THE ROLE OF EXECUTIVE FUNCTIONING IN ADOLESCENT RUMINATION AND DEPRESSION

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by

Kelsey S. Dickson, M.A.

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Dissertation written by
Kelsey S. Dickson,
B.A., Northwestern University, 2008
M.A., Kent State University, 2012
Ph.D., Kent State University, 2015

Approved by

_____, Chair, Doctoral Dissertation Committee
Jeffrey A. Ciesla, Ph.D.

_____, Members, Doctoral Dissertation Committee
John Dunlosky, Ph.D.

_____,
John Gunstad, Ph.D.

_____,
Christopher Was, Ph.D.

Accepted by
_____, Chair, Department of Psychology
Maria Zaragoza, Ph.D.

_____, Associate Dean, College of Arts and Sciences
Janis H. Crowther, Ph.D.

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CHAPTER 1

INTRODUCTION

Adolescence marks a critical time in the development of and lifetime consequences for depression. Whereas depression affects approximately 1% of children, the prevalence of depression significantly increases across development such that it affects more than 25% of adolescent youth (Kessler, Avenevoli & Merikengas, 2001). It is not until adolescence that the presentation and phenomenology of depression approximates that seen throughout the lifespan (Kessler et al., 2001). Rumination, a key risk factor for depression, is also a developmentally sensitive construct, with current data suggesting a distinct presentation of rumination in childhood compared to adolescence and adulthood (see Rood, Roelofs, Bogels, Nolen-Hoeksma, & Schouten, 2009). In order to better elucidate the shift in depression and rumination seen in adolescence, researchers have begun to examine the neuropsychological underpinnings of these constructs. Although empirical data supports a significant relationship between executive functioning (EF) and both rumination (Davis & Nolen-Hoeksema, 2000) and depression (Snyder, 2013), research has yet to fully explore the relationship among these constructs from a developmental prospective. This study aims to examine the relationship between various components of EF, rumination and depression in adolescents. A secondary aim of this study is to examine whether rumination mediates the relationship between EF and depression.

Depression. Although depression can occur throughout the lifespan, it is generally first experienced in adolescence (Kessler, Berglund, Demler, Jin, Merikangas & Walters, 2005). Specifically, the incidence of depression rises dramatically around age 13-14 and peaks between the ages of 15 and 18, with rates subsequently declining in early adulthood and beyond (Hankin, et al., 1998; Weissman, Warner, Wickramaratne, Moreau, & Olfson, 1997). Adolescent-onset depression is also associated with an increased risk for subsequent episodes, with as many as 70% of individuals experiencing more than one episode (Lewinson, Rohde, & Seeley, 1998; Kovacs, 1996). Furthermore, once an individual experiences an episode of depression, the risk of experiencing a second episode rises to 60% and continues to increase until the risk of developing four or more episodes is as high as 90% (Solomon et al., 2000). Given that an increasing number of individuals are experiencing their first depressive episode during adolescence, these findings suggest an increase in the number of possible episodes experienced during adolescence as well as the lifespan.

Adolescent-onset depression is also associated with an increase in risk for other negative outcomes throughout adolescence and beyond. In particular, most depressed adolescents experience comorbid anxiety and conduct disorders (Rao et al., 1995). These adolescents are also prone to significant psychosocial difficulties, including impairments in quality of life, interpersonal functioning, physical well-being, and vocational performance (Lewinson, Rohde, Seeley, Klein, & Gotlib, 2003; Rao et al., 1995). Consequently, adolescence marks a critical period in furthering our understanding of the

risk factors contributing to the development depression. Of these factors, the role of executive functioning in depression has recently received significant empirical attention.

Executive Functioning. Executive functioning (EF) is generally understood as a collection of cognitive processes necessary for goal-directed behavior (Luria, 1996; Stuss & Benson, 1986). Currently, a multitude of conceptualizations of what constitutes EF exist. For the purposes of this study, we will focus on the specific components that are consistent across various current models of EF, including set-shifting, monitoring, inhibition and perseveration. Furthermore, we chose to look at specific EF components versus EF more broadly given the evidence of a dissociable relationship between various subdomains of EF and both depression and rumination (Altamirano, Miyake & Whitmer, 2010; Holler, Kavanaugh, & Cook, 2013; Kyte Goodyer, Sahakian, 2005; Maalouf et al., 2013; Whitmer & Banich, 2007; Wilkinson & Goodyer, 2006;). Set-shifting involves the ability to change or shift mental tasks (Miyake et al., 2000). An example of a failure to set-shift includes an inability to shift from focusing on prior, irrelevant concerns or thoughts when trying to focus on a novel task. Monitoring is described as the ability to attend to and evaluate ongoing cognitions and strategy use (Brown, Bransford, Ferrara & Campione, 1983). Individuals with monitoring deficits often have difficulty observing the progress of their behaviors or thoughts and continually employ a strategy without assessing its effectiveness. In terms of inhibition, researchers debate whether this EF component is truly a unitary construct (see Friedman & Miyake, 2004). However, for the sake of this study, I will refer to inhibition as the ability to suppress an irrelevant or interfering prepotent response while enacting a less automatic response (Miyake et al.,

2000). Individuals with inhibitory deficits cannot disregard an underlying tendency (e.g., focusing on the negative) despite conscious attempts to focus on alternative or novel thoughts or stimuli. A component closely related to inhibition and set-shifting, perseveration has been thought of as the failure to modify behavior or respond flexibly despite environmental feedback, expected future consequences or contingences (Lezak, 1995). Individuals with increased perseverative focus often focus on the same stimuli or thoughts despite prompts or feedback guiding their attention towards alternatives.

As is the case with depression, adolescence is a key period in the development of EF. Specifically, despite emerging as early as the first year of life and developing gradually throughout the lifespan (see Best & Miller, 2010; Diamond, 2002; Welsh, 2002), many EF components are not fully mature until adolescence, or between the ages of 10-12. In support of this pattern of development, a wealth of research implies that mature or adult-like set-shifting abilities and the ability to minimize perseveration emerge during the ages of 10 and 12 (Anderson, Anderson, Northam, Jacobs, & Catroppa 2001; Chelune & Baer, 1986; Levin et al., 1991; Cepeda, Kramer, & Gonzales de Sather, 2001; Kray, Eber, & Lindenberger, 2004; & Crone, Bunge, van der Molen, & Ridderinkhof, 2006). Similarly, inhibitory (Brocki & Bohlin, 2004; Levin et al., 1991; Bedard et al., 2002; Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli 2002; Durston, et al., 2002; Huzinga, Dolan, & van der Molen, 2006; Vander Wildenberg & Van der Molen, 2004; Welsh, Pennington, & Grossier, 1991;) and monitoring abilities (Anderson et al. 2001; Chelune & Baer 1986; DeLuca et al., 2003; Klenberg, Korkman, & Lahti-Nuuttila, 2001) also appear to mature during the same time period. In contrast, there is data to suggest

that many executive components—including set-shifting and inhibition— continue to develop throughout adolescence (e.g., Huzinga et al., 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004). However, it seems that these abilities are generally mature by early adolescence given that there seems to be only small increases or changes observed during mid to late adolescence (Romine & Reynolds, 2005). Interestingly, the emergence of mature executive abilities in early adolescence appears to developmentally precede the significant increase in depression observed in mid to late adolescence, thereby suggesting a possible contributory role of EF in the development of depression. As such, I will now review the data highlighting the role of EF in depression.

Executive Functioning and Depression. There has been substantial interest in examining the role of EF in depression, especially among adults. Overall, evidence indicates increased EF deficits among depressed adults (see Austin, Mitchell, & Goodwin, 2001, Veiel, 1997; Ottowitz, Dougherty, Savage, 2002 for a review). In support of the considerable role of EF in depression, a recent meta-analysis found an overall medium effect size between depression and executive abilities (Snyder, 2013). Specifically, depressed individuals often exhibit impaired monitoring such that they fail to alter their performance in response to negative feedback (Channon, 1996; Elliott et al., 1997; Henriques, Glowacki, & Davidson 1994). Similarly, depressed individuals have significant difficulty with inhibition, especially inhibiting their attention away from negative emotionally laden stimuli (Joormann, Yoon, Zetsche, 2007). Lastly, significant difficulty with perseveration (Austin et al., 1999; Alexopoulos et al., 2005) and set-shifting (Austin et al., 1999; Beats et al., 1996; Channon, 1996; Lockwood, Alexopoulos,

& van Gorp, 2002) have been observed among depressed adults with varying ages and depression severity.

Despite the overwhelming evidence of executive dysfunction among depressed adults, researchers have only recently begun to explore the EF-depression relationship in youth. Several studies have found evidence of increased perseveration and impaired set-shifting (Baune, Czira, Smith, Mitchell, & Sinnamon, 2012; Emerson, Mollet, & Harrison, 2005; Holler et al., 2013; Wilkinson & Goodyer, 2006) as well as impaired inhibition (Brooks, Iverson, Sherman, & Roberge, 2010; Cataldo, Nobile, Loursso, Battaglia & Molteni, 2006; Kyte, et al., 2005) among depressed youth. In contrast, several studies have not observed these deficits (Favre et al., 2009; Frost, Moffitt & McGee, 1987; Klimkeit, Tonge, Bradshaw, Melvin & Gould, 2011; Matthews, Coghil & Rhodes, 2008; McClure, Rogess, & Thompson, 1997). Overall, this prior work provides a necessary starting point from which to build in understanding the relationship between EF and depression in youth, including exploring whether the relationship between EF and depression mirrors that observed among adults.

Within this emerging literature, however, it is common to see small sample sizes and use of non-standardized or less widely used measures. Furthermore, some of these studies included samples of either all males or females, individuals that were primarily Caucasian, or youth with comorbid diagnoses, including anxiety and externalizing disorders. Furthermore, some studies include a broad age range that spans from middle childhood through late adolescence. Not only do these methodological limitations restrict the generalizability of the findings but they may have also contributed to the

inconsistency in findings. Notably, given the developmental nature of these constructs and the identified importance of adolescence, we would not necessarily expect the relationship between EF and depression to be equivalent in childhood and adolescence. Thus, this study extends previous research by examining this relationship in a larger sample of normative adolescents using widely used and well-validated measures of depression and EF.

In addition to the methodological limitations, it is also possible that a more proximal intervening variable can account for these inconsistent findings. That is, perhaps there is an unexplored mediator that can explain the relationship between EF and depression. In addition to its significant causal role in the depression, research has also highlighted the significant relationship between rumination and EF. As such, perhaps EF indirectly effects depression through rumination. A secondary aim of this study is to evaluate the mediating effects of rumination on the relationship between executive abilities and depression. I hypothesize that the presence of EF deficits greatly contributes to an individual's tendency to ruminate, thereby increasing one's vulnerability to experience depressed mood. As such, I now review the rumination literature, including evidence suggestive of its mediating role.

Rumination. Over the past three decades, researchers have conceptualized rumination as a key risk factor for depression. Thought of as the tendency to passively and repetitively dwell on feelings of distress, rumination is one of the most consistent predictors of depression (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Although

initially evaluated in relation to depression in adults, rumination is well documented among youth (Rood et al., 2009). In addition to its concurrent relationship with depression (Abela, Aydin & Auerbach, 2007; Broderick & Korteland, 2004; Dancho, 2004; Hankin, 2008; Kuyken, Watkins, Holden, & Cook, 2006), rumination predicts both the onset and the duration of depressive episodes in adolescents (Abela et al., 2007; Broderick & Kortland, 2004; Burwell & Shirk, 2007; Driscoll, 2004; Hankin, 2008; Nolen-Hoeksema, Stice, Wade & Bohon, 2007). Higher levels of rumination are also associated with more severe levels of depressive symptoms among depressed adolescents (Kuyken, et al., 2006). Overall, rumination serves as a significant risk factor for depression in adolescents in a manner similar to that seen in adults.

Akin to depression, adolescence is critical time for the development and presentation of rumination. Of note, Rood and colleagues (2009) contend that the phenomenology of rumination may be different in childhood compared to adolescence and adulthood; that it is not until adolescence that youth develop this tendency to ruminate seen throughout adulthood. In support of this are data suggesting that although rumination is a consistent predictor of depression among adolescents and adults, this is not observed among children (Rood et al., 2009). Furthermore, the magnitude of the relationship between these constructs does not mimic that observed in adults until adolescence (Aldao, Nolen-Hoeksema, & Schwizer, 2010; Rood et al., 2009). From this, it is seems that developmental factor may be contributing to the shift in rumination seen from childhood to adolescence.

In addition to the change in the consequences to ruminative thought, adolescents also experience a marked increase in rumination. In fact, the amount of rumination observed in children is significantly lower than the amount observed throughout the rest of the lifespan (Rood et al., 2009). Ruminative behaviors increase in preadolescence, with levels continuing to rise across adolescence (Hampell & Peterson, 2005) and remaining high throughout adulthood (Rood et al., 2009). Evidence also suggests that increases in ruminative thought developmentally precede the normative increase in depressive symptoms. Specifically, largest developmental increase in ruminative though occurs in 10-12 year-olds (Jose & Brown, 2008), which precedes the developmental increase in depression observed between the ages of 13-18 (Hankin et al., 1998; Weissman et al., 1997). Further substantiating this progression, work by Abela and Hankin (2011) suggests that the increase in rumination observed during early and middle adolescence predicts the development of depression in late adolescence; this finding remained even after controlling for autoregressive factors (i.e., current symptoms and previous depressive episodes). Thus, rumination appears to developmentally precede and contribute to the increases in depression seen in late adolescence.

Given the highly cognitive nature of rumination, researchers have recently begun to focus on elucidating the neuropsychological correlates of rumination. In their recent review, Nolen-Hoeksema and colleagues (2008) posit that examining the cognitive precipitants to rumination, including EF, is the next step in understanding the development of and individual differences in rumination. In response to this, there has been an increased focus on exploring the role of EF in rumination, with promising results.

I will now review the theoretical and empirical work highlighting the neuropsychological underpinnings of ruminative thought.

Executive Functioning and Rumination. An examination of the current conceptualizations of rumination underscores its many similarities with EF. Davis and Nolen-Hoeksema (2000) characterized rumination as a manifestation of perseveration. In support of this conceptualization, research suggests that people do get "stuck" in the process of rumination; once they begin, it is difficult to disengage from further rumination (Papageorgiou & Wells, 2001; 2003). Some have even described ruminators as having a "sticky mind" such that they get stuck in the ruminative process (Altamirano et al., 2010). From this, it seems that these "sticky minded" individuals are unable to shift to an alternative thought process, thereby highlighting the similarity of this conceptualization with set-shifting.

Nolen-Hoeksema and colleagues (2008) also underscore the parallels between rumination and the EF component of inhibition. Specifically, they posit that individuals ruminate due to difficulty inhibiting their tendency to engage in this negative repetitive thought process when experiencing distressing feelings or stressors. This notion is furthered by findings indicating that that ruminators struggle to inhibit their prepotent ruminative response in the face of stressors or feelings of sadness (Lybuomirsky, Tucker, Caldwell, & Berg 1999). Lastly, work by Lyubomirsky and colleagues (1993; 1999) also support the similarities between rumination and the executive component of monitoring. In particular, individuals often ruminate in order to cope with negative emotions or experiences, despite the fact that rumination does little to actually solve or manage these

issues. In this sense, it is almost as though ruminators struggle to monitor the results of this process and recognize its unproductivity.

Additionally, studies specifically employing measures of EF indicate an association between EF and rumination. In one of the earliest studies using the Wisconsin Card Sorting Task, Davis and Nolen-Hoeksema (2000) demonstrated that ruminators committed significantly more perseverative errors than non-ruminators. Similarly, an association between rumination and set-shifting deficits has been indicated in more recent studies (Atlamirano et al., 2010; Connolly et al., 2014; De Lissynder, Koster, Derakshan, & Raedt, 2010; Whitmer & Branich, 2007). Empirical work also supports a relationship between rumination and inhibition such that individuals with a higher tendency to ruminate demonstrated impaired inhibition of irrelevant or interfering stimuli (Joormann, 2006; Joormann & Gotlib, 2010; De Lissynder, et al., 2010; Philippot & Brutoux, 2008; Watkins & Brown, 2002; Whitmer & Branich, 2007). Despite the theoretical overlap, no study to date has evaluated the relationship between rumination the executive component of monitoring.

Though research examining the association between rumination and EF provides promising results, there is a paucity of research examining this association from a developmental perspective. In the earliest study, Wilkinson & Goodyer (2006) did not find significant association between set-shifting and rumination. However, Connolly and colleagues (2014) more recently found set-shifting deficits among normative adolescents with higher levels of rumination. Their results suggested that rumination, but not depression, prospectively predicted increased set-shifting difficulties. Interestingly, the

reverse did not hold; more EF difficulties were not predictive of increased rumination or depression.

Despite promising results, this body of work presents several limitations in terms of supporting a relationship between rumination and EF. First, the extant literature exploring the relationship between rumination and EF in youth (i.e., Connolly et al., 2014; Wilkinson & Goodyer, 2006) has only utilized one measure of EF, the Test of Everyday Attention for Children (Manly et al., 2001). While this measure has been demonstrated to have good reliability and validity for use with children (Heaton et al., 2001; Manly et al., 2001), it does not permit a direct comparison with findings from studies that have utilized other well-known measures of EF used in prior studies (e.g., WCST, Trails A and B, Stroop task). Specifically, this measure does not permit direct comparison with adult studies given its developmentally limited nature. Thus, this study seeks to expand upon the existing literature by examining the relationship between rumination and EF in a normative sample of adolescents utilizing measures that, while developmentally sensitive, are directly comparable to those used in the adult literature.

Further, many of these studies linking EF and rumination have utilized a sample of depressed individuals. Given the significant EF-depression relationship, use of a depressed sample precludes researchers from examining the unique relationship between EF and rumination; it does not allow us to examine whether rumination is uniquely associated with EF, independent of depression. However, initial longitudinal data suggests a unique relationship between EF and rumination (Connolly et al., 2014). Furthermore, much of the current data precludes us from examining whether the EF-

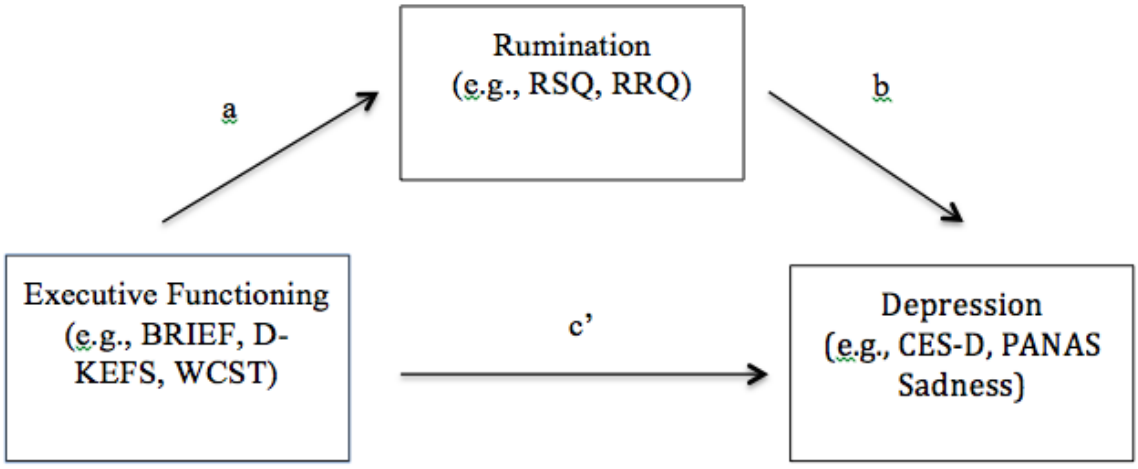
rumination relationship resembles that of EF and depression, including whether the same executive subdomains implicated in depression are also seen in rumination. Underscoring the need to explore this concept is concurrent work by Altamirano and colleagues (2010) demonstrating specificity in the EF-rumination and EF-depression relationships among young adults. As such, we hope to further clarify the specific relationships between EF, rumination, and depression in adolescence. Additionally, no known study has explored the impact of rumination on the EF-depression relationship. The current study will be the first of our knowledge to explore the possible mediating role of rumination.

The present study

The present study sought to examine the relationship between executive functioning, rumination and depression in a sample of normative adolescents. Specifically, an adolescent sample was selected due to the importance of adolescence is in the development of rumination, depression and the relationship between the two (Hankin et al., 1998; Weisman et al., 1997; Abela & Hankin, 2011). Although an association between executive abilities and both rumination and depression has been observed among depressed youth, further exploration of the nature of these relationships in a normative sample is needed. A secondary goal of this study was to examine the mediating effects of rumination on the relationship between EF and depression. Given the aims of the current study, I tested the following hypotheses: First, greater levels of executive dysfunction will be associated with higher levels of depressive symptomatology. This includes a greater degree of deficits in set-shifting, inhibition, monitoring and perseveration. Secondly, higher levels of executive dysfunction will also

be associated with higher levels of rumination. Lastly, I hypothesized that rumination mediates the relationship between executive functioning and depressive symptomatology (see Figure 1).

Figure 1. *Mediational model examining the impact of rumination on the association between EF and depressive symptoms.*



CHAPTER 2

METHOD

Participants

Eighty-six adolescents participated in the study. The adolescents were in the 11th or 12th grade and between the ages of 16-18 (M = 17.77, SD = .46); 64% of the adolescents were female. The sample was 84.9% Caucasian, 5.8% African American, 4.7% Biracial, 2.3% Hispanic, and 2.3% other. Twenty-three adolescents (26.7%) reported a previous cognitive evaluation, with the majority of these evaluations (95.65%) occurring prior to beginning high school. No histories of learning disorders were reported. Ten adolescents (11.6%) reported a history of a traumatic brain injury (TBI) and/or concussion. Of these ten individuals, only four individuals reported experiencing a TBI within the past year. Ten adolescents reported a history of medical conditions, including asthma (60%), a previous history of seizures (20%), chronic pain (10%) and a chronic cardiac condition (10%). Twelve adolescents (14%) reported a history of being diagnosed with a mental health disorder, including depression, ADHD and anxiety. Twelve adolescents (14%) reported currently taking medications, including stimulants (e.g., Aderall), antidepressants (e.g., Zoloft, Prozac), antibiotics (e.g., Amoxicillin, Doxycycline), and asthma medications (e.g., Dulera, Symicort).[1]

[1] Given the identified impact of medication and history of TBI on cognitive performance, we evaluated whether history of cognitive evaluations, TBI, medical conditions, and current medication status were significantly associated with any of the study variables. None of these variables were significantly related to any of the study variables (p's > .5).

Procedure

Participants were recruited within their high school via announcements made in their classrooms and were asked to participate in a two-part study about how cognition, thoughts and feelings impact one another. Interested adolescents were given more information about the study, including letters to their parents and both assent and consent forms. Prior to participation, written consent was obtained for interested participants over 18 years old and both adolescent assent and parental consent was obtained for those under 18 years old. Participants completed self-report questionnaires; upon completion of these questionnaires, they then completed the assessments.[2] Trained graduate students administered the assessments during participants' homeroom, study hall or lunch period. The assessments were conducted in a quiet, private space within their school library. The average time between completing the self-report questionnaires was 14 days (M = 14.71, SD = 20.46). Upon completion of the study, participants were entered into a raffle to win one of two $50 gift cards the end of the study. The study received ethics approval in advance by the Kent State University Institutional Review Board.

Measures[3]

Demographic Information. Participants completed a questionnaire regarding their age, gender, race and other general personal information.

The *Centers for Epidemiological Studies Depression Scale* (CES-D; Radloff,

[2] Participants completed all self-report questionnaires except the BRIEF-SR before completing the assessments. The BRIEF-SR was completed at the time of assessments.
[3] See Appendix A for self-report questionnaires

1977). The CES-D is a widely used 20-item self-report measure of depressive symptoms, with higher scores reflecting higher symptomatology. Participants rated their depressive symptoms over the past week using a four-point Likert scale from "rarely or none of the time" to "most or all of the time." Sample questions include "I felt sad" and "I was bothered by things that don't usually bother me." The CES-D has been shown to have good internal consistency (α= .75-.89) and validity (Radloff, 1997; Myers & Winters, 2002). Cronbach's alpha was .92 in the current study.

The *Positive and Negative Affect Schedule-X; Sadness Subscale* (PANAS-X; Watson & Clark 1994). The PANAS-X is a widely used self-report measure that assesses levels of various positive and negative affective states. The PANAS-X is an extended version of the original PANAS allowing for the creation of specific affect subscales through the inclusion of additional items. A subset of six items from the PANAS-X were selected to permit the creation of a sadness subscale. Participants rated the extent to which they experienced each of the affective states using a four-point Likert scale from "very slightly or not at all" to "extremely." The PANAS-X has been shown to have good internal consistency (α= .85-.90) (Watson & Clark, 1994). Cronbach's alpha for the sadness subscale was .87 in the current study.

The *Response Styles Questionnaire* (RSQ; Nolen-Hoeksema & Morrow, 1991). The RSQ is a 25-item self-report measure that assesses the tendency to ruminate. Participants indicated how often they agree with various statements during times when they feel sad or depressed using a four-point Likert scale from "almost never" to "almost

always," with higher scores reflective of a higher tendency to ruminate. The RSQ is the most widely used measure of rumination and has demonstrated high internal consistency (α= .80-.92) in a number of studies with youth (Broderick & Korteland, 2004; Burwell & Shirk, 2007; Hong, et al., 2010; Jose & Brown, 2008; Kuyken, Watkins, Holden & Cook, 2006; Nolen-Hoeksema, et al., 2007; Schwartz & Koenig, 1996). Cronbach's alpha was .94 in the current study.

The *Rumination-Reflection Questionnaire* (RRQ; Trapnell & Campbell, 1999). The RRQ is a 24-item self-report measure that assesses one's tendency to engage in self-reflective and self-ruminative thought. Sample questions include "I tend to "ruminate" or dwell over things that happen to me for a really long time afterward" (rumination) and "I love exploring my inner self" (reflection). Participants indicated their level of agreement with statements using a five-point Likert scale from "strongly disagree" to "strongly agree," with higher scores reflective of a higher levels of rumination. The RRQ has demonstrated good internal consistency (α=.90) and validity (Trapnell & Campbell, 1999). Cronbach's alpha was .91 in the current study.

The *Behavior Rating Inventory of Executive Function- Self Report; Shifting, Monitoring and Inhibition scales* (BRIEF-SR; Guy, Gioia, & Isquith, 2004). The BRIEF-SR is an 86-item self-report questionnaire of executive functioning for youth ages 5-18. Individuals reported on their executive abilities, including abilities related to shifting, monitoring and inhibition. Sample questions include "I get stuck on one topic of activity" (shifting), "I forget what I am doing in the middle of things" (monitoring), and "I interrupt others" (inhibition). Scores yielded T-scores, with higher T-scores indicative of

more executive dysfunction. The BRIEF-SR has good internal consistency (α= .80-.98) and test-retest reliability (Guy et al., 2004). In the current study, Cronbach's alphas for the Shifting, Monitoring and Inhibition scales were .76, .43, and .81, respectively.

The *Wisconsin Card Sorting Test* (WCST; Heaton, Chelune, Talley, Kay & Curtiss, 1993). The WCST is a widely used test of executive functioning. Participants were initially presented with four key cards that varied in stimulus characteristics (e.g., red triangle, green stars, yellow crosses, and blue circles). Drawing from the response deck, individual were instructed to match consecutive cards to one of the four key cards, wherever he or she thinks it ought to go. The response deck contained cards that had the same three dimensions as the key cards but varied in color (red, green, yellow, or blue), in number (one to four), and in form (triangles, stars, crosses, or circles). Participants were instructed whether each response is right or wrong; he or she was never told the correct sorting principle or that the category of correct response changes. The object of the test was to sort cards according to each principle (i.e., color, form, number). The cards must be sorted correctly to each principle in order to complete the task successfully. The participant continued with the task until all the cards were correctly sorted according to all six categories or ran out of cards. Estimates of set-shifting include perseverative errors and number categories completed (number of successful switches completed). Non-perseverative errors were also examined in order to examine whether results were due to difficulties with set-shifting (i.e., higher perseverative errors) or other cognitive impairments independent of set-shifting (i.e., more non-perseverative errors). With the exception of categories completed, results yielded T-scores. Lower scores are reflective

of more difficulty. The WSCT has good reliability and validity in use with youth (Heaton et al., 1993).

The *Delis Kaplan Executive Function System*, *selected subtests*. (D-KEFS; Delis, Kaplan, & Kramer, 2001). The D-KEFS is a widely used and well-normed measure of battery of executive functioning tests for individuals age 8-89. The D-KEFS includes subtests to specifically measure inhibition, set-shifting and perseveration, and monitoring. In the Verbal Fluency task, participants generated as many words possible based on semantic or phonemic similarities in 60 seconds. They then generated words, alternating between two semantic categories (e.g., vegetables and type of cars) in sixty seconds. The Trail-Making task is a version of the widely used Trail Making Task, parts A and B (Reitan & Wolfson, 1985). Participants were asked to connect a series of numbers as quickly as possible. They were then asked to alternate between connecting numbers and letters. In the Design Fluency task, participants were presented with squares filled with an array of dots and were asked to create unique designs by connecting filled dots, empty dots, and alternating between filled and empty dots. Lastly, the Color-Word Inhibition test is an alternative of the Stroop task. Participants first read the color words written on the page. They were then asked to inhibit a dominant or automatic response (e.g., reading the word written) in favor of another (stating the ink color of that word). Their responses yielded contrast scores, which quantify performance on higher-level, more executive tasks relative to more baseline tasks (e.g., Trail-Making switching task versus number sequencing, Color-Word inhibition versus color word reading). The various subtests of the D-KEFS have good internal consistency (α= .62-.92) and test-retest reliability (Delis

et al., 2001).

The Wide Range Achievement Test, 4th edition, *Reading Subtest* (WRAT-4-Reading; Wilkinson & Robertson, 2006). The Reading subtest of the WRAT-4 is a standardized measure of achievement for individuals aged 5-64. For the reading subtest, participants read single words audibly. The number of words read correctly determines an individual's score. Reading scores have been shown to give an estimate of premorbid cognitive abilities (see Baade, Heinrichs, Coady, & Stropes, 2010) and will be administered as a way to control for the impact of intellectual ability on the constructs of interest. The WRAT-4 Reading has good internal consistency (α= .93-.96) and test-retest reliability (Wilkinson & Robertson, 2006).

Power Analysis

Power was estimated using the G*Power 3 program (Faul, Erdfelder, Lang, & Butcher, 2007). Assuming a Type I error rate (α) of .05 and Type II error rate (β) of .80, power was measured using standardized effect sizes of Cohen (1988). Power was assessed for the maximum number of predictors in the hypotheses, which was four (three control variables and one predictor). The total number of participants in this study was 85. Given this, the power to detect a small effect (f^2= .02) was .36, a medium effect (f^2 = .15) was .97, and a large effect was .99.

CHAPTER 3

DATA ANALYTIC PLAN

To test the first two hypotheses examining whether difficulties with EF was independently associated with higher levels of depressive symptomatology and rumination, a series of separate hierarchical linear regressions were conducted. Covariates for each regression model were entered at step one. At step two, estimates of EF, as measured by the BRIEF, D-KEFS, and WCST, served as predictor variables in separate regression models. In the first set of analyses, scores from the CES-D and PANAS Sadness subscale served as the dependent variables. In the second set of analyses, RSQ rumination and RRQ rumination served as dependent variables.

Due to the large number of statistical tests, I reported the traditional p-value as well as whether this p-value remains significant ($p < .05$) after adjustment for alpha inflation. Specifically, the False Discovery Rate (FDR) was used to adjust for alpha inflation. The false discovery rate is preferable over other methods of protecting against Type I errors (e.g., Bonferroni correction, sequential Bonferroni correction) due to its utility at controlling for the possibility of Type I errors (or false discoveries) without sacrificing statistical power to detect true effects (Benjamini & Hochberg, 1995). In particular, the Bonferroni correction controls for the chance of making even a single false discovery, thereby decreases the power to detect all but strong effects and increases the chances of committing a Type II error (Verhoeven, Simonsen & McIntyre, 2005). As an

alternative, the FDR controls for the expected proportion of Type I errors, permitting a more powerful way of controlling for false discoveries while retaining an accurate family-wise error rate. Storey (2002; 2003) designed a procedure for applying and interpreting the FDR in which a significance threshold, or q-value, is derived for each individual hypothesis test. Similar to the p-value, the q-value quantifies whether an individual hypothesis test within a larger family of tests can be considered significant given an expected proportion of false discoveries. For example, a q-value of .05 signifies that the expected proportion of false discovery rate for that hypothesis is less than 5% and that the observed significant effect is not likely to be a false discovery. In this study, an estimate was only be interpreted as significant if both the p-value for that estimate was less than .05 as well as the corresponding q-value for that estimate was also less than .05.

A secondary goal of this study was to examine the impact of rumination on the relationship between EF and depression. As such, a meditational model was used. Specifically, a bootstrapping method to test for mediation was used (Hayes, 2009; Mackinnon, Lockwood & Williams, 2004). This method is preferable to other meditational methods due to providing more accurate confidence estimates of indirect effects, thereby minimizing Type I error, and not requiring a normally distributed sampling distribution of the indirect effect. This method involved a non-parametric method of repeated re-sampling with replacement. In terms of mediation, a 95% confidence interval was constructed around the point estimate of the indirect effect. There was evidence of significant mediation if zero was not included in this confidence interval. These analyses were conducted using an extension of the SPSS Process macro

(Precher & Hayes, 2004) for Stata, which simultaneously tested for meditational effects as well as provided estimates of statistical significance of the mediated effect, including the Sobel test and corresponding bootstrapped results.

CHAPTER 4

RESULTS

Preliminary Analyses

The dataset was constructed by the primary investigator. The analyses were performed using IBM SPSS 20 (SPSS Inc., 2011) and Stata 11 (StataCorp, 2009).

*Normality***.** Preliminary analyses were conducted to assess for normality, linearity, outliers in the data. Descriptive information for the variables of interest is presented in Table 1. In order to assess for the presence of multicollinearity, correlations between variables of interest were examined; these correlations can be found in Table 2.

Table 1. *Descriptive Statistics of Study Variables.*

Variables	Mean	SD	Range
CES-D	35.45	11.19	21.00-75.00
PANAS Sadness	10.13	4.80	6.00-29.00
RSQ Rumination	48.25	16.50	25.00-92.00
RRQ Rumination	41.40	9.92	16.00-60.00
D-KEFS Trails Contrast Score	9.79	0.25	3.00-19.00
D-KEFS Verbal Fluency Category Contrast Scaled Score	9.55	0.34	4.00-19.00
D-KEFS Verbal Fluency Switching Contrast Scaled Score	9.16	0.38	1.00-17.00
D-KEFS Design Fluency Contrast Scaled Score	10.36	0.30	5.00-18.00
D-KEFS Color Word Contrast Scaled Score	11.21	0.21	7.00-17.00
BRIEF Inhibition T-Score	52.32	10.15	37.00-85.00
BRIEF Shifting T-Score	55.82	10.31	34.00-83.00
BRIEF Monitoring T-Score	48.90	9.31	37.00-80.00
WCST Perseverative Errors T-Score	58.28	9.01	20.00-73.00
WCST Categories Completed	5.86	.67	1.00-6.00
WCST Non-Perseverative T-Score	56.44	7.61	29.00-69.00

Table 2. *Bivariate Correlations between Major Study Variables.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. CES-D	--												
2. PANAS Sadness	.72**	--											
3. RSQ Rumination	.70**	.69**	--										
4. RRQ Rumination	.48**	.56**	.67**	--									
5. D-KEFS Trails Switching Contrast Score	-.03	-.13	.02	.07	--								
6. D-KEFS Verbal Fluency Switching Contrast Score	.12	.04	.06	.03	-.06	--							
7. D-KEFS Design Fluency Contrast Scaled Score	-.10	-.03	-.13	-.04	.03	-.05	--						
8. D-KEFS Color Word Contrast Scaled Score	-.06	-.05	-.10	-.05	.07	.19	.09	--					
9. BRIEF Inhibition	.20	.32**	.23*	.23*	.01	.01	-.12	-.07	--				
10. BRIEF Shifting	.36**	.41**	.38**	.41**	-.04	-.04	.20	.01	.16	--			
11. BRIEF Monitoring	.19	.31**	.17	.25*	-.06	-.11	-.08	-.04	.27*	.27*	--		
12. WCST Perseverative Errors	-.22	-.28**	-.17	-.11	.18	.16	.12	.27*	-.13	-.13	-.09	--	
13. WCST Non-Perseverative	-.07	-.16	<-.01	.05	.12	.05	-.02	.02	-.09	-.08	-.19	.50**	--
14. WCST Categories Completed	-.08	-.20	-.11	.14	.25*	.05	.19	.13	.04	.04	.01	.64**	.25*

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

Gender. Given the well-documented relationship between gender and several study variables of interest (e.g., depression (Nolen-Hoeksema, 2001), rumination (Rood et al., 2009)), differences in the study variables by gender were explored. There was a trend towards females (M = 36.99, SD = 12.24) having higher rates of depression scores than males (M = 32.70, SD = 8.56), $t(84) = -1.73$, $p = .09$. Gender was unrelated to all other study variables. Given these results, gender was included as a covariate in all regression models.

Age. Participants ranged from 16 to 18 years old (M = 17.77, SD = 0.46). Given the developmentally sensitive nature of current constructs, differences in the study variables by age were explored. Results revealed that there were significant differences in WCST Perseverative Errors (β = -.25, $p < .05$), and D-KEFS Verbal Fluency Category Switching (β = -.24, $p < .05$) by age. Age was unrelated to all other study variables. Given these results, age was included as a covariate in all of the regression models.

Ethnicity. The sample was 84.9% Caucasian, 5.8% African American, 4.7% Biracial, 2.3% Hispanic, and 2.3% Other. Given the number of individuals in each minority group, there was not enough statistical power to detect differences between each group using an ANOVA. Therefore, two groups were formed: a majority group that included Caucasian individuals and a general minority group that included the remaining participants. Differences between the two groups were explored using t-tests and no significant differences were found between the majority and minority group.

WRAT Reading. Given evidence suggesting a significant relationship between IQ executive functioning (Ardilla, Pineda, & Rosselli, 2000; Dempster, 1991), differences in

study variables by WRAT Reading Scores were examined. WRAT Reading scores were significantly positively associated with WCST Perseverative Errors (β = .07, p < .01). There was also a trend towards WRAT Reading scores being significantly positively associated with D-KEFS Verbal Fluency Category Switching (β = .03, p = .09). WRAT Reading scores were unrelated to all other study variables. Given these results, WRAT Reading Score were included as a covariate in all regression models.

Other Demographic Variables. All other demographic variables were unrelated to study variables (p >.10).

Main Hypotheses

Hypothesis 1: Greater levels of executive dysfunction will be associated with higher levels of depressive symptomatology.

To explore whether EF difficulties were associated with higher levels of depressive symptomatology, I explored whether measures of EF were associated with of depressive symptomatology, as measured by the CES-D and PANAS Sadness. As stated previously, gender, age and WRAT Reading scores were entered as covariates. Results suggested that the EF components of perseveration, set-shifting and monitoring difficulties were most consistently related to higher levels of depressive symptomatology. Specifically, BRIEF Shifting was significantly related to higher levels of both CES-D depression (p < .01; See Table 3) and PANAS Sadness (p < .01; See Table 3). BRIEF Monitoring was also significantly associated with of higher levels of sadness as measured by the PANAS-S (p < .01; See Table 4) and there was a trend towards a significant association with CES-D depression (p < .05; See Table 4). BRIEF Inhibition was

significantly related to higher levels of PANAS Sadness ($p < .01$; See Table 5) but was unrelated to CES-D depression ($p > .05$; See Table 5). In terms of the Wisconsin Card Sort, more perseverative errors were seen among higher levels of CES-D depression ($p = .01$; See Table 6) and PANAS Sadness ($p < .01$; See Table 6). Similarly, the number of categories completed was negatively related to PANAS Sadness ($p < .05$; See Table 7) but was unrelated to CES-D depression ($p > .10$; See Table 7). Non-perseverative errors was not significantly associated with either CES-D depression or PANAS Sadness ($p > .08$; See Tables 8). Finally, none of D-KEFS contrast scores were significantly associated with of depressive symptoms (all p's > .23; See Tables 9 - 12).

Table 3. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from BRIEF Shifting.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	20.94	54.05		.39	.70	1.48(3,81)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.23	2.83	.01	.08	.94	
	Gender	-4.69	2.57	-.20	-1.82	.07	
Step 2	Constant	-12.62	51.78		-.24	.81	4.15(4,80)
	WRAT Reading Score	.11	.09	.14	1.28	.21	$\Delta R^2 = .12$
	Age	.94	2.68	.04	.35	.73	
	Gender	-.4.59	2.42	-.20	-1.90	.06	
	BRIEF Shifting	.38	.11	.35	3.40	$<.01^+$	
PANAS-S							
Step 1	Constant	19.24	23.90		.81	.42	.28(3,80)
	WRAT Reading Score	.01	.04	.01	.12	.91	
	Age	-.52	1.25	-.05	-.42	.68	
	Gender	-.81	1.13	-.08	-.72	.48	
Step 2	Constant	1.20	22.47		.09	.93	4.03(4,79)
	WRAT Reading Score	.01	.04	.01	.13	.90	$\Delta R^2 = .16$
	Age	-.14	1.16	-.01	-.12	.91	
	Gender	-.80	1.05	-.08	-.76	.45	
	BRIEF Shifting	.19	.05	.40	3.89	$<.01^+$	

$^+$ Remains significant after FDR

Table 4. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from BRIEF Monitoring.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	20.94	54.05		.39	.70	1.48(3,81)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.23	2.84	.01	.08	.94	
	Gender	-4.69	2.57	-.20	-1.82	.07	
Step 2	Constant	-22.70	57.33		-.40	.69	2.16(4,80)
	WRAT Reading Score	.15	.09	.19	1.63	.11	$\Delta R^2 = .05$
	Age	1.73	2.88	.07	.60	.55	
	Gender	-4.97	2.53	-.21	1.97	.05	
	BRIEF Monitoring Score	.27	.13	.22	2.01	$<.05^{+}$	
PANAS-S							
Step 1	Constant	19.24	23.90		.81	.42	.28(3,80)
	WRAT Reading Score	.01	.04	.01	.12	.91	
	Age	-.52	1.25	-.05	-.42	.68	
	Gender	0.81	1.13	-.08	-.72	.48	
Step 2	Constant	-8.61	24.49		-.35	.73	2.58(4,79)
	WRAT Reading Score	.03	.04	.08	.72	.48	$\Delta R^2 = .11$
	Age	.43	1.23	.04	.35	.73	
	Gender	-.98	1.08	-.10	-.91	.37	
	BRIEF Monitoring Score	.17	.06	.34	3.06	$<.01^{+}$	

$^{+}$ Remains significant after FDR

Table 5. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from BRIEF Inhibition.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	20.94	54.05		.38	.70	1.48(3,81)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.23	2.84	.01	.08	.94	
	Gender	-4.69	2.57	-.20	-1.82	.07	
Step 2	Constant	-2.81	55.16		-.05	.96	1.88(4,80)
	WRAT Reading Score	.12	.09	.14	1.26	.21	$\Delta R^2 = .03$
	Age	.94	2.84	.04	.33	.74	
	Gender	-4.44	2.55	-.19	-1.74	.09	
	BRIEF Inhibition Score	.21	.12	.19	1.72	.09	
PANAS-S							
Step 1	Constant	19.24	23.90		.81	.42	.28(3,80)
	WRAT Reading Score	.01	.04	.01	.12	.91	
	Age	-.52	1.25	-.05	-.42	.68	
	Gender	-.81	1.13	-.08	-.72	.48	
Step 2	Constant	1.01	23.68		.04	.97	2.38(4,79)
	WRAT Reading Score	.01	.04	.02	.19	.85	$\Delta R^2 = .10$
	Age	.04	1.21	<.01	.04	97	
	Gender	-.67	1.08	-.07	-.62	.54	
	BRIEF Inhibition Score	.15	.05	.32	2.93	$<.01^{+}$	

$^{+}$ Remains significant after FDR

Table 6. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from WCST Perseverative Errors*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	18.45	53.26		.35	.73	1.52(3,82)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.38	2.79	.02	.14	.89	
	Gender	-4.77	2.55	-.21	-1.87	.06	
Step 2	Constant	53.32	53.32		1.00	.32	2.85(4,81)
	WRAT Reading Score	.18	.09	.22	1.88	.06	$\Delta R^2 = .07$
	Age	-.79	2.74	-.03	-.29	.77	
	Gender	-4.88	4.46	-.21	-1.98	.05	
	WCST Perseverative Errors	-.35	.14	-.48	-2.56	$.01^{+}$	
PANAS-S							.29(3,81)
Step 1	Constant	20.60	23.55		.87	.38	
	WRAT Reading Score	.01	.04	.02	.13	.90	
	Age	-.60	1.23	-.06	-.49	.63	
	Gender	-.77	1.12	-.08	-.68	.50	
Step 2	Constant	37.77	23.16		1.63	.11	2.53(4,80)
	WRAT Reading Score	.04	.04	.11	.92	.36	$\Delta R^2 = .10$
	Age	-1.17	1.19	-.11	-.98	.33	
	Gender	-.85	1.07	-.09	-.79	.43	
	WCST Perseverative Errors	-.18	.06	-.34	-3.02	$<.01^{+}$	

$^{+}$ Remains significant after FDR

Table 7. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from WCST Categories Completed.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	18.48	53.26		.35	.73	1.52(3,82)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.38	2.79	.02	.14	.89	
	Gender	-4.77	2.55	-.21	-1.87	.06	
Step 2	Constant	40.69	55.47		.73	.47	1.61(4,81)
	WRAT Reading Score	.13	.09	.16	1.37	.18	$\Delta R^2 = .02$
	Age	-.11	2.80	<-.01	-.04	.97	
	Gender	-5.49	2.59	-.24	-2.12	.04	
	WCST Categories Completed	-2.52	1.86	-.15	-1.36	.18	
PANAS-S							
Step 1	Constant	20.60	23.55		.87	.38	.29(3,81)
	WRAT Reading Score	.01	.04	.02	.13	.90	
	Age	-.60	1.23	-.06	-.49	.63	
	Gender	-.77	1.12	-.08	-.68	.50	
Step 2	Constant	36.41	24.05		1.51	.13	1.48(4,80)
	WRAT Reading Score	.01	.04	.04	.35	.73	$\Delta R^2 = .06$
	Age	-.95	1.21	-.09	0.78	.44	
	Gender	-1.28	1.12	-.13	-1.14	.26	
	WCST Categories Completed	-1.79	.80	-.25	-2.24	$.03^{+}$	

$^{+}$ Remains significant after FDR

Table 8. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from WCST Non-perseverative Errors.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	18.45	53.26		.35	.73	1.52(3,82)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.38	2.79	.02	.14	.89	
	Gender	-4.77	2.55	-.21	-1.87	.06	
Step 2	Constant	32.37	54.82		.59	.56	1.42(4,81)
	WRAT Reading Score	.13	.09	.16	1.38	.17	$\Delta R^2 = .01$
	Age	.05	2.81	<.01	.02	.99	
	Gender	-5.00	2.55	-.22	-1.96	.05	
	WCST Non-perseverative Errors	-.17	.16	-.12	1.06	.29	
PANAS-S							
Step 1	Constant	20.60	23.55		.87	.38	.29(3,81)
	WRAT Reading Score	.01	.04	.02	.13	.90	
	Age	-.60	1.23	-.06	-.49	.63	
	Gender	-.77	1.12	-.08	-.68	.50	
Step 2	Constant	29.48	23.84		1.23	.22	.96(4,80)
	WRAT Reading Score	.02	.04	.05	.45	.65	$\Delta R^2 = .04$
	Age	-.79	1.22	-.08	-.65	.52	
	Gender	-.97	1.12	-.10	-.87	.39	
	WCST Non-perseverative Errors	-.12	.07	-.19	-1.72	.09	

Table 9. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from D-KEFS Trails Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							1.52(2, 82)
Step 1	Constant	18.44	53.26		0.35	0.73	
	WRAT Reading Score	0.12	0.09	0.14	1.23	0.22	
	Age	0.38	2.79	0.02	0.14	0.89	
	Gender	-4.77	2.55	-0.21	-1.87	0.06	
							1.19(4, 81)
Step 2	Constant	21.23	53.81		0.40	0.69	$\Delta R^2 < .01$
	WRAT Reading Score	0.12	0.09	0.14	1.24	0.22	
	Age	0.37	2.80	0.02	0.13	0.90	
	Gender	-4.89	2.57	-0.21	-1.90	0.06	
	D-KEFS Trails Switching Contrast	-0.28	0.58	-0.05	-0.49	0.63	
PANAS-S							
Step 1	Constant	20.60	23.55		0.87	0.38	.29(3,81)
	WRAT Reading Score	0.01	0.04	0.02	0.13	0.90	
	Age	-0.60	1.23	-0.06	-0.49	0.63	
	Gender	-0.77	1.12	-0.08	-0.68	0.50	
Step 2	Constant	24.28	23.67		1.02	0.31	.67(4,80)
	WRAT Reading Score	0.01	0.04	0.02	0.15	0.88	$\Delta R^2 = .02$
	Age	-0.65	1.23	-0.06	-0.53	0.60	
	Gender	-0.88	1.12	-0.09	-0.78	0.44	
	D-KEFS Trails Switching Contrast	-0.31	0.25	-0.14	-1.22	0.23	

Table 10. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from D-KEFS Verbal Fluency Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	18.44	53.36		.35	.73	1.52(3,82)
	WRAT Reading Score	.12	.09	.14	1.23	.22	
	Age	.38	2.79	.02	.14	.89	
	Gender	-4.77	2.55	-.21	-1.87	.06	
Step 2	Constant	12.19	54.59		.22	.82	1.21(4,18)
	WRAT Reading Score	.11	.10	.13	1.12	.27	$\Delta R^2 < .01$
	Age	.66	2.84	.03	.23	.82	
	Gender	-4.50	2.60	-.19	-1.73	.09	
	D-KEFS VF Switching Contrast	.23	.39	.07	.57	.57	
PANAS-S							
Step 1	Constant	20.60	23.55		.87	.38	.29(3, 81)
	WRAT Reading Score	.01	.04	.02	.13	.90	
	Age	-.61	1.23	-.06	-.49	.63	
	Gender	-.77	1.12	-.08	-.68	.50	
Step 2	Constant	20.19	24.12		.84	.41	.22(4, 80)
	WRAT Reading Score	.01	.04	.01	.11	.91	$\Delta R^2 < .01$
	Age	-.59	1.26	-.06	-.47	.64	
	Gender	-.75	1.15	-.08	-.65	.52	
	D-KEFS VF Switching Contrast	.02	.17	.01	.09	.93	

Table 11. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from D-KEFS Design Fluency Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	4.46	55.21		.08	.94	1.11(3,74)
	WRAT Reading Score	.09	.10	.12	.95	.35	
	Age	1.30	2.88	.06	.45	.65	
	Gender	-4.57	2.65	-.20	-1.72	.09	
Step 2	Constant	6.98	55.40		.13	.90	1.01(4,73)
	WRAT Reading Score	.09	.10	.11	.89	.38	$\Delta R^2 < .01$
	Age	1.43	2.89	.06	.50	.62	
	Gender	-4.56	2.66	-.20	-1.72	.09	
	D-KEFS DF Switching Contrast	-.41	.48	-.10	-.84	.40	
PANAS-S							
Step 1	Constant	17.88	25.13		.711	.48	.17(3,73)
	WRAT Reading Score	.<.01	.04	<-.01	-.02	.98	
	Age	-.41	1.31	-.04	-.32	.75	
	Gender	-.69	1.20	-.07	-.57	.57	
Step 2	Constant	18.23	25.32		.72	.48	.14(4,72)
	WRAT Reading Score	<-.01	.05	<-.01	-.04	.97	$\Delta R^2 < .01$
	Age	-.39	1.32	-.04	-.30	.77	
	Gender	-.68	1.21	-.07	-.56	.58	
	D-KEFS DF Switching Contrast	-.06	.22	-.03	-.27	.77	

Table 12. *Hypothesis 1: Hierarchical Multiple Regression Analyses Predicting CES-D and PANAS Sadness from D-KEFS Color Word Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
CES-D							
Step 1	Constant	22.47	53.85		.42	.68	1.55(3,81)
	WRAT Reading Score	.13	.10	.15	1.34	.19	
	Age	.07	2.84	<.01	.02	.98	
	Gender	-4.55	2.58	-.20	-1.77	.08	
Step 2	Constant	18.72	53.96		.35	.73	1.43(4,80)
	WRAT Reading Score	.15	.10	.18	1.52	.13	$\Delta R^2 = .01$
	Age	.62	2.89	.03	.21	.83	
	Gender	-4.97	2.61	-.21	-1.90	.06	
	D-KEFS CW Contrast	-.73	.71	-.12	-1.03	.31	
PANAS-S							
Step 1	Constant	21.47	23.85		.90	.37	.31(3,80)
	WRAT Reading Score	.01	.04	.02	.19	.85	
	Age	-.67	1.26	-.06	-.53	.60	
	Gender	-.72	1.14	-.07	-.63	.53	
Step 2	Constant	20.79	24.00		.87	.39	.89(4,79)
	WRAT Reading Score	.01	.04	.03	.29	.77	$\Delta R^2 < .01$
	Age	-.56	1.28	-.05	-.44	.66	
	Gender	-.80	1.16	-.08	-.70	.49	
	D-KEFS CW Contrast	-.15	.31	-.06	.49	.63	

Hypothesis 2: Higher levels of executive dysfunction will be associated with higher levels of rumination.

A series of separate hierarchical linear regressions covarying for age, gender and WRAT Reading scores were conducted to explore whether EF was significantly associated with rumination. Consistent with depression, difficulties with set-shifting were related to higher levels of rumination; however inhibition, monitoring and perseveration were not. Specifically, BRIEF Shifting was significantly associated with higher levels of RSQ rumination ($p < .01$; See Table 13) as well as RRQ rumination ($p < .01$; See Table 13). BRIEF Monitoring and Inhibition were unrelated to both RSQ and RRQ rumination (p's $> .05$, See Tables 14 - 15). Overall, scores from the Wisconsin Card Sorting Task (p's $> .03$; see Tables 16 - 18) as well as D-KEFS contrast scores (all p's $> .30$; See Tables 19 – 22) were unrelated to rumination.

Table 13. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from BRIEF Shifting.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	126.05	81.16		1.55	.12	.48(3,80)
	WRAT Reading Score	02	.14	.01	.11	.91	
	Age	-4.44	4.27	-.12	-1.04	.30	
	Gender	-1.06	3.87	-.03	-.27	.78	
Step 2	Constant	75.53	77.01		.98	.33	3.65(4,79)
	WRAT Reading Score	.01	.13	.01	.10	.92	$\Delta R^2 = .14$
	Age	-3.49	3.99	-.10	-.88	.38	
	Gender	-.72	3.61	-.02	-.20	.84	
	BRIEF Shifting	.60	.17	.37	3.69	<.01[+]	
RRQ Rumination							
Step 1	Constant	110.94	48.22		2.30	.02	.79(3,81)
	WRAT Reading Score	-.06	.08	-.08	-.71	.48	
	Age	-3.56	2.53	-.16	-1.41	.16	
	Gender	-.60	2.29	-.03	-.26	.80	
Step 2	Constant	77.27	45.30		1.71	.09	4.50(4,80)
	WRAT Reading Score	-.06	.08	-.09	-.80	.43	$\Delta R^2 = .16$
	Age	-2.85	2.34	-.13	-1.22	.23	
	Gender	-.50	2.12	-.02	-.24	.81	
	BRIEF Shifting	.38	.10	.40	3.90	<.01[+]	

[+] Remains significant after FDR

Table 14. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from BRIEF Monitoring.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	126.05	81.16		1.55	.12	.48(3,80)
	WRAT Reading Score	.02	.14	.01	.11	.91	
	Age	-4.44	4.27	-.12	-1.04	.30	
	Gender	-1.06	3.87	-.03	-.27	.78	
Step 2	Constant	80.63	87.15		.93	.36	.84(4,79)
	WRAT Reading Score	.06	.14	.05	.39	.70	$\Delta R^2 = .02$
	Age	-2.89	4.39	-.08	-.66	.51	
	Gender	-1.35	3.85	-.04	-.35	.73	
	BRIEF Monitoring	.28	.20	.16	1.4	.17	
RRQ Rumination							
Step 1	Constant	110.94	48.22		2.30	.02	.79(3,81)
	WRAT Reading Score	-.06	.08	-.08	-.71	.48	
	Age	-3.56	2.53	-.16	-1.41	.16	
	Gender	-.60	2.29	-.03	-.26	.80	
Step 2	Constant	72.20	51.16		1.411	.16	1.61(4,80)
	WRAT Reading Score	-.03	.08	-.04	-.30	.76	$\Delta R^2 = .05$
	Age	-2.23	2.57	-.10	-.87	.39	
	Gender	-.85	2.26	-.04	-.38	.71	
	BRIEF Monitoring	.24	.12	.22	2.00	<.05	

Table 15. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from BRIEF Inhibition.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	126.05	81.16		1.55	.12	.48(3,80)
	WRAT Reading Score	.02	.14	-.03	-.27	.78	
	Age	-4.44	4.27	-.12	-1.04	.30	
	Gender	-1.06	3.87	-.03	-.27	.78	
Step 2	Constant	87.43	82.34		1.06	.29	1.29(4,79)
	WRAT Reading Score	.02	.14	.02	.13	.90	$\Delta R^2 = .04$
	Age	-3.32	4.24	-.09	-.78	.44	
	Gender	-.57	3.81	-.02	-.15	.88	
	BRIEF Inhibition	.35	.18	.21	1.92	.06	
RRQ Rumination							
Step 1	Constant	110.94	48.22		2.30	.02	.79(3,81)
	WRAT Reading Score	-.06	.08	-.08	-.71	.48	
	Age	-3.56	2.53	-.16	-1.41	.16	
	Gender	-.60	2.29	-.03	-.26	.80	
Step 2	Constant	87.04	48.96		1.78	.08	1.56(4,80)
	WRAT Reading Score	-.06	.08	-.08	-.70	.49	$\Delta R^2 = .04$
	Age	-2.84	2.52	-.13	-1.13	.26	
	Gender	-.34	2.26	-.02	-.15	.88	
	BRIEF Inhibition	.21	.11	.21	1.95	.05	

Table 16. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from WCST Perseverative Errors.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	131.02	80.00		1.64	.11	.55(3,81)
	WRAT Reading Score	.02	3.83	-.03	-.23	.82	
	Age	-4.74	4.19	-.13	-1.13	.26	
	Gender	-.89	3.83	-.03	-.23	.82	
Step 2	Constant	172.25	81.15		2.12	.04	1.44(4,80)
	WRAT Reading Score	.09	.14	.07	.63	.53	$\Delta R^2 = .05$
	Age	-6.10	4.17	-.17	-1.46	.15	
	Gender	-1.06	3.76	-.03	-.28	.78	
	WCST Perseverative Errors	-.42	.21	-.23	-2.01	.05	
RRQ Rumination							
Step 1	Constant	103.12	47.91		2.15	.03	.69(3,82)
	WRAT Reading Score	-.06	.08	-.08	-.73	.47	
	Age	-3.10	2.51	-.14	-1.23	.22	
	Gender	-.86	2.29	-.04	-.38	.71	
Step 2	Constant	118.21	49.43		2.39	.02	.87(4,81)
	WRAT Reading Score	-.03	.09	-.05	-.40	.69	$\Delta R^2 = .02$
	Age	-3.60	2.54	-.17	-1.42	.16	
	Gender	-.91	2.28	-.04	-.40	.69	
	WCST Perseverative Errors	-.15	.13	-.14	-1.19	.23	

Table 17. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from WCST Categories Completed.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	131.02	80.00		1.64	.11	.55(3,81)
	WRAT Reading Score	.02	.14	.01	.12	.91	
	Age	-4.74	4.19	-.13	-1.13	.26	
	Gender	-.89	3.83	-.03	-.23	.82	
Step 2	Constant	162.91	83.41		1.95	.05	.83(4,80)
	WRAT Reading Score	.04	.14	.03	.25	.81	$\Delta R^2 = .02$
	Age	-5.43	4.21	-.15	-1.29	.20	
	Gender	-1.91	3.90	-.06	-.49	.63	
	WCST Categories Completed	-3.60	2.79	-.15	-1.29	.20	
RRQ Rumination							
Step 1	Constant	103.12	47.91		2.15	.03	.68(3,82)
	WRAT Reading Score	-.06	.08	-.08	-.73	.47	
	Age	-3.10	2.51	-.14	-1.23	.22	
	Gender	-.86	2.29	-.04	-.38	.71	
Step 2	Constant	109.19	50.41		2.17	.03	.55(4,81)
	WRAT Reading Score	-.06	.09	-.08	-.68	.50	$\Delta R^2 < .01$
	Age	-3.23	2.54	-.15	-1.27	.21	
	Gender	-1.06	2.35	-.05	-.45	.66	
	WCST Categories Completed	-.69	1.69	-.05	-.41	.68	

Table 18. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from WCST Non-perseverative Errors.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	131.02	80.00		1.64	.11	.55(3,81)
	WRAT Reading Score	.02	.14	.01	.12	.91	
	Age	-4.74	4.19	-.13	-1.13	.26	
	Gender	-.89	3.83	-.03	-.23	.82	
Step 2	Constant	136.42	82.89		1.65	.10	.42(4,80)
	WRAT Reading Score	.02	.14	.02	.16	.87	$\Delta R^2 < .01$
	Age	-4.87	4.25	-.14	-1.15	.26	
	Gender	-.98	3.87	-.03	-.25	.81	
	WCST Non-perseverative Errors	-.07	.25	-.03	-.27	.79	
RRQ Rumination							
Step 1	Constant	103.12	47.91		2.15	.03	.68(3,82)
	WRAT Reading Score	-.06	.08	-.08	-.73	.47	
	Age	-3.10	2.51	-.14	-1.23	.22	
	Gender	-.86	2.29	-.04	-.38	.71	
Step 2	Constant	98.71	49.61		1.99	.05	.54(4,81)
	WRAT Reading Score	-.07	.09	-.09	-.77	.44	$\Delta R^2 < .01$
	Age	-2.99	2.54	-.14	-1.18	.24	
	Gender	-.79	2.31	-.04	-.34	.73	
	WCST Non-perseverative Errors	.06	.15	.04	.37	.71	

Table 19. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from D-KEFS Trails Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	131.02	80.00		1.64	.11	.55(3,81)
	WRAT Reading Score	.02	.14	.01	.12	.91	
	Age	-4.74	4.19	-.13	-1.13	.26	
	Gender	-.89	3.83	-.03	-.23	.82	
Step 2	Constant	130.35	80.96		1.61	.11	.41(4,80)
	WRAT Reading Score	.02	.14	.01	.11	.91	$\Delta R^2 < .01$
	Age	-4.733	4.22	-.13	-1.12	.27	
	Gender	-.86	3.87	-.03	-.22	.82	
	D-KEFS Trails Switching Contrast	.02	.14	.01	.11	.91	
RRQ Rumination							
Step 1	Constant	103.12	47.91		2.15	.03	.68(3,82)
	WRAT Reading Score	-.06	.08	-.08	-.73	.47	
	Age	-3.10	2.51	-.14	-1.23	.22	
	Gender	-.86	2.29	-.04	-.38	.71	
Step 2	Constant	99.93	48.36		2.07	.04	.61(4,81)
	WRAT Reading Score	-.06	.08	-.09	-.75	.46	$\Delta R^2 < .01$
	Age	-3.08	2.52	.14	-1.22	.22	
	Gender	-.72	2.31	-.04	-.31	.76	
	D-KEFS Trails Switching Contrast	.32	.52	.07	.63	.53	

Table 20. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from D-KEFS Verbal Fluency Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	131.02	80.00		1.64	.11	.55(3,81)
	WRAT Reading Score	.02	.14	.01	.12	.91	
	Age	-4.74	4.19	-.13	-1.13	.26	
	Gender	-.89	3.83	-.03	-.23	.82	
Step 2	Constant	127.38	82.21		1.55	.13	.42(4,80)
	WRAT Reading Score	.01	.14	.01	.08	.94	$\Delta R^2 < .01$
	Age	-4.57	4.29	-.13	-1.07	.29	
	Gender	-.74	3.91	-.02	-.19	.85	
	D-KEFS VF Switching Contrast	.13	.59	.03	.22	.83	
RRQ Rumination							
Step 1	Constant	103.12	47.91		2.15	.03	
	WRAT Reading Score	-.06	.08	-.08	-.73	.47	.68(3,82)
	Age	-3.10	2.51	-.14	-1.23	.22	
	Gender	-.86	2.29	-.04	-.38	-.71	
Step 2	Constant	102.58	49.20		2.08	.04	.51(4,81)
	WRAT Reading Score	-.06	.09	-.09	-.72	.47	$\Delta R^2 < .01$
	Age	-3.07	2.56	-.14	-1.20	.23	
	Gender	-.84	2.34	-.04	-.36	.72	
	D-KEFS VF Switching Contrast	.02	.36	.01	.06	.96	

Table 21. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from D-KEFS Design Fluency Switching Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	139.52	83.36		1.67	.10	.46(3,73)
	WRAT Reading Score	-.04	.15	-.03	-.27	.79	
	Age	-4.84	4.35	-.14	-1.11	.27	
	Gender	-.65	4.01	-.02	-.16	.87	
Step 2	Constant	143.54	83.44		1.72	.09	.60(4,72)
	WRAT Reading Score	-.05	.15	-.04	-.35	.73	$\Delta R^2 = .01$
	Age	-4.57	4.36	-.13	-1.05	.30	
	Gender	-.68	4.01	-.02	-.17	.87	
	D-KEFS DF Switching Contrast	-.74	.73	-.12	-1.01	.31	
RRQ Rumination							
Step 1	Constant	104.34	48.67		2.14	.04	.79(3,74)
	WRAT Reading Score	-.09	.09	-.13	-1.02	.31	
	Age	-.300	2.55	-.14	-1.18	.24	
	Gender	-.96	2.35	-.05	-.41	.68	
Step 2	Constant	105.26	49.13		2.14	.04	.62(4,73)
	WRAT Reading Score	-.09	.09	-.13	-1.04	.30	$\Delta R^2 < .01$
	Age	-2.96	2.57	-.14	-1.15	.25	
	Gender	-.96	2.36	-.05	-.41	.69	
	D-KEFS DF Switching Contrast	-.15	.43	-.04	-.35	.73	

Table 22. *Hypothesis 2: Hierarchical Multiple Regression Analyses Predicting RSQ and RRQ Rumination from D-KEFS Color Word Contrast Scores.*

Outcome	Predictor	B	SEB	β	t	p-value	F(df)
RSQ Rumination							
Step 1	Constant	137.26	80.90		1.70	.09	.64(3,80)
	WRAT Reading Score	.04	.14	.03	.27	.79	
	Age	-5.21	4.28	-.14	-1.22	.23	
	Gender	-.55	3.88	-.02	-.14	.89	
Step 2	Constant	132.43	81.23		1.63	.11	.67(4,79)
	WRAT Reading Score	.07	.15	.05	.44	.66	$\Delta R^2 < .01$
	Age	-4.52	4.36	-.12	-1.04	.30	
	Gender	-1.08	3.94	-.03	-.28	.74	
	D-KEFS CW Contrast	-.91	1.06	-.10	-.86	.39	
RRQ Rumination							
Step 1	Constant	109.69	48.18		2.28	.03	.75(3,81)
	WRAT Reading Score	-.04	.09	-.05	-.44	.66	
	Age	-3.60	2.54	-.16	-1.42	.16	
	Gender	-.50	2.31	-.02	-.22	.83	
Step 2	Constant	108.82	48.57		2.24	.03	.57(4,80)
	WRAT Reading Score	-.03	.09	-.04	-.37	.71	$\Delta R^2 < .01$
	Age	-3.47	2.60	-.16	-1.33	.19	
	Gender	-.60	2.35	-.03	-.25	.80	
	D-KEFS CW Contrast	-.17	.64	-.03	-.27	.79	

Hypothesis 3: Rumination mediates the relationship between executive functioning and depressive symptomatology

When rumination was significantly associated with both depressive symptomatology and EF, mediation was explored. To test for mediation, I utilized both the Sobel test and statistical bootstrapping in order address whether the indirect effect (i.e., the effect of the predictor variable on the dependent variable that is attributable to the mediator) was significant. As before, gender, age and WRAT Reading scores were included as covariates in all models.

In the first set of analyses, I tested whether RSQ rumination mediated the relationship between BRIEF Shifting and CES-D depression. Significant mediation was observed, both through the use of the Sobel test ($Z = 3.38$, $p<.01$) and the bootstrap method (.25; CI [.09, .44]). The RRQ also significantly mediated the relationship between set-shifting and the CES-D ($Z = 2.81$, $p<.01$), (.18; CI [.06, .34]).

Similar results were observed when measures of rumination were examined as potential mediators of the relationship between BRIEF shifting and PANAS Sadness. The RSQ was a significant mediator, both on the Sobel test ($Z = 3.20$, $p<.01$), and the bootstrap method (.11; CI[.04, .21]). Finally, this mediation was also observed using the RRQ as a measure of mediation. Similarly, this mediation was observed on the Sobel test ($Z=3.05$, $p<.01$) and the bootstrap method (.09; CI[.04, .16]).

CHAPTER 5

DISCUSSION

The present study sought to examine the relationship between executive functioning, depression and rumination in a normative sample of adolescents. In hypothesis 1, I postulated that difficulties with executive functioning would be related to higher levels of depression. For hypothesis 2, I posited that executive dysfunction would be associated with higher levels of rumination given the data linking rumination and EF. For hypothesis 3, I explored the mediating effects of rumination on the association between EF and depression. In support of hypothesis 1 and 2, a significant relationship between EF and both rumination and depressive symptomatology was observed. Specifically, I found increased perseveration, monitoring and set-shifting difficulties among individuals with higher levels of depressive symptoms and greater feelings of sadness. Further, there was some evidence of increased inhibitory impairments, although this was not consistently observed across measures of depressive symptomatology. Increased set-shifting deficits were also observed with higher levels of rumination; however, I did not find evidence of a relationship between rumination and perseveration, monitoring, or inhibition deficits. Finally, with respect to the third hypothesis, rumination significantly mediated the relationship between set-shifting difficulties and depressive symptomatology.

Generally, the current findings coincide with the larger body of literature demonstrating EF deficits in depression (Baune, et al., 2012; Brooks et al., 2010; Gunther, Konrad, De Brito, Herpertz-Dahlmann, & Vloet, 2011; Han et al., 2011; Holler, et al., 2013; Wilkinson & Goodyer, 2006), but are inconsistent with studies that have not observed these deficits (Favre et al., 2009; Frost et al., 1987; McClure et al. 1997). In particular, the findings align with the previous literature demonstrating increased perseveration and decreased set-shifting among depressed adolescents (Baune, et al., 2012; Emerson, et al. 2005; Holler, et al., 2013; Wilkinson & Goodyer, 2006), but contrast those studies that did not find these impairments (Matthews et al., 2008, Klimkeit et al., 2011). Furthermore, the current results suggesting that individuals with more sad affect experience more difficulty with inhibition are consistent with related research (Brooks et al., 2010; Cataldo et al., 2006; Kyte et al., 2005), but not all findings (Holler et al., 2013; Klimkeit al., 2011). In contrast to perseveration, set-shifting and inhibition, I know of no studies that have specifically explored the relationship between monitoring and depression in youth. Yet, the current results with monitoring suggest that this may be an important component to consider in further studies exploring the EF-depression relationship.

The current findings suggest that rather than a global deficit, depression affects executive abilities more specifically. In particular, the results imply that while adolescents may experience minimal difficulties with inhibition, they experience significant perseveration as well as shifting and monitoring impairments that contribute to their depressive symptomology. The pattern of results is consistent with prior research

tying depression to specific executive domains versus an overall deficit (Holler et al., 2013; Kyte et al., 2005; Maalouf et al., 2013). In fact, none of the recent research with youth supports a relationship between global EF impairments (Brooks et al., 2010; Emerson et al., 2005; Gunther et al., 2011; Han et al., 2012; Holler et al., 2013; Klimkeit et al., 2011; Kyte et al., 2005; Maalouf et al., 2011; Matthews et al., 2008; Wilkinson & Goodyer, 2006). Instead, there is specificity with respect to which EF components are implicated in depression among adolescents. As such, it will be important for future research to shift towards identifying those specific executive subdomains versus examining EF deficits more broadly. In doing so, we might be able to better clarify the nature of EF in depression.

Moving a step further, recent work contends that the nature of executive dysfunction in adolescent depression reflects a combination of time-variant (state) and time-invariant (trait) EF deficits (Holler et all, 2013; Kyte et al., 2005; Klimkeit et al., 2006; Maalouf et al., 2011). Turning to the current results, perhaps the limited findings with inhibition are due to impairments in this area being more state-like than trait-like. Notably, Maalouf et al. (2011) and Holler et al. (2013) respectively observed impaired set-shifting and inhibition deficits among acutely depressed but not dysphoric or recently remitted adolescents. These results suggest more state-like impairments such that adolescents only demonstrate EF impairments in the context of more depressive symptomatology. In other words, these two EF deficits may be better viewed as symptoms of depression rather than being etiologies. In addition to examining specific

executive subdomains versus EF more broadly, it will be important to also continue exploring whether these domains reflect more state versus trait deficits of depression.

The current rumination results are consistent with research demonstrating a significant relationship between rumination and impaired set-shifting among depressed adolescents (Altamirano et al., 2012; Wilkinson & Goodyer, 2006). Further, they are consistent with the work of Connolly et al. (2014), who demonstrated a similar effect temporally such that rumination was predictive of increases in set-shifting deficits. As I know of no study to date that has explored the relationship between inhibition and rumination among youth, I turn to the adult literature to better understand our results with inhibition. I did not observe the same inhibitory deficits that have been noted in previous studies with adults (Joormann, 2006; Joormann & Gotlib, 2010; De Lissnyder et al., 2010). However, only taking into account those measures of EF similar to those utilized in the current study (i.e., emotionally-neutral tasks), the results are generally consistent. Further, there is also evidence to suggest that the link between rumination and inhibitory deficits is moderated by the severity of depression such that this relationship was stronger among more severely depressed individuals (Philippot & Brutoux, 2008). Perhaps the current null results with rumination and inhibition are due to the low level of depression severity observed in our sample.

In terms of perseveration, I did not replicate the findings of Davis and Nolen-Hoeksema (2000) demonstrating higher levels of perseveration among adult ruminators (Davis & Nolen-Hoeksema, 2000); this is especially perplexing given the significant theoretical overlap between the construct of rumination and both perseveration and

inhibition. There are several possible explanations to account for this inconsistency. This divergence in findings may stem from developmental differences in the EF-rumination relationship. In particular, whereas the current sample only included adolescents between the ages of 16 and 18 (M = 17.77), Davis and Nolen-Hoeksema utilized a sample of young adults (M = 20.27). This suggests a possible developmental shift that does not come online until late adolescence; that is, the role of perseveration in rumination may not emerge until late adolescence. In support of this possibility is the data suggesting that, although generally mature, there are continued changes in executive abilities in late adolescence (Huzinga et al., 2006; Luna et al., 2004) that may contribute to this developmental shift. Lastly, it is also possible that the presence of Type-I or Type-II errors is contributing to difficulty in replicating the prior findings of Davis and Nolen-Hoeksema (2000).

Similar to what is seen in the depression literature, the present results highlight the importance of moving beyond examining the general association between EF and rumination and further exploring the possible nuances that exist. Of note, rumination was associated with impairments in set-shifting but was unrelated to inhibition, monitoring and perseveration. Although this is in contrast to the work of Whitmer and Banich (2007) demonstrating a significant association with inhibition and only a moderate associated with set-shifting, it supports the importance of examining the specificity in the EF-rumination relationship. Again, the distinction between state and trait effects may be useful in understanding these findings given evidence of a specific relationship between executive subdomains and trait and state rumination. Prior work has found inhibition

particularly related to state rumination (Philippot & Brutoux, 2008; Watkins & Brown, 2002). More recently, Whitmer and Gotlib (2012) observed that whereas only increased inhibitory deficits were related to trait rumination, set-shifting was only related to state rumination among depressed adults. I know of no study to date that has examined the relationship between specific executive components and state rumination in youth. As such, further research clarifying the precise pattern of relationship between EF components and rumination, including both state and trait rumination, in youth is warranted.

Across both depression and rumination, recent evidence suggests that the valence of the stimuli included within performance measures of EF also influences the relationship among these constructs. For example, depressed individuals have been found to demonstrate inhibitory deficits when reading emotion words (e.g., misery, discouraged) but not neutral words (e.g., carpet, domestic) during a modified Stroop task (Gotlib & Cann, 1987; Gotlib & McCann, 1984). This concept has also been observed in further tests of inhibition (e.g., Joormann & Gotlib, 2008; 2010) as well as tests of set-shifting (e.g., Deveny & Deldin, 2006) and attention (e.g., Kyte et al., 2006). Interestingly, the effect of stimuli valence has also been supported with respect to rumination (e.g., De Lissnyder et al., 2010; Joormann, 2006). Thus, it is possible that I may have observed different results had I utilized emotionally-valenced performance measures of EF.

It is important to note that the use of emotionally-valenced stimuli addresses conceptually distinct questions from those in this study. In the current study, I utilized

non-valenced or neutral stimuli in order to make inferences regarding general executive abilities among adolescents. That is, the use of neutral stimuli allowed us to examine whether EF deficits are related to depression. In contrast, the use of valenced stimuli usually is taken as evidence of a different hypothesis. Specifically, it addresses the issue of depressive schema and whether depressed individuals respond differently to negative stimuli compared to neutral stimuli. However, given the limited developmental work incorporating depression-related processing, especially in the context of rumination, this may be an important next step for the literature.

Turning our attention to the mediation results, rumination mediated the relationship between set-shifting and depressive symptomatology. That is, perhaps individuals with impaired set-shifting are more prone to rumination, leaving them vulnerable to negative consequences associated with this repetitive thought process, namely increased depression. The mediating effects of rumination are not surprising, given the data demonstrating that the relationship between EF deficits and depression may be better accounted for by impact of rumination (De Lissnyder et al., 2010; Whitmer & Banich, 2007). Furthermore, my findings with rumination, a form of emotion regulation, align with a recent model proposed by Joormann (2010). In particular, Joormann hypothesized that executive abilities (namely inhibition) influence depression through their impact on an individual's emotion regulation abilities. In particular, she argued that impaired inhibitory abilities contribute to an increased reliance on maladaptive emotion regulation strategies and, subsequently, leads to increases in depressive symptomatology. It is important to note, however, the current mediation

results should be interpreted with caution as they are based on a cross-sectional sample and thus are not a true test of mediation (see Maxwell & Cole, 2007). As such, future studies examining the mediating effects of rumination on the EF-depression relationship using a prospective design are warranted.

Lastly, the pattern of the current results is worth mentioning. With the exception of the measure of perseverative errors on the WCST, I only observed significant results with our self-report measures such that only self-reported EF difficulties (versus performance on measures of EF) were related to higher levels of depressive symptomatology and rumination. This pattern of findings introduces the possibility of mono-method bias. Interestingly, there are several instances in which consistent results were not found across multi-methods within the developmental literature examining the relationship between impairments in EF and depression (Cataldo et al., 2005; Holler et al., 2013; Kyte et al., 2005). The current results may also stem from a measurement specific factor as there is some question regarding whether EF measures are validly able to assess specific components of EF. For instance, some have suggested that the cognitive processes underlying the WCST are still poorly understood and may be better described as a general measurement of EF rather than a measure of specific abilities (Greve, Stickle, Love, Bianchini & Stanford, 2005). It is also possible that the use of a normative (versus a clinical) sample may have hindered the utility of some performance measures of EF. Furthermore, the D-KEFS manual even discusses its limited utility with a normative population (Delis et al., 2001) whereas our self-report measures have demonstrated utility

with normative samples (Radloff, 1977; Treynor et al., 2003). Thus, further research comparing the utility of these measures in a normative sample is warranted.

Limitations to the current study should be noted. In terms of depressive symptomatology, I examined self-reported levels of depressive symptoms and sad affect in a normative sample. As such, it is unclear how these results will generalize to the development of depressive disorders in adolescents. It is also unclear whether the same pattern of results would be observed in a more severe population. The generalization of our current findings may also be constrained by the use of a primarily Caucasian sample. Furthermore, the cross-sectional nature of the study limits us from speaking about the temporal relations between study variables. Although prior research has demonstrated a predictive relationship between rumination and depression (Rood et al., 2009) as well as EF deficits (Connolly et al., 2014) in youth, the developmental progression among these three constructs is not yet fully understood. Lastly, the current sample only included late adolescents. Given the noted importance of early adolescence with respect to significant increases in rumination (Jose & Brown, 2008), the results cannot speak to how EF deficits impact the development of ruminative tendencies. As such, further prospective investigations are warranted, including those that explore the developmental progression between EF, rumination and depression during adolescence.

This study extends previous work by providing evidence of executive impairments in both depressive symptomatology and rumination among a sample of normative adolescents. It also highlights the mediating effects of rumination on the EF-depression relationship, notably set-shifting. Further studies are needed to further

elucidate the relationship between EF and rumination and depression among youth; this includes prospective studies to better understand the developmental progression among these constructs.

APPENDIX A

MEASURES USED IN THIS STUDY

Demographics Questionnaire

For each item below, please circle or fill in the answer that best applies to you.

1. What is today's date (DD/MM/YR): _____

2. What is your birth date (DD/MM/YR): _____

3. What grade are you in?
   a. 6th
   b. 7th
   c. 8th
   d. 9th
   e. 10th
   f. 11th
   g. 12th

4. What is your gender?
   a. Female
   b. Male

5. What is your ethnicity of origin?
   a. Caucasian/White
   b. African American/Black
   c. Asian American/pacific Islander
   d. Native American/Alaskan Native
   e. Hispanic/Latino(a)
   f. Biracial
   g. Other (please specify:_____)

6. What is the highest level of education obtained by your mother?
   a. Doctoral degree
   b. Masters degree
   c. 4-year college degree
   d. 2-year college degree
   e. Some college
   f. Trade school
   g. High school
   h. Part of high school
   i. 8th grade
   j. Less than 8th grade

7. What is the highest level of education obtained by your father?

a. Doctoral degree
b. Masters degree
c. 4-year college degree
d. 2-year college degree
e. Some college
f. Trade school
g. High school
h. Part of high school
i. 8th grade
j. Less than 8th grade

8. Do you have any siblings? Yes No

a. How many siblings do you have? _____

- How many are biological siblings? _____
- How many are step siblings? _____
- How many are half siblings? _____
- How many are adopted? _____

9. What is your current paid work-status?

a. Part-time
b. Full-time
c. I currently do not work (skip to question 10)

10. How many hours a week do you conduct paid work?

a. 0-10 hours
b. 11-20 hours
c. 21-30 hours
d.31-40 hours
e. 41 or more hours

11. Have you ever had a cognitive evaluation (to be enrolled in gifted courses or specialized classes)?

Yes No If so, when? _____

12. Have you ever been diagnosed with a learning disorder or disability (e.g., dyslexia, math disorder)?

Yes No If so, please explain:_____

13. Have you recently suffered a concussion or any other head injury?

Yes No If so, please explain:_____

14. Do you have any current or prior medical conditions (e.g., seizures, diabetes, cerebral palsy)?

Yes No If so, please explain:_____

CES-D

Using the scale below, indicate the number which best describes how often you felt or behaved this way –DURING THE PAST WEEK.

1 = Rarely or none of the time (less than 1 day)
2 = Some or a little of the time (1-2 days)
3 = Occasionally or a moderate amount of time (3-4 days)
4 = Most or all of the time (5-7 days)

	DURING THE PAST WEEK:	rarely or none of the time	some or little of the time	occasionally or a moderate amount of time	most or all of the time
1.	I was bothered by things that don't usually bother me.	1	2	3	4
2.	I did not feel like eating; my appetite was poor.	1	2	3	4
3.	I felt that I could not shake off the blues even with help from my family or friends.	1	2	3	4
4.	I felt that I was just as good as other people.	1	2	3	4
5.	I had trouble keeping my mind on what I was doing.	1	2	3	4
6.	I felt depressed.	1	2	3	4
7.	I felt that everything I did was an effort.	1	2	3	4
8.	I felt hopeful about the future.	1	2	3	4
9.	I thought my life had been a failure.	1	2	3	4
10.	I felt fearful.	1	2	3	4
11.	My sleep was restless.	1	2	3	4
12.	I was happy.	1	2	3	4
13.	I talked less than usual.	1	2	3	4
14.	I felt lonely.	1	2	3	4
15.	People were unfriendly.	1	2	3	4
16.	I enjoyed life.	1	2	3	4
17.	I had crying spells.	1	2	3	4
18.	I felt sad.	1	2	3	4
19.	I felt that people disliked me.	1	2	3	4
20.	I could not get "going."	1	2	3	4

To what extent did you feel _____ today?

1	**2**	**3**	**4**	**5**
very slightly or not at all	**a little**	**moderately**	**quite a bit**	**extremely**

1. Sad _____
2. Blue _____
3. Downhearted _____
4. Unhappy _____
5. Lonely _____
6. Nervous _____
7. Afraid _____
8. Scared _____
9. Worried _____
10. Angry _____
11. Hostile _____
12. Irritable _____
13. Happy _____
14. Joyful _____
15. Delighted _____
16. Cheerful _____
17. Lively _____
18. Energetic _____

RSQ-25

People think and do many different things when they feel depressed. Please read each of the items below and indicate whether you never, sometimes, often or always think or do each one when you feel down, sad, or depressed. Please indicate what you *generally* do, not what you think you should do.

	Almost Never	**Sometimes**	**Often**	**Almost Always**
1. Think about how alone you feel	○	○	○	○
2. Think "I won't be able to do my work/job because I feel so badly"	○	○	○	○
3. Think about your feelings of fatigue and achiness	○	○	○	○
4. Think about how hard it is to concentrate	○	○	○	○
5. Think about how passive and unmotivated you feel	○	○	○	○
6. Analyze recent events to try to understand why you are depressed	○	○	○	○
7. Think about how you don't seem to feel anything any more	○	○	○	○
8. Think "Why can't I get going?"	○	○	○	○
9. Think "Why do I always react this way?"	○	○	○	○
10. Go away by yourself and think about why you feel this way	○	○	○	○
11. Write down what you are thinking about and analyze it	○	○	○	○
12. Think about a recent situation, wishing it had gone better	○	○	○	○
13. Think "Why do I have problems other people don't have?"	○	○	○	○
14. Think about how sad you feel	○	○	○	○
15. Think about all your shortcomings, failings, faults, mistakes	○	○	○	○
16. Think about how you don't feel up to doing anything	○	○	○	○
17. Analyze your personality to try to understand why you are depressed	○	○	○	○
18. Go someplace alone to think about your feelings	○	○	○	○
19. Think about how angry you are with yourself	○	○	○	○
20. Listen to sad music	○	○	○	○
21. Isolate yourself and think about the reasons why you feel sad	○	○	○	○
22. Try to understand yourself by focusing on your depressed feelings	○	○	○	○
23. Think "What am I doing to deserve this?"	○	○	○	○
24. Think "Why can't I handle things better?"	○	○	○	○
25. Think "I won't be able to concentrate if I keep feeling this way"	○	○	○	○

Instructions:

For each of the statements located on the next two pages, please indicate your level of agreement or disagreement by circling one of the scale categories to the right of each statement. Use the scale as shown below:

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

1.	My attention is often focused on aspects of myself I wish I'd stop thinking about…….	1	2	3	4	5
2.	I always seem to be "re-hashing" in my mind recent things I've said or done……..	1	2	3	4	5
3.	Sometimes it's hard for me to shut off thoughts about myself.	1	2	3	4	5
4.	Long after an argument or disagreement is over with, my thoughts keep going back to what happened……..…..	1	2	3	4	5
5.	I tend to "ruminate" or dwell over things that happen to me for a really long time afterward……	1	2	3	4	5
6.	I don't waste time re-thinking things that are over & done with	1	2	3	4	5
7.	Often I'm playing back over in my mind how I acted in a past situation……...	1	2	3	4	5
8.	I often find myself re-evaluating something I've done…….....	1	2	3	4	5
9.	I never ruminate or dwell on myself for very long……	1	2	3	4	5
10.	It is easy for me to put unwanted thoughts out of my mind…...	1	2	3	4	5
11.	I often reflect on episodes in my life that I should no longer concern myself with……..	1	2	3	4	5
12.	I spend a great deal of time thinking back over my embarrassing or disappointing moments……	1	2	3	4	5
13.	Philosophical or abstract thinking doesn't appeal to me that much……	1	2	3	4	5
14.	I'm not really a meditative type of person……	1	2	3	4	5
15.	I love exploring my "inner" self……..	1	2	3	4	5
16.	My attitudes and feelings about things fascinate me……..	1	2	3	4	5
17.	I don't really care for introspective or self-reflective thinking…	1	2	3	4	5
18.	I love analyzing why I do things……	1	2	3	4	5
19.	People often say I'm a "deep", introspective type of person…	1	2	3	4	5
20.	I don't care much for self-analysis……	1	2	3	4	5
21.	I'm very self-inquisitive by nature……	1	2	3	4	5
22.	I love to meditate on the nature and meaning of things……	1	2	3	4	5
23.	I often love to look at my life in philosophical ways……...	1	2	3	4	5
24.	Contemplating myself isn't my idea of fun……..	1	2	3	4	5

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