeggi, Buschkuehl, Jonides, & Perrig, 2008; Olesen, Westerberg, & Klingberg, 2004).

Adaptive training that focuses on the control of attention has also been shown to have similar effects and may provide a method of promoting successful ER in young adults (Bishop et al., 2004). A growing body of research suggests that attention allocation can be trained and this training can improve ER through multiple methods. For example, training gaze patterns (Johnson, 2009b), clinical training methods (Mohlman, 2004; Wells, 1990), and meditative attention training (Brefczynski-Lewis, Lutz, Schaefer, Levinson, & Davidson, 2007; Chambers, Lo, & Allen, 2008; Tang, Posner, & Rothbart, 2014), have been shown to increase attentional control. Even though individual differences exist in determining what type of training procedure may be most useful, at a general level meditation has been suggested to have the most potential for improving attentional control and modifying a broad range of ER outcomes (Wadlinger & Isaacowitz, 2010). Other ways to target attentional control include training individuals to attend to positive information (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007), as well as training individuals to disengage from negative emotional

information and reorient toward neutral information (Mohlman, 2004). As an example, promoting the disengagement from negative, self-focused internal dialogue and instead promoting the reorientation toward external cues (e.g., the breath, a specific object, or other environmental cues), has been associated with improvements in symptoms of psychopathology (Mohlman, 2004; Siegle, Ghinassi, & Thase, 2007). Therefore, if individuals can be effectively trained to reorient their maladaptive attentional patterns toward more neutral content, they may be able to more effectively control their emotional states. Overall attention training is a promising method for clinical application in emerging adulthood. Attentional difficulties are a frequent symptom of different forms of psychopathology (MacLeod, Mathews, & Tata, 1986; Mogg, Millar, & Bradley, 2002; Watson & Purdon, 2008), and individuals often lack the knowledge that they can focus and shift their attention to control their emotions (Mohlman, 2004). Therefore, if efforts are made to effectively train attentional control among young adults, then they may be able to more effectively control their emotional states and protect against psychological disturbances.

Lastly, methods of promoting inhibitory control may serve as additional resources in supporting adaptive ER in young adults. However, research in this area has yielded inconsistent results, and from available studies, it is not clear whether inhibitory control can be successfully trained. For instance, there is research to suggest that inhibitory control may improve indirectly through near-transfer effects of training other EF components (see Enriquez-Geppert, Huster, & Hermann, 2013 for a review; Morrison & Chein, 2011; Motes et al., 2014) however, there are also studies indicating that when inhibitory control is trained directly, there are no transfer effects (Enge et al., 2014;

Thorell, Lindgvist, Bergman, Bohlin, & Klingberg, 2009). However, in a recent study conducted by Daches and Mor (2014) inhibition training procedures that were designed to increase inhibition to negative stimuli effectively reduced brooding (Daches & Mor, 2014). Although there is no consensus about the exact classification of efficacy of inhibitory control training, this component of EF has been widely considered to be one of the important factors in cognitive and behavioral regulation (Aron, Robbins, & Poldrack, 2004; Diamond, 2013; Miyake et al., 2000; Salthouse, Atkinson, & Berish, 2003). Thus, further examinations of explicit inhibitory control training are necessary to better delineate whether this component of EF cane be improved in young adults.

Taken together, these findings demonstrate substantial and durable plasticity of EFs across adulthood and shows promising results for training lower order EFs in young adults. Given that the improvement of EFs is of high individual and social significance and can provide therapeutic potential for cognitive deficits, training gains that can be attributed to real changes in the trained function are of particular value (e.g., Klingberg, 2010). Because each EF is associated with different training techniques and influence different networks in unique ways, combining strategies of various EF components (i.e., working memory, attentional control, and inhibitory control) may magnify their effect in improving ER in young adults. Practicing multiple training techniques may uniquely influence more widespread neuroanatomical structures (Raz & Buhle, 2006) and may keep training more engaging, novel, and perhaps more beneficial for young adults.

The present research also has important clinical implications. This research is in line with cognitive behavioral conceptualizations of psychopathology, within which, deficits in cognitive ER strategies lie at the center of many psychological disorders, in

particular mood and anxiety disorders (Joormann & Gotlib, 2010). Recent research suggests that individuals may be more successful regulating their emotions when they use strategies for which they have the prerequisite cognitive resources in a given situation (Ochsner & Gross, 2005; Opitz, Rauch, Terry, & Urry, 2012; Urry & Gross, 2010). Related, our findings also have valuable implications in informing which types of therapeutic strategies may be most effective with this population. For instance, cognitive reappraisal is at the foundation of cognitive behavioral therapy (CBT) (Beck, 1989). However, our findings suggest that young adults may not have fully matured cognitive control systems available to help facilitate the use of this particular ER strategy. There is a growing body of research that demonstrates EFs including the ability to inhibit overlearned behaviors develop earlier in life whereas working memory, cognitive flexibility, and attentional control have a much longer development (Davidson et al., 2006; Huizinga, Dolan, & van der Molen, 2006; Jurado & Rosseli, 2007). This may account for why emerging adults often resort to suppression as a fundamental ER strategy in their daily lives (Gross et al., 2006). Moreover, young adults have a greater cognitive cost associated with regulating their emotions compared to older adults (Scheibe & Blanchard-Fields, 2009), often times rigidly suppressing their emotions, rather than engaging in a more adaptive ER strategy (e.g., cognitive reappraisal). Therefore, our findings can help inform how CBT approaches may be tailored to better meet the needs of young adults. Cognitive training uses diverse approaches to enhance cognitive functioning and this has been consistently shown to optimize well-being in mental health disorders and among various populations (Butler, Chapman, Forman, & Beck, 2006). Moreover, cognitive training can also be used as a preventative or pre-emptive

intervention. However, a recent review on cognitive training demonstrated that the field is barely at the threshold for understanding the key active ingredients for the development of training methods that maximize cognitive and functional gains (Keshavan, Vinogradox, Rumsey, Sherrill, & Wagner, 2014). Cognitive training approaches have been applied across various mental illnesses, developmental stages, and have used a variety of methods in current research (e.g., Dobson, 1989; Durlak, Fuhrman, & Lampman, 1991; Heyn, Abreu, & Ottenbacher, 2004; Pinquart & Sorensen, 2001; Sitzer, Twamley, & Jeste, 2006). As a result, it has become difficult to integrate findings and draw definitive conclusions in order to suggest best practices for young adults specifically. Few studies have systematically examined how the effects of age or neurodevelopmental stage associated with young adulthood impact their response to cognitive training. Instead, the majority of the focus has largely been on childhood (Gleacher et al., 2011; Legerstee et al., 2010) and early adolescence (Garvik, Idsoe, & Bru, 2014; Klein, Jacobs, & Reinecke, 2007). Therefore, there are limited empirical studies focused on ways CBT can be better suited for young adult populations. This lack of research is coincided by a lack of healthcare professionals trained in working with young adults (Rickwood, Deane, & Wilson, 2007), and together has contributed to the various barriers that exist and prevent young adults from seeking treatment. Recently however, there has been a growing interest in CBT techniques through Internet or web-based modalities for young adults that have proven to be efficacious in treating psychopathology symptoms among this population (Andrews, Cuijpers, Craske, McEvoy, & Titov, 2010; Clark et al., 2009; Johnston et al., 2014; Kandalaft, Didehbani, Krawczyk, Allen, & Chapmen, 2013; Nahum et al., 2014; Rickwood, Deane, & Wilson, 2007). For

example, a review of the literature suggests that brief interventions computer- and/or Internet-delivered treatment are likely to result in higher adherence rates in young adults (O'Kearney, Gibson, Christensen, & Griffiths, 2006; Sethi, 2013). Typical CBT lessons in these programs include education on basic principles of cognitive therapy, strategies for monitoring and challenging thoughts as well as, instructions about skills for helping manage physical and emotional symptoms (Dear et al., 2011; Johnston et al., 2014). Written homework tasks and clinical vignettes are also commonly used as supplemental methods to aid in the lessons over the course of therapy. These techniques are used to provide young adults with further examples on how to manage symptoms and apply the skills taught in lessons in their everyday life. Using age-appropriate language and providing examples of CBT skills have been shown to be useful tools that help young adults manage some of the difficulties that they are commonly faced it (e.g., managing the demands of education, leaving the family home, balancing workplace and social life). Although the field is not quite there yet in determining best practices of CBT for young adults, a trend in utilizing technological devices is emerging as an effective method in supporting this population. Future studies should look at ways of implementing CBT and other ER strategies in electronic devices such as cell phone applications or online calendars to perhaps aid in traditional face-to-face CBT for this population. For instance, sending reminders or cues, or providing young adults with ER strategies via electronic communication devices may prove quite useful for this population. Some work in this area has begun, and results provide optimistic and promising avenues for future research in providing developmentally appropriate methods of therapy.

Limitations and Future Directions

The present study outlines the EF correlates of cognitive reappraisal and expressive suppression ability, which enhances our understanding of the processes involved in successful ER. Despite this contribution, there are some limitations of the current study that should be addressed in future research.

First, the sample in the present study was fairly homogeneous in terms of age and educational background, which limits the generalizability of the results. The majority of the sample was functioning at a high level and few had clinically significant levels of anxiety and depression. Although the levels of psychopathology are similar to that of other studies examining similar populations, this may place constraints on the generalizability of this study. Future studies should replicate our findings using a more diverse sample including a greater range of psychopathology by recruiting young persons outside of a higher education context. Moreover, future studies should apply the model in the context of individuals with confirmed psychiatric diagnoses. This will likely make a contribution to expanding the current knowledge base to include a wider segment of the population, including both clinical and non-clinical samples.

Second, our study was one of few to integrate both negative sentences and negative pictures in the ER paradigm. Although our ER task included diverse stimuli (i.e., sentences and images) we examined ER success based on performance on the ER task as a whole, not examining these stimuli separately. It is relevant to examine pictures and sentences separately as recent research suggests that ER success may be impacted by the ways in which emotions are generated (McRae et al., 2012c). Thus, by examining how successful individuals are at regulating their emotions when generated from either

the bottom-up, that is, emotions that are elicited by the presentation of a stimulus that has simple physical properties that are inherently emotional (i.e., negative images) or from the top-down, that is, emotions that are elicited by the activation of an appraisal that a situation is relevant to one's goals (Scherer, 2001) (i.e., negative sentences that might elicit an emotion-inducing appraisal) we can then begin to better understand the interactions between emotion generation and regulation. Given that in the present study we combined and considered negative sentences and images together to describe ER success, future research should examine the differential impact these types of stimuli have on subsequent ER success.

Additionally, we chose to utilize the ER instructions for cognitive reappraisal, expressive suppression and appraisal based on Vanderhasselt and colleagues' (2012) paradigm. Although this was relevant for the purpose of our study in terms of replicating previous research findings, there are a number of critiques and avenues for future research. Firstly, aspects of the task instructions used in Vanderhasselt and colleagues' (2012) ER paradigm had a degree of ambiguity, specifically the instructions surrounding expressive suppression. As seen in Figure 3, instructions for expressive suppression included phrases such as "…you may not feel anything... try not to feel and show no emotional facial expression". It is unclear based on these instructions whether the focus of expressive suppression as an ER technique was on the suppression of the *expressed* emotion or the actual *experience* of emotion itself. If participants interpreted the instructions according to the latter, then these instructions do not accurately capture the goal of expressive suppression reflected within current theoretical frameworks, namely, Gross's process model view of ER (1998). Again, although the use of the ER training

instructions were relevant for this study, specific revisions and clarifications may be required in the future in order to make the task instructions more accurately reflect current conceptualizations of ER. As proposed by Gross (1998), cognitive reappraisal is an ER technique that challenges how an individual thinks about a situation as a way of decreasing its emotional impact. Thus, the focus of cognitive reappraisal is to decrease the experience and behavioral expression of emotion (e.g., thinking about a negative situation in a more positive way which, in turn may help reduce one's negative emotions). On the other hand, expressive suppression includes the act of inhibiting the outward sign of emotion with the goal of decreasing the behavioral expression. For example, 'putting on a poker face' so that others cannot infer how you are feeing at a particular moment. In this way, expressive suppression focuses on suppressing the expressions of emotion but might not necessarily decrease to the experience of emotion itself. Thus, one important distinction that should be clearly indicated in future ER paradigms are the focus of the ER technique (i.e., regulating the *expressed* emotion vs. the *emotion* itself) being targeted, and this should be clearly articulated in the task instructions.

Lastly, appraisal as an ER technique (i.e., "doing nothing" as instructed in this study) is also an important ER strategy, which can look quite different among various individuals. However, prevailing research has focussed on cognitive reappraisal and in more recent years, expressive suppression. As such, this aspect of ER (i.e., appraisal of emotions or "doing nothing") has not been studied to the same extent. Physiological measures in addition to self-report indices may provide useful avenues for future research

as a way of better understanding this ER strategy, and how a range of factors may impact how individuals' 'appraise' their emotions.

In addition, the analyses used in this study were based solely on multiple regression. Although this method was appropriate for the research questions addressed in this study, it may be limited in its power and scope given the characteristics of the data set. Analyses were conducted by using a median split, characterizing participants as being either above or below the sample median on tasks of EF. Again, although this was suitable for the current study, this method halves the sample size and reduces the statistical power in our analyses.

Although sex was not exclusively examined in the present study due to limited power (i.e., majority of participants were female), future studies should account for sex when examining relations between ER and EFs. This is especially important because recently a variety of sex differences have been found in ER (Nolen-Hoeksema, 2012; Zlomke & Hahn, 2010). One of the most pronounced differences in ER strategy use between men and women as suggested in current research includes the tendency for women to use rumination far more than men (Tamres, Janicki, & Helgeson, 2002), whereas men are more likely to use emotion suppression (Gross & John, 2003). Moreover, women have been shown to be more likely to analyze and engage in conscious attempts to regulate emotion (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008; Nolen-Hoeksema, 2012). These findings shed light on the importance of considering sex as a relevant factor in understanding ER and EF processes, one that should be examined in future research to increase clarity and understanding of these relations. Thus, findings in

the present study should be interpreted with caution given that most of the sample was female and therefore, this model and current findings might not generalize to males.

Finally, although young adults have been found to be reliable reporters of their internal experiences (Achenbach, McConaughy, & Howell, 1987) this study relied on self-report data, which may be open to biases and as such may provide the potential for error. Therefore, future studies should not only examine whether EFs predict self-reported outcomes of emotion regulation (i.e., psychopathology) but also other indicators of emotion dysregulation including psychophysiological indicators for instance, heart rate variability. The integration of behavior, physiology, and subjective experience is central to ER; thus, future studies should examine this relationship to provide more of a multifaceted and richer understanding of ER processes.

Conclusion

This study highlights the fact that EFs play a critical role in ER for emerging adulthood. More specifically, this study demonstrates that EFs play a moderating role in the relationship between emotion dysregulation and psychopathology symptoms in young adults. Thus, the unique developmental period that young adults in this sample were undergoing at the time of the study, that is the transition to adulthood, is a crucial opportunity for prevention and intervention efforts aimed at reducing risk of emotion dysregulation and psychopathology symptoms. Emerging adulthood is a critical transitional period associated with increased levels of perceived stress, changing developmental roles, and maturing cognitive control networks. Therefore it is important to study emerging adults specifically in order to provide best practises and effectively serve this population. Future research is warranted in order to better understand the

factors contributing to the significant mental health difficulties commonly experienced by this population. Efforts should be geared towards educating and facilitating the use of adaptive ER strategies among this population. Moreover, a better understanding of the moderating effect of EFs is crucial. Future research endeavours should focus on understanding these factors in order to inform therapeutic practises and support young adults through this transitional period. Then we can begin to provide the resources necessary to help mobilize and facilitate emerging adults in a focused and targeted way to help reduce susceptibility to psychopathology during this time. As of yet, we have only limited understanding of ER and EF processes and how these processes interact. We are optimistic that continued theoretical and empirical work on these processes will yield increased clarity and provide a better conceptual understanding that can then be used to inform best practises among this population.

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Appendix A

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **during the last month**. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

0 = Never 1 = Almost Never 2 = Sometimes 3 = Fairly Often 4 = Very Often

1.	In the last month, how often have you been upset because of something that happened unexpectedly?	0	1	2	3	4
2.	In the last month, how often have you felt that you were unable to control the important things in your life?	0	1	2	3	4
3.	In the last month, how often have you felt nervous and "stressed"?	0	1	2	3	4
4.	In the last month, how often have you felt confident about your ability to handle your personal problems?	0	1	2	3	4
5.	In the last month, how often have you felt that things were going your way?	0	1	2	3	4
6.	In the last month, how often have you found that you could not cope with all the things that you had to do?	0	1	2	3	4
7.	In the last month, how often have you been able to control irritations in your life?	0	1	2	3	4
8.	In the last month, how often have you felt that you were on top of things?	0	1	2	3	4
9.	In the last month, how often have you been angered because of things that were outside of your control?	0	1	2	3	4
10.	In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	0	1	2	3	4

Appendix B

Emotion Regulation Questionnaire (ERQ)
Gross & John
9/03

The Emotion Regulation Questionnaire is designed to assess individual differences in the habitual use of two emotion regulation strategies: cognitive reappraisal and expressive suppression.

Citation

Gross, J.J., & John, O.P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. Journal of Personality and Social Psychology, 85, 348-362.

Instructions and Items

We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1	2	3	4	5	6	7
strongly disagree			**neutral**			**strongly agree**

1. ____ When I want to feel more *positive* emotion (such as joy or amusement), I *change what I'm thinking about*.
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less *negative* emotion (such as sadness or anger), I *change what I'm thinking about*.
4. ____ When I am feeling *positive* emotions, I am careful not to express them.
5. ____ When I'm faced with a stressful situation, I make myself *think about it* in a way that helps me stay calm.
6. ____ I control my emotions by *not expressing them*.
7. ____ When I want to feel more *positive* emotion, I *change the way I'm thinking* about the situation.
8. ____ I control my emotions by *changing the way I think* about the situation I'm in.
9. ____ When I am feeling *negative* emotions, I make sure not to express them.
10. ____ When I want to feel less *negative* emotion, I *change the way I'm thinking* about the situation.

Appendix C

Difficulties in Emotion Regulation Scale (DERS)

Response categories:

1 Almost never (0-10%)
2 Sometimes (11-35%)
3 About half the time (36-65%)
4 Most of the time (66 – 90%)
5 Almost always (91-100%)

1. I am clear about my feelings.
2. I pay attention to how I feel.
3. I experience my emotions as overwhelming and out of control.
4. I have no idea how I am feeling.
5. I have difficulty making sense out of my feelings.
6. I am attentive to my feelings.
7. I know exactly how I am feeling.
8. I care about what I am feeling.
9. I am confused about how I feel.
10. When I'm upset, I acknowledge my emotions.
11. When I'm upset, I become angry with myself for feeling that way.
12. When I'm upset, I become embarrassed for feeling that way.
13. When I'm upset, I have difficulty getting work done.
14. When I'm upset, I become out of control.
15. When I'm upset, I believe that I will remain that way for a long time.
16. When I'm upset, I believe that I'll end up feeling very depressed.
17. When I'm upset, I believe that my feelings are valid and important.
18. When I'm upset, I have difficulty focusing on other things.
19. When I'm upset, I feel out of control..
20. When I'm upset, I can still get things done.
21. When I'm upset, I feel ashamed with myself for feeling that way.
22. When I'm upset, I know that I can find a way to eventually feel better.
23. When I'm upset, I feel like I am weak.
24. When I'm upset, I feel like I can remain in control of my behaviors.
25. When I'm upset, I feel guilty for feeling that way.
26. When I'm upset, I have difficulty concentrating.
27. When I'm upset, I have difficulty controlling my behaviors.
28. When I'm upset, I believe there is nothing I can do to make myself feel better.
29. When I'm upset, I become irritated with myself for feeling that way.
30. When I'm upset, I start to feel very bad about myself.
31. When I'm upset, I believe that wallowing in it is all I can do.
32. When I'm upset, I lose control over my behaviors.
33. When I'm upset, I have difficulty thinking about anything else.
34. When I'm upset, I take time to figure out what I'm really feeling.
35. When I'm upset, it takes me a long time to feel better.
36. When I'm upset, my emotions feel overwhelming.

Appendix D

Demographic and Life-Stress Questionnaire

ID #:

Age:

Gender: 1-M / 2-F

Current Program of study:

Current year of study (e.g., 1st year, 2nd)

What week in the semester are you?

Race/Ethnicity:

Highest Level of Education:

Marital Status:

Current Living Situation:

Work Status:

Country Where You Were Born:

How many times in your life have you moved to a different city or town?

How many times in your life have you moved to a different country?

Past: Would you say, in your life, that you have had an average level of stress, a less-than-average level of stress, or an above-average level of stress?

Past: What are the three most stressful events that have ever happened in your life, and when did those occur?

Recent: Would you say that *within the last week*, you have an average level of stress, a less-than-average level of stress, or an above-average level of stress?

Recent: In a typical week, would you say that you feel stressed:

Never
Rarely (1-2 times a week)
Often (3-5 times a week)
Very Often (6-7 times a week)
Always (Everyday)

Has anyone in your family ever been diagnosed with a psychological condition disorder?

(If yes) Was this person ever given a diagnosis? Y N

Was this person a first-degree relative (such as parent, sibling, or child)? Y N

How do you generally cope with your negative emotions? (e.g., exercise, hang out with friends, listen to music)

Do you ever use any substances to help regulate your emotions? (e.g., alcohol, marijuana, other substance use)

1-never
2-once or twice a month
3- 3-5 times a month
4- 6-9 times a month
5 10 + times a month

Recent History: On average, over the last 3 months, how many hours per week have you typically run for the purpose of exercise?
1
0
2
1-2
3
3-4
4
5-6
5
7 or more

Past History: On average, over the last 2 years, how many hours per week have you typically run for the purpose of exercise?
1
0
2
1-2
3
3-4
4
5-6
5
7 or more

Recent History: On average, over the last 3 months, how many hours per week have you typically participated in other aerobic exercise? (Ex. Swimming, elliptical, cycling)
1
0
2
1-2
3
3-4
4
5-6
5
7 or more

Past History: On average, over the last 2 years, how many hours per week have you typically participated in other aerobic exercise? (Ex. Swimming, elliptical, cycling)

1
0
2
1-2
3
3-4
4
5-6
5
7 or more

Recent History Part A: What is the most alcohol you have consumed on a single occasion within the past 2 weeks? (Where 1 drink = 1 beer, 1 glass of wine, or 1 ounce of liquor)
1
0-1
2
2-3
3
4-5
4
6 or more

Recent History Part B: When did the consumption event occur?
1
N/A
2
1 - 2 days ago
3
3 - 4 days ago
4
4 - 5 days ago
5
6 - 7 days ago
6
1 - 2 weeks ago

Past History: Considering the past 3 month period, what is your typical alcohol consumption on an average daily basis? (Where 1 drink = 1 beer, 1 glass of wine, or 1 ounce of liquor)
1
0-1
2
2-3
3
4-5
4
6 or more

Recent History Part A: What is the most marijuana you have consumed on a single occasion within the past 2 weeks? (Where 1 = 1 primary inhalation of marijuana smoke)
1
0
2
1-2
3
2-4

4
4-6
5
7 or more

Recent History Part B: When did this consumption event occur?
1
N/A
2
1 - 2 days ago
3
3 - 4 days ago
4
4 - 5 days ago
5
6 - 7 days ago
6
1 - 2 weeks ago

Past History: Considering the past 3 month period, what is your typical marijuana consumption on an average daily basis? (Where 1 = 1 primary inhalation of marijuana smoke)
1
0
2
1-2
3
2-4
4
4-6
5
7 or more

Recent History Part B: When did this consumption event occur?
1
1 - 2 days ago
2
3 - 4 days ago
3
4 - 5 days ago
4
6 - 7 days ago
5
1 - 2 weeks ago
6
N/A

Appendix E

Neuropsychological Tests, With Citations

Note: The majority of these tests are copyrighted and produced by test publishing companies. This typically means that these tests have been standardized and gone through rigorous reliability and validity studies. Due to copyright laws (and ethical protection of clinical neuropsychological tests), we are unable to provide the actual test here. Rather, we have provided the citation and the test publisher information.

Behavior Rating Inventory of Executive Function- Adult Version (BRIEF-A): Roth, R. M., Isquith, P. K., & Gioia, G. A. (2005). *BRIEF-A: Behavior Rating Inventory of Executive Function--Adult Version: Professional Manual*. Psychological Assessment Resources.

Appendix F

Computerized Cognitive Tasks

1. Emotion Regulation Paradigm: This task requires participants to view aversive pictures and sentences on a computer screen and explicitly apply an emotion regulation strategy to reduce their negative emotions when viewing the stimuli.

(The following tasks were developed in the laboratory of Dr. Mauricio Garcia-Barrera, Clinical Neuropsychology faculty at UVic):

2. Go/No-Go Task
This task requires that participants look at a computer screen where they are presented with a series of letters. Participants must press the spacebar whenever a letter appears on the screen, but not when they see the letter "J".

3. The Number-Letter Task: This task will be used to indicate attentional control. On this task, participants will be shown a number-letter pairing (e.g., 4A), which will appear in one of four quadrants on a computer screen. Depending on the location of the stimulus, participants must respond to either the letter or number component by pressing one of two buttons (*i.e.* odd/even number OR vowel/consonant).

4. N-Back Task: This task requires that participants press a button if a letter stimulus appearing on the screen matches the letter appearing a certain number of trials previously. For example, in the "1-back" condition, if the participant is shown an "L", the participant must press a button if the previous stimulus was also an "L". In the "2-back" condition, the button would be pressed if an "L" appeared 2 trials previously, and so on.