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Trait Rumination, Depression, and Executive Functions in Early Adolescence

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Abstract

Although deficits in executive functions have been linked with both depression and rumination in adulthood, the nature of the relationship between these constructs is not well understood and remains understudied in adolescence. The present study examined the relationship of rumination and depression to deficits in executive functions in early adolescence, a critical developmental period for the emergence of depression and rumination and the development of executive functions. Participants were 486 early adolescents (52.7% female; 47.1% African American, 48.8% Caucasian; 4.2% Biracial/Multiracial/Other; *M* age = 12.88 years; *SD* = .62) and their mothers, recruited through local schools. Measures included (a) a semi-structured diagnostic interview of the mother and adolescent, (b) youth self-report forms assessing depressive symptoms and trait rumination, (c) mother-report forms assessing demographic information, and (d)

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Ethical Standards
This study was approved by the institution's internal review board and has therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. All persons gave their informed consent prior to their inclusion in the study. The authors declare no conflicts of interest.

Authors' Contributions
L.B.A. and L.Y.A. conceived of the large scale longitudinal study that is the source of the archival data used for this research, including selection of study measures. C.W. conceived of the study question and hypotheses, assisted in data collection, performed the statistical analysis, drafted and wrote the manuscript. L.B.A. assisted in formulation of hypotheses and interpretation of research findings and reviewed and edited the manuscript. All authors read and approved the final manuscript.

behavioral tests of executive function (sustained, selective and divided attention, attentional set shifting, and working memory). Gender moderated rumination-set shifting associations, such that rumination predicted better set shifting in boys only. The current level of depressive symptoms moderated rumination-sustained attention associations, such that rumination predicted better sustained attention in those with low levels of depressive symptoms and worse sustained attention in those with high levels of depressive symptoms. Rumination did not predict performance on other measures of executive functions. Likewise, depressive symptoms and diagnosis were not associated with executive functions. Implications for future research are discussed.

Keywords

Executive functions; rumination; depression; adolescence; gender

Introduction

The prevalence of unipolar depression increases across adolescence, with approximately 15.4% of adolescents meeting criteria for lifetime major depressive disorder or dysthymia by age 17–18 (Merikangas et al., 2010). This is of concern as depression in youth has been associated with negative outcomes including a high rate of relapse, suicide attempts, and impaired psychosocial functioning (e.g., Naicker et al., 2013; Weissman et al., 1999). Given its high prevalence rates and negative impact, a clearer understanding is needed of the expression, causes, and consequences of the disorder. In adults, research has linked executive functions deficits to unipolar depression and related risk factors, including rumination. However, this area of research has received far less attention in adolescence, despite the ongoing cognitive development and risk for emergence of depression characteristic of this critical developmental period. The present study sought to address this gap in the literature, which we expand upon further below.

Depression and Executive Functions in Adults and Youth

Empirical research has linked unipolar depression to impairment in executive functions (EF), which are conceptualized as separable but interrelated skills (Miyake et al., 2000) necessary to purposeful, goal-directed activity and behavior (Welsh, Pennington, & Groisser, 1991). Although theories of executive control vary (e.g., Anderson, 2002; Duncan, 2001; Miller & Cohen, 2001), and executive functions are not operationalized consistently, they are thought to involve higher level cognitive processes modulating or exerting control over lower level ones according to task demands so that behavior is not driven solely by immediate environmental triggers (Alvarez & Emory, 2006; Gilbert & Burgess, 2008), permitting flexible behavior under novel environmental conditions or when multiple responses are possible. Subsumed under the umbrella of executive functions are higher level cognitive processes, including set shifting and maintenance, interference control, inhibition, integration across space and time, planning, and working memory (Pennington & Ozonoff, 1996).

Several theoretical approaches highlight the potential link between executive function deficits and unipolar depression. From a cognitive perspective, the resource allocation model

(Ellis & Ashbrook, 1988) has postulated that depression occupies limited capacity cognitive resources, impairing ability to engage in effortful cognitive processes. Others have proposed that depressed individuals have specific difficulty performing at the level of non-depressed individuals in unstructured situations requiring cognitive control (Gotlib & Joormann, 2010). A large body of research examining profiles of executive function in adults with unipolar depression has yielded inconsistent findings, but several reviews have concluded that, in adults, unipolar depression is characterized by deficits in attention and executive control (Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, & Lonnqvist, 2008; Rogers et al., 2004). Two recent meta-analyses have shown evidence of neuropsychological deficits in adults with unipolar depression, suggesting impairments in cognitive flexibility and verbal fluency (Wagner, Doering, Helmreich, & Lieb, 2011) and set-shifting, inhibition, working memory, and planning (Snyder, 2013). There is ongoing debate as to whether deficits in executive control precede first onset of unipolar depression and are trait markers that are etiologically linked to the disorder, and as to whether they persist following remission, or dissipate when individuals are no longer in the acute phase of a depressive episode (Hasselbalch, Knorr, & Kessing, 2011). In adults with a lifetime history of unipolar depression currently in remission, deficits have been found in executive functions, attention, memory, and psychomotor speed (for review, see Austin, Mitchell, & Goodwin, 2001; Douglas & Porter, 2009; Hammar & Ardal, 2009; Kessing, 1998), and there has been some suggestion that deficits in attention and executive function are trait markers of the disorder that persist following remission (Boeker et al., 2012; Douglas & Porter, 2009; Kessing, 1998; Yamamoto & Shimada, 2012). Based on a qualitative review of 11 methodologically strong studies comparing remitted individuals with MDD and controls, Hasselbalch and colleagues (2011) noted deficits in sustained and selective attention, memory, and executive functions, but concluded that there is insufficient evidence regarding patterns of deficits to date.

Studies examining neuropsychological profiles of children or adolescents with unipolar depression have yielded evidence that depression in adolescence is characterized by deficits in behavioral performance on tests of executive function (e.g., Baune, Czira, Smith, Mitchell, & Sinnamon, 2012; Cataldo, Nobile, Loruso, Battaglia, & Moltem, 2005; Gunther, Konrad, De Brito, Herpertz-Dahlmann, & Vloet, 2011; Micco et al., 2009; Wilkinson & Goodyer, 2006). Studies have found evidence for worse performance among depressed youth relative to controls on tests of sustained attention (Cataldo et al., 2005; Wilkinson & Goodyer, 2006), set shifting (Gunther et al., 2011; Micco et al., 2009; Wilkinson & Goodyer, 2006), working memory (Baune et al., 2012), prepotent response inhibition (Gunther et al., 2011), and selective attention (Cataldo et al., 2005; Wilkinson & Goodyer, 2006). However, findings regarding specific impairments have been inconsistent, and some studies have obtained no evidence of executive function impairments on emotionally neutral tasks (e.g., Gunther, Holtkamp, Jolles, Herpertz-Dahlmann, & Konrad, 2004; Frost, Moffitt, & McGee, 1989; Kyte, Goodyer, & Sahakian, 2005). Inconsistencies may be explained partly by methodological limitations, including the use of small heterogeneous treatment-seeking or high risk samples with wide age ranges. Studies primarily have employed samples in the acute phase of disorder, thus conflating state-dependent effects of depressed mood (for which they often fail to control) with trait profiles of executive function that may

persist into remission or be etiologically linked to disorder. The single study to date comparing performance on emotionally neutral tests of executive function in adolescents in remission versus acute phase of the disorder did not obtain evidence of deficits beyond the acute phase (Maalouf et al., 2011), and more research is needed elucidating profiles of executive function in those with depression diagnosis who are currently depressed versus in remission.

Rumination and Executive Functions in Adulthood

Cognitive theories of depression postulating that maladaptive cognitive styles confer vulnerability for the onset and more severe course of the disorder have garnered support in child and adolescent samples (for review, see Abela & Hankin, 2008). A promising avenue of research integrating cognitive vulnerability-stress models of depression with empirical evidence of impaired executive control among those who are depressed draws on response styles theory (Nolen-Hoeksema, 1991), which proposes that an individual's response to depressed mood influences the severity and duration of depression. Response styles theory conceptualizes rumination as "a mode of responding to distress that involves repetitively and passively focusing on symptoms of distress and on the possible causes and consequences of these symptoms" (Nolen-Hoeksema, Wisco, & Lyubomirsky, 2008). Rumination is trait-like, relatively stable across changes in level of depressive symptoms, and, although the content of rumination is typically negatively valenced, it is the perseverative *style* (not the content) of thought that is conceptualized as central to rumination (Nolen-Hoeksema et al., 2008). There is substantial evidence of an association between rumination and deficits in executive control over emotionally valenced information (for review, see Gotlib & Joormann, 2010), but a growing body of literature also has linked rumination and performance on emotionally neutral tests of executive functions.

Theoretical conceptualizations of rumination converge in positing that rumination should be associated with greater impairments in aspects of executive function, although they differ as to the causal direction of this hypothesized association (Altamirano, Miyake, & Whitmer, 2010; Koster, De Lissnyder, Derakshan, & DeRaedt, 2011; Levens, Muhtadie, & Gotlib, 2009). Studies have tested this hypothesis either by examining the impact of an experimentally induced state of rumination on executive function performance, or by examining the cognitive correlates of scores on self-report measures of trait rumination (Whitmer & Gotlib, 2012a). Inducing state rumination (e.g., Watkins & Brown, 2002) has been found to impair performance on tests of executive function, but induced rumination is qualitatively distinct from trait rumination, which is the focus of the present study and has shown a unique pattern of associations with performance on emotionally neutral cognitive tasks (Whitmer & Gotlib, 2012a). In community samples of adults, trait rumination has been associated with difficulties with attentional switching and cognitive inflexibility (Altamirano et al., 2010; Davis & Nolen-Hoeksema, 2000; Owens & Derakshan, 2013; Whitmer & Banich, 2007). These findings have been primarily cross-sectional and correlational but have been interpreted as evidence that cognitive inflexibility contributes to a tendency to engage in rumination (Davis & Nolen-Hoeksema, 2000), that deficits in inhibition of previously relevant task sets may contribute to trait rumination (Whitmer & Banich, 2007), that impairments in inhibition may drive individuals to continue to ruminate even though it is

maladaptive (Owens & Derakshan, 2013), and that a habitual tendency to ruminate reflects an underlying attentional inflexibility (Altamirano et al., 2010). Thus, competing explanations for observed associations between rumination and executive functions in adulthood have been suggested.

Intriguingly, trait rumination has not been associated with poorer performance across all aspects of executive functions and has exhibited patterns of association distinct from those of depressive symptoms. For example, studies have not found evidence of an association between trait rumination and impaired selective attention on emotionally neutral Stroop tasks (Altamirano et al., 2010; Meiran et al., 2011). In a nonclinical sample of adults, Altamirano and colleagues (2010) reported that rumination was associated with *enhanced* goal maintenance and the ability to ignore irrelevant distractors on a modified Stroop task, after controlling for depressive symptoms, whereas depressive symptoms were associated with poorer performance on this task after controlling for rumination. Rumination was associated with poorer task switching performance after controlling for depressive symptoms, which were not associated with task performance after controlling for rumination. Whitmer and Banich (2007) found that rumination was associated with inhibitory deficits after controlling for depressive symptoms, but depressive symptoms were not associated with this inhibitory deficit after controlling for rumination. These differential patterns of association point to the possibility that a specific cognitive profile contributes to a tendency to ruminate, and that this profile may be evident in the absence of current depressive symptoms and even when the individual is not in a state of rumination, but may be masked by the distinct negative impact of concurrent depressive symptoms on task performance. In summary, specific deficits in executive functions characterize adults high in trait rumination in the absence of current depression, and these appear to be distinct from general deficits characteristic of those who are currently depressed.

Trait rumination also has been associated with impaired performance on emotionally neutral tests of executive function in samples of adults with clinical diagnoses of depression. Controlling for diagnosis among patients with MDD and OCD and healthy controls, Meiran and colleagues (2011) reported that trait rumination was associated with poorer performance on a working memory updating task, and greater difficulties with preparation towards a task switch on a task switching paradigm, and did not report evidence that rumination interacted with diagnosis to predict task performance. Berman and colleagues (2011) noted a marginally significant correlation between greater rumination and lower operation span scores in a sample of adults with unipolar depression and healthy controls. In young adults with MDD and healthy controls, Levens and colleagues (2009) examined moderation of rumination-executive functions associations by diagnosis and found that trait rumination was associated with greater impairment on a dual task paradigm (specifically greater cross-task rerouting interference) among depressed participants only. In a sample of adults with depression diagnoses and healthy controls, Whitmer and Gotlib (2012b) found that trait rumination was significantly associated with deficits in inhibition of a previously relevant task set while task switching. This remained marginally significant controlling for diagnosis, and trait rumination did not interact with depression diagnosis to predict inhibitory deficits (Whitmer & Gotlib 2012b). Thus, evidence is mixed as to whether associations between task

performance deficits and trait rumination are present regardless of diagnostic status or are specific to individuals with a depression diagnosis.

Women are approximately twice as likely as men to have experienced a depressive episode, a gender difference that begins to emerge in early adolescence (Hankin et al., 1998; Merikangas et al., 2010). Therefore, it has been recommended that researchers evaluate and report potential gender differences routinely (Hankin, Wetter, & Cheely, 2008). In the study of rumination, this is of particular relevance given evidence that girls ruminate more than boys beginning in early adolescence (Jose & Brown, 2008). Davis and Nolen Hoeksema (2000) found that rumination was associated with more inflexible sorts on an advanced portion of the Wisconsin Card Sorting Task (WCST) in men, but not women. Other studies that have found evidence for an association between rumination and executive functions in adults typically have not reported controlling for gender or examining whether gender moderates hypothesized associations, even in cases where samples were predominately male or female (e.g., Altamirano et al., 2010; Whitmer & Banich, 2007). Thus, in adults, it remains unclear whether the relationship between rumination and executive functions varies based on presence of clinical diagnosis of depression or male or female gender.

Rumination and Executive Functions in Childhood and Adolescence

Compared with the adult literature, very few studies have examined the association between trait rumination and executive functions in children or adolescents. Wilkinson and Goodyer (2006) assessed sustained attention, attentional control/set shifting, and selective attention, as well as self-reported rumination and self-reported and rater-assigned depressive symptoms in a sample (age 11–17) of demographically matched healthy controls (n = 38) and treatment seeking adolescents with current unipolar depression (n = 40). Whereas associations were obtained between depression diagnosis and attentional deficits (sustained attention, attentional set shifting, and marginally significant associations with selective attention), self-reported rumination was not associated with attentional set shifting, and both rumination and attentional set shifting uniquely predicted depression diagnosis. However, this study did not examine whether diagnostic status interacted with rumination to predict attentional difficulties or control for concurrent depressive symptoms in examining the association between rumination and attention. Moreover, the study did not report associations between rumination and measured performance on tests of sustained or selective attention. Finally, whereas the authors matched depressed and non-depressed groups for gender, they did not control for gender in examining associations between rumination and executive functions and did not examine whether gender moderated outcomes. In a sample of 200 adolescents (age 12–13), Connolly and colleagues (2013) examined prospective associations between performance on tests of executive function (selective, sustained, and divided attention, set shifting, and working memory) and rumination and depressive symptoms at baseline and fifteen month follow-up. Baseline rumination (but not depressive symptoms) prospectively predicted decreases in attentional set shifting and selective attention (but not working memory or sustained or divided attention) at follow-up. Conversely, baseline performance on tests of executive function did not predict changes in rumination or depressive symptoms. This study relied on a subset of a larger longitudinal sample of youth and examined self-reported depressive symptoms but not

clinical diagnosis of depression. Moderation of rumination-executive functions associations by gender was not examined. Thus, few studies to date have examined associations between trait rumination and executive functions in adolescents, and none have examined whether such associations are moderated by gender or depression diagnosis.

Developmental Perspective

Given limited research to date, additional research employing child and adolescent samples is needed. From a clinical perspective, research examining depression and executive functions in youth may provide unique information not available from adult samples, given that youth are less likely to have experienced a prolonged course of disorder, whereas executive functions deficits observed in adults may represent “scars” of prior episodes. From a developmental perspective, it cannot be assumed that patterns of deficits observed in adults can be extended downward to unipolar depression in youth, as pre-pubertal pediatric depression may differ in important ways from post-pubertal depression that emerges in adolescence or adulthood (Avenevoli, Knight, Kessler, and Merikangas, 2008). Moreover, the adolescent transition is important in understanding vulnerability to depression, given increases in prevalence of depression and the emergence of the gender difference in depression prevalence during this time (e.g., Hankin et al., 1998). The period of entry into adolescence may be particularly important for understanding ruminative tendencies given cross-sectional evidence that rumination increases significantly between the ages of 12 and 17 (Jose & Brown, 2008).

Development of executive abilities necessary for self-regulation is also occurring at this time, and continues through young adulthood (Casey, Giedd, & Thomas, 2000; Luna & Sweeney, 2004; Steinberg, 2008). Performance on behavioral tests of executive function has indicated distinct trajectories of development for different sub-processes, which often emerge in infancy or early childhood, show different rates of development across childhood and adolescence (for reviews see Spear, 2010; Steinberg, 2008), and undergo refinement throughout adolescence and beyond (Luna & Sweeney, 2004). Development of these cognitive competencies co-occurs with ongoing structural brain maturation throughout adolescence (particularly of the prefrontal cortex and cortical association areas, as well as subcortical regions that receive projections from higher order association areas; Blakemore & Choudhury, 2006, Casey et al., 2000, 2005; Diamond 2002; Durston & Casey, 2006; Giedd et al., 1999; Giedd, 2004, 2008; Gogtay et al., 2004; Lenroot & Giedd, 2006; Poletti, 2009, Somerville & Casey, 2010; Sowell et al., 2004; Spear, 2010). Ongoing synaptic pruning and myelination reflected in increased ratio of white to gray matter across adolescent development (Casey et al., 2008), as well as increasing integrity of white matter tracts connecting frontal, parietal and subcortical regions (Asato, Terwilliger, Woo, & Luna, 2010; Casey et al., 2005; Liston et al., 2006) is observed with increasing age. Likewise, as previously noted, functional imaging during engagement in tests of executive function suggests a developmental shift occurs from childhood to adulthood, characterized by more focal or fine-tuned recruitment of regions implicated in cognitive control in conjunction with attenuated recruitment of task irrelevant regions (Brown et al., 2005; Durston et al., 2006; Luna, Padmanabhan, & O’Hearn, 2010), as well as increases in coordinated activity between neural networks (Rubia, Smith, Taylor, & Brammer, 2007), and increases in functional

connectivity between distant regions (Fair et al., 2007, 2009). Thus, during the transition from childhood to adulthood, individuals must navigate an increasingly challenging and stressful environmental context (Ge, Lorenz, Conger, Elder, & Simons, 1994; Ge, Conger, & Elder, 2001), while they do not yet possess mature executive functions necessary for self-regulation. The shift from childhood to early adolescence may be a time when the impact of preexisting individual differences in ruminative tendencies and/or executive control becomes amplified. Research is needed elucidating associations between rumination, executive functions, and depression during this important developmental period. Examining these questions in this age group is particularly important, as findings can potentially inform clinical interventions to prevent the development of ruminative tendencies in youth and/or to ameliorate the potential negative impacts of ongoing rumination and depression on executive functions.

Current Study

The first aim of the present study was to provide a snapshot of how individual differences in trait rumination relate to individual differences in executive functions in a community sample of early adolescents. This age range was thought likely to display substantial variability in trait rumination and also in performance on measures of executive function, permitting elucidation of associations between these constructs in the context of relatively low concurrent depressive symptoms. This is important as we wished to determine whether executive functions deficits are present in youth who report a tendency to ruminate, but who are not currently depressed, and thus, not likely to be actively ruminating during task completion (e.g., not in a state of rumination). If so, this would support the view that executive functions deficits contribute to a tendency to ruminate. It was hypothesized that trait rumination would significantly predict performance on tests of executive functions, controlling for concurrent depressive symptoms. Specifically, it was hypothesized that controlling for concurrent depressive symptoms, higher levels of rumination would predict poorer attentional set shifting performance and better sustained attention. This hypothesis is drawn from findings in the adult literature (Altamirano et al., 2010), which has suggested that individuals high in trait rumination may be characterized by poorer attentional flexibility and better goal maintenance than those low in trait rumination. Support for this hypothesized pattern of executive functions deficits after controlling for concurrent depressive symptoms, would be consistent with the conclusion that a tendency to ruminate habitually reflects a more general profile of cognitive inflexibility.

The second aim of this study was to examine whether impaired performance on measures of executive functions was associated with unipolar depression diagnosis or current depressive symptoms in a well-defined socioeconomically diverse and racially different community sample of male and female early adolescents. Given evidence of executive functions deficits in the acute phase of unipolar depression, we hypothesized that self-reported current depressive symptoms would impair performance on an array of tests of executive functions. In addition, we examined the profile of executive functions in adolescents with a diagnosed history of depression relative to the rest of our sample. As described below, adolescents in our sample were not recruited or selected based on risk for depression; however, following recruitment, a subset of the adolescents in our sample were identified as meeting DSM-IV

and/or RDC diagnostic criteria for a lifetime history of unipolar depression based on a well-validated semi-structured diagnostic interview. The vast majority of these adolescents were in remission and thus not currently depressed. Based upon inconsistent findings in the adult literature (Hasselbalch, Knorr, & Kessing, 2011) and a dearth of research on this question in adolescents, it was tentatively hypothesized that those with a diagnosis of depression would be characterized by specific impairments in executive functions, more circumscribed than those arising as a result of current depressive symptoms. Evidence of deficits in executive functions in those with diagnosed depression history relative to those without a history of depression would support the notion that deficits in executive functions are trait markers of the unipolar depressive disorders that may either be etiologically linked to depression or may be “scars” of prior episodes that persist into remission.

Finally, we examined whether gender, depression diagnosis, or current depressive symptoms moderated the association between rumination and executive functions. Based on preliminary findings in adults (Davis & Nolen-Hoeksema, 2000), it was expected that rumination would be more strongly associated with executive functions in boys compared with girls. This finding would be consistent with the previously suggested possibility that different factors drive a tendency to ruminate in females than males (Davis & Nolen-Hoeksema, 2000). The present study examined trait rumination, a habitual tendency to ruminate, which, as described above, is distinct from state rumination. Inducing state rumination in depressed adults has been shown to negatively impact performance on tests of executive functions (Watson & Brown, 2002). Individuals who report that they tend to ruminate and who are also concurrently depressed are likely to be in a state of rumination that will negatively impact performance on tests of executive functions. We, therefore, hypothesized that high levels of depression symptoms or depression diagnosis would interact with trait rumination to predict greater impairment in executive functions.

Methods

Participants and Procedures

Participants were recruited as part of an NIMH-funded prospective longitudinal study of the development of depressive disorders in adolescence. Participants consisted of a community sample of early adolescents. Caucasian and African American male and female adolescents and their mothers or primary female caretakers were recruited from the School District of Philadelphia and other Philadelphia area public and private middle schools. With the schools’ permission, research staff contacted the parents of enrolled students by telephone, explained the purpose of the study, and invited participation. Interested participants were screened for eligibility and invited to schedule an appointment. Advertisements through local newspapers with a study contact telephone number were used as an alternate method of recruitment. Inclusion criteria included age (age 12–13), fluency in English, and the absence of developmental, cognitive, and emotional disability that would preclude comprehension of study measures. Measures were collected during the Time 1 (T1) phase of the study. Mother-child dyads who met study inclusion and exclusion criteria were invited to complete the T1 assessment. During the T1 assessment, the following relevant information was collected. Current and lifetime history of DSM-IV-TR Axis I psychopathology in

adolescents was assessed based on integration of parent and child report on The Kiddie-Schedule for Affective Disorders and Schizophrenia-Epidemiological Version (K-SADS-E; Orvaschel, 1995). Child self-report of depressive symptoms was obtained using the Children's Depression Inventory (CDI; Kovacs, 1992). Child report on the Children's Response Styles Questionnaire (CRSQ; Abela, Vanderbilt, & Rochon, 2004) was used to assess rumination.

Working memory was assessed via the Digit Span subtest of the Wechsler Intelligence Scale for Children – Fourth Edition (WISC-IV; Wechsler, 2003). Components of attention, including auditory sustained attention, selective attention, attentional set shifting, and divided attention were assessed via subtests from the Test of Everyday Attention for Children (TEA-Ch; Manly et al., 2001). Demographic information was obtained via parent questionnaire. Initially, mothers and adolescents completed informed consent and assent, respectively, and were each reimbursed $30 as a thank you for their time. The current study was comprised of youth and their mothers who completed T1 (N = 486), including 256 females and 230 males. The sample was racially different, with 48.8% of participants identifying as Caucasian (*n* =237), 47.1% as African American (*n* = 229), and 4.2% as Biracial, multiracial, or other (*n* = 20). In addition, 44.7% of participants came from lower (N =258; 44.7%) SES households. Of adolescents who met criteria for unipolar depression (*n* = 68), 11 (16.18%) met criteria for a current depressive episode (8 major depression, 1 minor depression, 2 dysthymia) and an additional 57 participants met criteria for a past (but not current) episode of depression currently in remission (42 major depression, 10 minor depression, 2 dysthymia, 2 depression not otherwise specified).

Measures

Demographic Information—Demographic information was assessed via parent self-report questionnaire. Parents were asked to report parents' years of education, family income, child eligibility for school lunch, and their own age, race and ethnicity and that of their child. Given that all individuals in the sample identified as (1) white or European, (2) African American, or (3) Biracial, or Multiracial, two dummy variables were created for race (Dummy variable Race 1: African American = 1, Not African American = 0; Dummy variable Race 2: Biracial or multiracial = 1, Not Biracial or Multiracial = 0) and used in all analyses controlling for race. A single dichotomous SES variable was computed based on parent reported income and child eligibility for school lunch. Those in the top three brackets (with a household income of $60,000 and higher) were coded as high in SES; those in the bottom three brackets (with a household income under $50,000) were coded as low in SES, and those in the middle income bracket (with a household income of $45,000–59,000) were coded as of high SES unless they reported eligibility for school lunch (45.3% of those in this income bracket reported eligibility for school lunch), in which case they were coded as low in SES.

Executive Functions - Attention—Executive functions, including selective attention, sustained attention, divided attention, and attentional set-shifting were assessed via the Test of Everyday Attention for Children (TEA-Ch; Manly et al., 2001). The TEA-Ch assesses the attentional capacities of youths age 6 to 16. It is a game-like test that was designed to

provide an ecologically valid measure of attention. The TEA-Ch has demonstrated a 3-factor structure across multiple studies and cultural contexts. Specifically, 3 latent factors corresponding to the theoretical constructs of sustained and selective attention and attentional control/switching have been identified through confirmatory factor analysis (Manly et al., 2001). The test has demonstrated satisfactory test-retest reliability in over a 5–20 day interval (*r*s .64–.92; Manly et al., 2001). It also has demonstrated satisfactory convergent (with measures of selective attention; Manly et al., 2001) and discriminant validity (WISC and WRAT subtests; Manly et al., 2001). Consistent with previous research (Wilkinson & Goodyer, 2006), TEA-Ch raw scores were transformed to age and gender-scaled scores. Scores were derived from a normative sample, with a mean of 10 and a standard deviation of 3. This conversion was made to render means more easily interpretable, to facilitate comparison with previous research findings and across adolescents of different ages and gender, and to convert the data to a normal distribution appropriate for multiple regression. Thus, for each of the following subtests, higher scores are indicative of better performance.

Attentional Set Shifting: Attentional Creature Counting is a subtest assessing ability to shift attention. Children are instructed to count the number of "creatures in their burrow," and count visually presented pictures of creatures interspersed along a winding path. In order to do so, they must alternate/switch between counting forwards and backwards (from 1 up to 12 and vice versa) in response to visual cues (pictures of upwards and downwards arrows interspersed among the "creatures"). This subtest thus requires inhibition of no-longer-relevant task sets, shifting to new and previously inhibited task sets, and inhibition of prepotent mental sequencing. Difficulty on this task reflects difficulty flexibly shifting attention from one goal or task to another. This subtest yields an accuracy score (number of correctly counted trials out of 7), with higher scores indicating greater accuracy, as well as a set shifting time score (completion time scores for correct trials), with higher scores indicating shorter completion time (e.g., better performance). Examination of the data indicated that 7% of the data were missing scores for set shifting time. The missingness for this variable can be explained by the fact that the TEA-Ch manual specifies that set shifting time cannot be calculated for those with raw set shifting accuracy scores lower than 3. Due to the high level of missingness, including systematic missingness as a function of set shifting accuracy, and consistent with previous research (Wilkinson & Goodyer, 2006), rather than excluding participants with low set shifting accuracy scores from analyses, analyses employed accuracy (not time) as the primary measure of set shifting.

Selective Attention: Selective attention was assessed via Sky Search, a sub-test of the TEA-Ch involving a timed visual search task requiring inhibition of irrelevant visual stimuli. Children are required to view an array of 128 pairs of space ships and are instructed to find and circle targets (pairs of matching space ships) while ignoring very similar distracters (pairs of dissimilar space ships) and instructed to work as quickly as possible. A second, motor control condition requires children to circle targets as quickly as possible in the absence of distracters, providing a control for individual differences in psychomotor speed. This subtest yields measures of selective attention accuracy (number of the 20 possible targets correctly identified), time per target, and an Attention score which subtracts the ratio

of targets found to time elapsed in the motor control condition (containing no distractors) from the selective attention condition (containing distractors). The Attention score was used as a measure of selective attention for the current study, as it controls for individual variability in motor speed. Adolescents who have trouble with selective attention may have difficulty disregarding irrelevant information or ignoring distractions and staying on task.

Sustained Attention: Auditory sustained attention was assessed via Score, a TEA-Ch task, which consists of a 5.5 minute audio recording of identical tones (ranging from 9 to 15) presented at irregular intervals in 10 trials of variable length. Children are asked to count silently the scoring sounds and to tell the recorder how many sounds they heard when a siren sound signals the end of a trial. Performance on this task reflects ability to focus attention and remain consistently on-task for a prolonged period of time. Difficulties with sustained attention can impact performance on many real-world tasks, from reading the newspaper to following a teacher's instructions in a classroom.

Divided Attention: Sky Search Dual Task is a cross-modal dual task test requiring sustained and divided attention. Children, who have previously completed Score and Sky Search Subtests, simultaneously perform both tasks. Children circle targets (matching ship pairs) while ignoring distractors (dissimilar ship pairs), and provide a count of the number of scoring sounds when a siren signals the end of each trial. This task yields a dual task decrement score, computed by subtracting the time per target score for Sky Search DT from the time per target score for Sky Search. Difficulties with divided attention would be likely to impact an individual's ability to effectively multi-task in the real world.

Executive Functions – Working Memory—The WISC-IV has been standardized and normed for children age 6 to 18. The digit span subtest assesses auditory-verbal working memory. In the "forward" condition, children are instructed to listen to and then repeat a series of numbers presented at approximately 1 second intervals. In the "backwards" condition, children are asked to repeat the numbers in reverse order. Raw scores from the two conditions were summed to create a total score and transformed to age scaled scores with a mean of 10 and a standard deviation of 3. Outside of the laboratory, difficulties with working memory may translate into inability to remember phone numbers, conversations, or instructions delivered by a teacher, or perform mental math, problem solve, or plan ahead.

Lifetime History of Depression—Lifetime history of unipolar depression diagnosis was assessed via the Kiddie – Schedule for Affective Disorders and Schizophrenia – Epidemiological Version (K-SADS-E; Orvaschel, 1995). The K-SADS-E is a semi-structured diagnostic interview that assesses current and lifetime Axis I disorders in youth based on Diagnostic and Statistical Manual of Mental Disorders – Fourth Edition criteria (DSM-IV-TR; APA, 2000). Interviewers interviewed mothers before youth and then assigned summary symptom and diagnostic ratings based on integrated parent and child report. Given evidence of disagreement between parent and child report of symptoms and lack of current consensus on how to integrate discrepant parent and child reports, summary ratings were based on the interviewer's 'best-estimate' clinical judgment (e.g., Cantwell, Lewinsohn, Rohde, & Seeley, 1997). The K-SADS-E is a well-validated diagnostic measure

that has demonstrated good inter-rater and retest reliability (Orvaschel, 1995), with κ's of .73 and .72 for Major Depression and Dysthymia, respectively, .63–.75 for anxiety disorders, and .51–.77 for other disorders (Orvaschel, 1995). Interviewers were Clinical Psychology postdoctoral fellows and Ph.D. students, and trained research staff with Clinical or Counseling Masters degrees or BAs. Interviewers participated in a 2-day intensive training session led by Dr. Orvaschel, a creator of the K-SADS-E and completed ~200 hours of instruction on diagnostic assessment methods, including didactics, exposure to case vignettes and videotaped interviews, and role-playing. They observed and conducted live interviews with supervision and feedback prior to commencing independent interviewing. Inter-rater reliability (based on 120 pairs of ratings consisting of 5 raters for each of 24 diagnoses from 10 K-SADS interviews) was κ = .85.

Current Depressive Symptoms—Current depressive symptoms were assessed via the Children's Depression Inventory (CDI; Kovacs, 1992) is a self-report measure of depressive symptoms in children and adolescents (age 7–17). Participants rated 27 items, assessing affective, behavioral, and cognitive symptoms of depression on a 3-point scale (0 = "never," 1 = "sometimes," 2 = "always"). Ratings were summed, yielding total scores ranging from 0 to 54, with higher scores indicating higher depressive symptoms. In previous research, scores on the CDI have demonstrated good internal consistency (Abela, Brozina, & Haigh, 2002) and acceptable test-retest reliability (Smucker, Craighead, Craighead, & Green, 1986), as well as convergent (Shain, Naylor, & Alessi, 1990) discriminant (Timbremont, Braet, & Dreessen, 2004) validity. The CDI demonstrated good internal consistency in the current sample (α = .85).

Trait Rumination—Trait rumination was assessed via the Children's Response Styles Questionnaire (CRSQ; Abela et al., 2004) is a 25-item self-report questionnaire that asks participants to rate the frequency of thoughts and feelings when sad on 4-point scales of never, sometimes, often, or almost always. Responses are summed to yield total scores, with higher scores representing greater tendency to ruminate, distract, or problem solve. The rumination subscale used in the current study consists of 13 items indicating self-focused responses to depressed mood. In previous research CRSQ rumination scale scores have demonstrated validity and moderate internal consistency in youth of the age range of our current sample (Abela et al., 2002) as well as adequate test-retest reliability over a onemonth interval (Abela, Aydin, & Auerbach, 2007). The rumination subscale demonstrated good internal consistency in the current sample (α = .87)

Results

Descriptive Statistics

Variable means and standard deviations and bivariate correlations are presented in Table 1. With regard to associations between demographic variables and predictor and outcome variables of interest, age was not significantly associated with rumination or CDI scores (*p*s > .08). Girls (*M* = 25.22, *SD* = 8.25) had marginally higher rumination scores than boys (*M* = 23.91, *SD* = 7.22), *t*(480) = −1.31, *p* = .067) and significantly higher CDI scores (*M* = 7.74, *SD* = 6.85) than boys (*M* = 6.58, *SD* = 4.94), *t*(483) = −2.14, *p* = .03). Independent

samples t-tests indicated that participants of high SES did not differ from those of low SES on measures of rumination or CDI scores (all *p*s > .36). A one-way ANOVA examining racial group differences yielded no significant differences between groups with regard to rumination or CDI scores (*p*s > 0.51). Independent samples t-tests indicated that children with a current or lifetime history of unipolar depression did not differ in age ($p = .51$). Chi-square analyses indicated child diagnostic status was independent of gender, $\chi^2(2) = .94$, $p = .19$, and SES, $\chi^2(2) = .06$, $p = .90$.

Some gender differences were observed in performance relative to same-age same-gender peers. Girls ($M = 7.95$, $SD = 2.38$) performed significantly better than boys ($M = 7.4$, $SD = 2.68$) on divided attention, $t(474) = -2.34$, $p = .02$). In addition, girls ($M = 10.32$, $SD = 2.88$) outperformed boys ($M = 9.37$, $SD = 3.13$) on working memory, $t(459) = -3.41$, $p = .001$). Girls ($M = 9.74$, $SD = 3.02$) likewise performed marginally significantly better than boys ($M = 9.23$, $SD = 3.11$) on sustained attention, $t(483) = -1.84$, $p = .07$.

Adolescents of high SES ($M = 10.07$, $SD = 2.88$) performed significantly better than those of low SES ($M = 9.29$, $SD = 3.22$) on measures of set shifting accuracy, $t(471) = -2.76$, $p = .006$. Those of high SES ($M = 9.75$, $SD = 3.05$) performed marginally significantly better than those of low SES ($M = 9.26$, $SD = 3.09$) on the test of sustained attention, $t(472) = 1.72$, $p = .09$. Age was significantly associated with sustained attention ($r(483) = -.20$, $p = .000$) and working memory ($r(459) = -.13$, $p = .006$) scaled scores. A one-way ANOVA examining racial group differences yielded significant findings for set shifting accuracy, ($F(2, 481) = 8.54$, $p = .000$) and sustained attention ($F(2, 482) = 3.88$, $p = .02$). Bonferroni post-hoc tests indicated significantly better performance among Caucasian ($M = 10.19$, $SD = 2.82$) relative to African American ($M = 9.08$, $SD = 3.29$) participants on tests of set shifting accuracy (Mean difference = 1.11; Standard Error = .28; $p = .000$; 95% CI = .43–1.79). Likewise, significantly better performance was observed among Caucasian ($M = 9.89$, $SD = 2.89$) relative to African American ($M = 9.14$, $SD = 3.18$) participants on tests of sustained attention (Mean difference = .75; Standard Error = .28; $p = .03$; 95% CI = .07–1.42). Given these findings, primary analyses controlled for demographic variables, including age, race, SES, and gender. All analyses used the full sample (N=486), with the exception of analyses for hypothesis 2, which was limited to adolescents with depression diagnosis in remission (N = 57) and those with no depression diagnosis (N = 418).

Primary Analyses

Rumination and Depressive Symptoms Predicting Executive Functions—To test hypothesis 1, a series of five hierarchical linear regression analyses were used to predict executive functions. This analytic approach is consistent with that of similar prior cross-sectional studies in the adult literature (e.g., Altamirano et al., 2010), which have typically examined whether rumination significantly predicts executive functions (EF) task performance, controlling for the impact of current depressive symptoms. Controlling for the impact of current CDI scores on EF is important given previous evidence that current depressive symptoms may impact EF task performance in a way that masks the unique associations between trait rumination and EF task performance (e.g., Altamirano et al., 2010).

Demographic variables were entered in Step 1, CDI scores in Step 2, and rumination was entered in Step 3. A Bonferroni correction was used to control for familywise error (criterion alpha = .008). Results are summarized in Table 2. As can be seen in Table 2, rumination did not significantly predict executive functions (all *p*s ≥ .05), with or without controlling for concurrent depressive symptoms. A single marginally significant positive association was obtained, with higher levels of rumination predicting better set shifting performance. This was the case controlling for depressive symptoms (β = .10, *p* = .05) and when depressive symptoms were not controlled (β = .09, *p* = .04). As presented in Table 2, CDI scores did not predict EF task performance after controlling for demographic covariates (all *p*s ≥ .06). The model in Table 2 is reported with nonsignificant covariates retained in the model; however, no change in significance was observed after removing CDI scores and/or nonsignificant demographic covariates from Steps 1 and 2, indicating that findings are not attributable to controlling for CDI scores or retention of nonsignificant covariates. A second regression analysis was run, examining whether CDI scores predicted executive functions after controlling for rumination. Demographic covariates were entered in Step 1, rumination in Step 2, and CDI scores in Step 3. Results are presented in Table 3. CDI scores did not significantly predict measures of EF controlling for rumination. After controlling for rumination, a single marginally significant negative association was obtained, with higher levels of depressive symptoms predicting poorer sustained attention (β = −.13, *p* = .01).

Executive Functions and Lifetime History of Depression—To test hypothesis 2, a hierarchical logistic regression was used to predict adolescent diagnostic status (presence versus absence of a lifetime history of unipolar depression in remission). For these analyses, we omitted the 11 adolescents with current diagnosis of depression, as we were interested in examining profiles of executive functions among those who had previously experienced depression, but were currently in remission. Demographic variables were controlled in Step 1, and measures of EF (selective attention, sustained attention, set shifting, divided attention, and working memory) were entered simultaneously in Step 2. All demographic covariates were non-significant (*p*s >.18) and were therefore not retained in the model. Results are presented in Table 4. No measures of executive functions predicted diagnosis (all *p*s > .16).

Moderation by Gender, Current Depressive Symptoms, and Depression Diagnosis—Separate hierarchical linear regressions were conducted to examine whether gender moderated rumination-executive functions associations. Depressive symptoms and demographic covariates were controlled in Step 1, rumination (mean centered) and gender were entered in Step 2, and the interaction term (computed using gender and the mean centered measure of rumination) was entered in Step 3. A Bonferroni correction was used to control for familywise error (criterion alpha = .008). Significant findings (presented in Table 5) were obtained only with regard to set shifting accuracy. Specifically, after entering covariates in Step 1, rumination (mean centered) and gender in Step 2, and the interaction term in Step 3, a marginally significant main effect for rumination was obtained in Step 2 (β = .10, *p* = .05), resulting in a marginally significant increase in the predictive power of the model, $F(2, 461) = 3.17$, $p = .04$. The addition of the interaction term in Step 3 resulted in a statistically significant increase in the predictive power of the model, R^2 change = .026, $F(1, 460) = 12.82$, $p = .000$, and gender significantly moderated the association between

rumination and set shifting accuracy (β = −.26, *p* = .000). The results of the final model indicate that all predictors explained 8.3% of the variance (R^2 = .083, *F*(8,460) = 5.23, *p* = .000) in set shifting.

To elucidate the nature of the interaction, separate multiple regressions were run for males and females, predicting to set-shifting, with depressive symptoms and demographic covariates entered in Step 1 and rumination in Step 2. Results are presented in Table 6. Among females, rumination did not significantly predict set shifting accuracy (β = −.07, *p* = .45). A different pattern of findings was obtained among males. The addition of rumination in Step 2 was significant (β = .28, *p* = .000), such that higher levels of rumination predicted greater set shifting accuracy, resulting in a significant increase in the predictive power of the model, R^2 change = .07, *F*(1, 216) = 16.07, *p* = .000. Predictors explained 11.6% of the variance (R^2 = .116, *F*(6,215) =4.69, *p* = .000) in set shifting among males. Importantly, removing CDI scores from Step 1 did not result in any increase in significance of prediction for set shifting accuracy for females (β = −.05, *p* = .45), indicating it is not simply controlling for CDI scores that resulted in non-significant findings for females

Separate hierarchical linear regressions were conducted to examine whether child diagnostic status interacted with rumination to predict each measure of executive function. Gender was controlled in Step 1, rumination (mean centered) and diagnosis were entered in Step 2, and the rumination X diagnosis interaction term in Step 3. A Bonferroni correction was used for familywise error (alpha correction = .008). Diagnosis did not significantly moderate rumination-EF associations (all *p*s > .09).

Given the relatively low levels of depressive symptoms in our overall sample of adolescents and the primarily remitted nature of the sample of individuals with history of depression diagnosis, we additionally explored whether rumination predicted impairments in EF among youth relatively high in current depressive symptoms (CDI cut-off scores ≥13) versus those who were not (CDI scores < 13). Separate hierarchical linear regressions were conducted to examine whether current depression moderated rumination-executive functions associations. Demographic covariates were controlled in Step 1, rumination (mean centered) and current depression were entered in Step 2, and the interaction term (computed using depression category and the mean centered measure of rumination) was entered in Step 3. A Bonferroni correction was used to control for familywise error (criterion alpha = .008). Significant findings (presented in Table 7) were obtained only with regard to sustained attention. The addition of the interaction term in Step 3 resulted in a statistically significant increase in the predictive power of the model, R^2 change = .026, *F*(1, 461) = 13.24, *p* = .000, with current depression significantly moderating the association between rumination and sustained attention (β = −.23, *p* = .000). The results of the final model indicate that all predictors explained 8.7% of the variance (R^2 = .087, *F*(8,461) = 5.48, *p* = .000,) in sustained attention.

To elucidate the nature of this interaction, separate multiple regressions were run among those high versus low in current depressive symptoms (Table 8). Demographic covariates were entered in Step 1 and rumination in Step 2. Among those with high current depressive symptoms, rumination significantly predicted sustained attention, such that higher levels of rumination predicted worse sustained attention (β = −.30, *p* = .007), resulting in a significant

increase in the predictive power of the model, R^2 change = .08, $F(1, 74) = 7.66$, $p = .007$. The results of the final model indicate that all predictors explained 22.8% of the variance ($R^2 = .228$, $F(6,74) = 3.65$, $p = .003$) in sustained attention. Among those low in depressive symptoms, rumination significantly predicted sustained attention such that higher levels of rumination predicted better sustained attention ($\beta = .15$, $p = .003$), resulting in a significant increase in the predictive power of the model, R^2 change = .022, $F(1, 382) = 8.89$, $p = .003$. The results of the final model indicate that all predictors explained 6.6% of the variance ($R^2 = .066$, $F(6,382) = 4.50$, $p = .000$) in sustained attention.

Discussion

While executive functions deficits have been linked with both depression and rumination in adults, the nature of the relationship between these constructs is not well understood and remains understudied in adolescence. The present study examined the relationship of rumination and depression to deficits in executive functions in early adolescence, a critical developmental period for the emergence of depression and rumination and the development of executive functions. Evidence exists linking deficits on emotionally neutral tests of executive functions with rumination in adults (e.g., Altamirano et al., 2010; Whitmer & Banich, 2007), but only a few studies have examined whether children or adolescents who ruminate exhibit similar patterns of impairment, and these have yielded inconsistent findings (Connolly et al., 2014; Wilkinson & Goodyer, 2006). Although adults with diagnoses of unipolar depression have been found to exhibit executive functions deficits during the acute phase of the disorder, evidence in younger samples is inconsistent (e.g., Baune et al., 2012; Cataldo et al., 2005; Frost et al., 1989; Gunther et al., 2011, 2004; Kyte et al., 2005; Maalouf et al., 2011; Micco et al., 2009; Wilkinson & Goodyer, 2006), and it is unclear whether observed deficits are state dependent, normalizing when depression remits, or are trait markers of the disorder that persist beyond remission (Hasselbalch, Knorr, & Kessing, 2011). This question remains almost completely unexamined in youth.

The primary aim of this study was to examine whether adolescents high in trait rumination exhibited impairments in executive functions. It was hypothesized that, controlling for depressive symptoms, higher levels of trait rumination would significantly predict poorer attentional set shifting and better sustained attention. Support was not obtained for this hypothesis. Higher levels of rumination marginally significantly predicted better set shifting performance, but no significant associations between rumination and executive functions were obtained. It was further hypothesized that differential patterns of association between impairments in executive functions and depressive symptoms versus rumination might emerge. No support was obtained for this hypothesis. Depressive symptoms marginally significantly predicted worse sustained attention, whereas rumination marginally significantly predicted better set shifting performance, but no significant associations were obtained between rumination or depressive symptoms and executive functions.

Second it was hypothesized that current depressive symptoms would impair performance across a range of tests of executive functions, whereas youth with a depression diagnosis currently in remission would exhibit evidence of more circumscribed deficits in executive functions. No support was obtained for this hypothesis. Controlling for rumination, higher

depressive symptoms marginally significantly predicted poorer sustained attention, but depressive symptoms did not significantly predict performance on any measure of executive functions. Likewise, executive functions task performance did not predict depression diagnosis. Finally, we explored whether gender or depressive symptoms or diagnosis moderated rumination-executive functions associations. It was hypothesized that gender would moderate rumination – executive functions associations, such that rumination would be more strongly associated with executive functions in boys than girls. Partial support was obtained for this hypothesis, but the direction of associations was the opposite of that expected. Specifically, controlling for current depressive symptoms, higher levels of rumination predicted better set shifting performance among boys only. It was hypothesized that depression would moderate rumination – executive functions associations, such that rumination would predict greater impairments in executive functions among youth with depression. Only partial support was obtained for this hypothesis. Depression diagnosis did not moderate outcomes. However current depressive symptoms moderated the impact of trait rumination on sustained attention, such that higher levels of rumination significantly predicted *better* sustained attention among those with lower current symptoms of depression and significantly predicted *worse* sustained attention among those with higher current symptoms of depression. Several findings warrant additional attention.

With regard to the relationship between rumination and executive functions, the findings are not consistent with previous research in adults, which has suggested possible associations between trait rumination and cognitive inflexibility, attentional switching and inhibition of previously relevant task sets (e.g., Altamirano et al., 2010; Davis & Nolen-Hoeksema, 2000; Owens & Derakshan, 2013; Whitmer & Banich, 2007; Whitmer & Gotlib, 2012b). We found only a few associations between trait rumination and measures of executive functions, and these emerged only in interaction with other variables. Specifically, controlling for depressive symptoms, rumination predicted *better* set shifting performance in boys only. Likewise, rumination predicted *better* sustained attention among individuals with lower levels of current depressive symptoms. At the same time, among individuals with higher levels of current depressive symptoms, rumination predicted *worse* sustained attention. These findings should be interpreted with caution, given small effect sizes and the few numbers of significant associations obtained. However, a possible interpretation of these findings would be that trait ruminators have a particular cognitive profile that may render them *better* at performance on some executive functions tasks (Altamirano et al., 2010) and that they only exhibit broader deficits in executive functions when they are actively depressed and, thus, engaging in rumination during task completion.

From a theoretical perspective, the findings are potentially consistent with Whitmer and Gotlib's (2012a) recently formulated attentional scope model, which posits trait ruminators are characterized by a narrowed attentional scope, which may facilitate performance on tasks requiring that they ignore distracting, irrelevant information and impair performance only on more complex tasks requiring broad attention (Whitmer & Gotlib, 2012a). The findings are also potentially consistent with Alloy and Abramson's (2007) biocognitive vulnerability-stress model of depression, which embeds the cognitive vulnerability-stress model within the context of normative cognitive and brain development in adolescence. This

view suggests that normative brain maturation, including maturation of prefrontal cortex and concomitant normative cognitive development of self-regulatory executive functions (sustained and selective attention and executive control over attentional switching as well as working memory) serve as a prerequisite for adolescents to engage in rumination. The present study focused on individual differences in trait rumination and executive functions in a sample of adolescents, many of whom are poised to develop first onset of depression, but the majority of whom have not done so. Thus, it was not possible to test longitudinal associations or examine the causal relationship between development of executive functions and development of trait rumination over time. However, the direction of associations between executive functions and trait rumination is consistent with this formulation.

A resource depletion account of rumination would predict that rumination would predict widespread difficulties on executive functions tasks (for further discussion, see Whitmer & Gotlib 2012a). Because individuals who endorse high levels of trait rumination and are also experiencing depressed mood are likely to be actively ruminating (Whitmer & Gotlib, 2012a), our finding that trait rumination predicted worse sustained attention among those with high current depressive symptoms is potentially consistent with this account. It is surprising that this was evident only on the sustained attention task. However, in most of the TEA-Ch tasks, the test administrator elicits responses relatively frequently and engages frequently with the adolescent being tested. The sustained attention task is an exception to this, as it involves long durations of time in which the adolescent is simply asked to listen and count sounds at prolonged intervals with no redirection of attention by the administrator. This particular task may have been particularly conducive to mind wandering and rumination for those in a state of active rumination, and the finding that ruminators exhibited better performance on this task under low levels of depressive symptoms is consistent with evidence in adults that trait ruminators who are not depressed show enhanced performance on a task requiring goal maintenance relative to controls (Altamirano et al., 2010). The finding that trait rumination was not associated with worse set shifting performance is the most inconsistent with previous literature that has identified cognitive inflexibility as a characteristic of trait ruminators in adult samples (e.g., Whitmer & Banich, 2007). However, this may be attributable to features of the particular set shifting task employed in this study, which involved frequent engagement by the administrator and did not permit differentiation of inhibitory and switching deficits. An additional limitation of this task was the necessity of excluding set shifting time from the primary analyses because of systematic missingness due to the large number of participants whose performance on this variable could not be scored due to their low set shifting accuracy scores. This limitation was also noted by the only other study to examine TEA-Ch performance and rumination in adolescents (Wilkinson & Goodyer, 2006).

The present study had several limitations. These include its correlational nature and reliance solely on a selfreport measure of rumination. Studies using rumination-induction paradigms have documented impairments in executive function following rumination induction among depressed adults (e.g., Watkins & Brown, 2002). The current findings on correlates of trait rumination cannot speak to whether induced rumination may result in broad impairments in executive functions in depressed youth. Additional limitations include previously discussed features of the measures of executive functions, as well as low numbers of adolescents

meeting criteria for current depression diagnosis. The emphasis of this study was on individual differences in rumination and whether these are associated with individual differences in executive functions in early adolescents.

Despite limitations, the present study had a number of strengths. It addressed a current gap in knowledge of the relationship between executive functions and rumination in early adolescence. It employed a large diverse sample of early adolescents. Moreover, it used behavioral measures of executive functions and a well-validated semi-structured diagnostic interview to diagnose depression. Such strengths allowed the study to provide important preliminary findings on the relationship between rumination, diagnoses and symptoms of depression, and executive functions in this age group.

The study findings suggest a number of directions for future research. Research is needed using larger sample sizes of adolescents who meet criteria for current unipolar depression diagnoses, to clarify the degree of executive functions deficits characterizing full-blown depression in this age range. In addition, use of more fine-grained measures of executive functions is needed to permit differentiation of inhibitory and set switching deficits and set shifting latency in relationship to trait rumination in adolescents. This will help to clarify whether the deficits previously identified in adult ruminators (Whitmer & Gotlib, 2012a) are present in youth who ruminate. Likewise, research is needed using rumination-induction paradigms in early adolescents to examine the impacts of induced rumination on executive functions in early adolescence. Finally, prospective longitudinal research is needed integrating examination of rumination, clinically significant depression, and development of executive functions across adolescence. Such research can examine whether within-subject developmental changes in executive functions prospectively predict within-subject changes in levels of trait rumination and depression status over time (or vice versa) in order to clarify temporal and causal relationships between these constructs with the emergence of depression and its associated gender difference.

Conclusions

The present study contributed to understanding of profiles of executive functions characterizing adolescents high in trait rumination and depression. Building on scant existing research examining rumination and executive functions in adolescence (Connolly et al., 2010; Wilkinson & Goodyer, 2006), this is the first study to examine associations between symptoms and diagnoses of unipolar depression, rumination, and performance on tests of executive functions (selective attention, sustained attention, divided attention, attentional set shifting, and working memory) in a large, non-treatment-seeking community sample of early adolescents and to explore the potential role of gender and depression diagnosis and symptoms as moderators of rumination-executive functions associations in this sample.

No evidence was found for impairments in executive functions in the absence of current depression. Thus, the study findings do not support the hypothesis that executive functions persist for previously depressed adolescents following remission. Rather, the findings support the idea that impairments in executive functions (particularly sustained attention)

may be state-dependent, and further that they may be evident only in adolescents who ruminate when depressed.

This study identified correlates of trait rumination in early adolescents. The findings suggest that, among adolescent boys, a tendency to ruminate is characterized by better ability to shift attentional set. In contrast, among adolescents who are currently experiencing depression (and thus likely to be in a state of rumination), those who tend to ruminate experience greater difficulties with sustained attention. Evidence of moderation by gender suggests the possibility that different factors drive the development of a tendency to ruminate in adolescent males versus females, a possibility in need of further exploration. In this early adolescent sample, trait rumination was not characterized by the executive functions deficits that have been documented in adult samples (Altamirano et al., 2010; Whitmer & Banich, 2007). Rather, the findings suggested the possibility that, among early adolescents who are not currently depressed, trait rumination may be associated with *better* performance on some tasks. This finding is potentially consistent with the proposal that developmental increases in cognitive competencies may serve as prerequisites for the development of rumination in adolescence (Alloy & Abramson, 2007); however, prospective longitudinal research is needed to further test this possibility. The findings from this and future research may be used to inform interventions to interrupt the development of ruminative tendencies or to help manage or reduce the impacts of depression and rumination on adolescents' functioning. The present study suggests that, in the absence of depression, male adolescents who tend to ruminate may actually experience stronger performance on some cognitive tasks. At the same time, depressed adolescents who tend to ruminate may benefit from interventions targeting difficulties with sustained attention.

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Table 1

Correlations Between Continuous Measures

	Measure	Mean (SD)	1	3	4	5	6	7	8	9
1	Age	12.88 (0.62)	-							
3	Selective Attention	10.04 (2.7)	0.00	-						
4	Sustained Attention	9.5 (3.07)	−0.20***	0.10*	-					
5	Set Shifting Accuracy	9.68 (3.09)	0.08†	−0.06	0.14**	-				
6	Set Shifting Time	8.45 (2.6)	−0.05	0.21***	0.19***	0.13**	-			
7	Divided Attention	7.69 (2.54)	−0.06	−0.19***	0.16***	0.15***	0.10*	-		
8	Working Memory	9.87 (3.03)	−0.13**	0.11*	0.23**	0.16***	0.24***	0.10*	-	
9	Depressive Symptoms CDI	7.19 (6.04)	0.00	0.02	−0.08†	0.03	−0.01	0.04	−0.07	-
10	CRSQ – Rumination	24.60 (7.8)	0.00	−0.03	0.03	0.09†	−0.02	0.09*	−0.03	0.49***

*** $p < .001$,

** $p < .01$,

* $p < .05$,

† $p < .10$

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Table 2

Rumination Predicting Selective, Sustained, Divided Attention, Set Shifting, and Working Memory

	Selective Attention		Sustained Attention		Divided Attention		Set Shifting		Working Memory	
	ΔR^2	**β**	**ΔR^2**	**β**	**ΔR^2**	**β**	**ΔR^2**	**β**	**ΔR^2**	**β**
Predictor										
Step 1	.006		.053**		.019		.049**		.058**	
Gender		.06		.07		0.12††		0.07		.16**
Age		.00		−.17**		−.06		.11††		−.11††
Race (1)		−.05		−.09		−0.02		−.16*		−.03
Race (2)		−.02		−.06		−0.02		0.03		−.05
SES		.01		.03		−0.03		.05		.10††
Step 2	.000		.007		.001		.001		.006	
CDI		.02		−.08		0.03		.03		−.08
Step 3	.002				.007		.008††		.000	
Rumination		−.05		.10		0.09		.10††		−.01
Total R^2	.008		0.067		.026		.064		.058	
Adjusted R^2	−.007		.053		.011		.049		.043	
F (df)	.549(7,460)		4.73(7,462)**		1.76 (7, 454)		4.04(7, 461)**		4.31(7, 441)**	

Note. CDI = Children's Depression Inventory Scores. Rumination = Children's Response Styles Questionnaire Scores. Race (1) and Race (2) = dummy coded race variables. SES = socioeconomic status.

†† $p \leq .05$,

† $p \leq .01$,

* $p \leq .008$,

** $p \leq .001$

Table 3

CDI Scores Predicting Selective, Sustained, Divided Attention, Set Shifting, and Working Memory

	Selective Attention		Sustained Attention		Divided Attention		Set Shifting		Working Memory	
	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Predictor										
Step 1	.006		.053**		.019		.049**		.058**	
Gender		.06		.07		0.12†		0.07		.16**
Age		.00		−.17**		−.06		.11††		−.11††
Race (1)		−.05		−.09		−0.02		-.16*		−.03
Race (2)		−.02		−.06		−0.02		0.03		−.05
SES		.01		.03		−0.03		.05		.10††
Step 2	.001				.007		.008††		.002	
Rumination		−.03		.04		0.09		.09††		−.04
Step 3	.001		.013†		.000		0.001		.004	
CDI		0.04		−.13†		−.02		−.03		−.07
Total R^2	.008		.067		.026		.058		.064	
Adjusted R^2	−.007		.053		.011		.043		.049	
F (df)	4.73(7,462)		.549(7,460)		1.76(7,454)		4.04(7, 461)		4.31 (7 ,441)	

Note. CDI = Children's Depression Inventory Scores. Rumination = Children's Response Styles Questionnaire Scores. Race (1) and Race (2) = dummy coded race variables. SES = socioeconomic status.

†† $p \leq .05$,

† $p \leq .01$,

* $p \leq .008$,

** $p \leq .001$

Table 4

Executive Functions Predicting Depression Diagnosis in Remission

	χ^2	df	B(SE)	Wald	OR	95% CI
Predictor						
Step 1	6.71	5				
Selective Attention		1	.04(.06)	.51	1.04	.93–1.16
Sustained Attention		1	−.06(.05)	1.21	.95	.86–1.04
Divided Attn		1	.06(.06)	1.13	1.07	.95–1.20
Set Shifting		1	−.05(.05)	1.26	.96	.86–1.04
Working Memory		1	−.08(.05)	2.00	.93	.83–1.03
Overall χ^2	6.71	5				
N	437					

Note. CDI = Children's Depression Inventory Scores. Selective Attn = TEACH Selective Attention Score. Sustained Attn: TEACH Sustained Attention Score. Divided Attn = TEACH Dual Task Decrement Score. Set Shifting = TEACH Creature Count Accuracy Score. Working Memory: WISC Digit Span Total Score.

$^{\dagger}p < .10$,

$^{*}p < .05$,

$^{**}p < .01$,

$^{***}p < .001$.

Table 5

Gender Moderating Rumination-Set Shifting Associations

	ΔR^2	B	SE	β
Predictor				
Step 1	.044**			
CDI		.02	.02	.03
Race(1)		−1.02	.32	−.16**
Race(2)		.45	.73	.03††
SES		.30	.31	.05
Step 2	.013††			
CDI		−.01	.03	−.03
Race(1)		−1.05	.32	−.17
Race(2)		.53	.73	.03
SES		.27	.31	.04
Gender		.40	.28	.07
Rumination		.04	.02	.10††
Step 3	.026**			
CDI		.00	.03	.01
Race(1)		−1.02	.32	−.16
Race(2)		.48	.72	.03
SES		.43	.31	.07
Gender		.37	.28	.06
Rumination		.11	.03	.29**
Rumination × Gender		−.13	.04	−.26**
Total R^2	.083**			
Adjusted R^2	.067**			
N	469			

Note. CDI = Children's Depression Inventory Scores. Set Shifting = TEACH Set Shifting Accuracy Score.

†† $p < .05$,

† $p < .01$,

* $p < .008$,

** $p < .001$

Table 6

Rumination Predicting Set Shifting in Males (Left)) and Females (Right)

	ΔR^2	B	SE	β	ΔR^2	B	SE	β
Predictor								
Step 1	.05†				.048†			
CDI		.04	.04	.05		.00	.037	.01
Race(1)		−1.28	.48	−.20*		−.74	.43	−.12††
Race(2)		.23	1.08	.02		.78	1.02	.05
Age		.36	.36	.07		.69	.31	.14†
SES		.17	.47	.03		.43	.42	.07/
Step 2	. 07**				.004			
CDI		−.03	.05	−.04		.02	,03	.05
Race(1)		−1.39	.47	−.21*		−.71	.43	−.12
Race(2)		.27	1.04	.02		.70	1.02	.04
Age		.32	.35	.06		.67	.31	.14†
SES		.35	.46	.05		.49	.43	.08
Rumination		.13	.03	.28**		−.03	.03	−.07
Total R^2	.116**				.051			
Adjusted R^2	.09**				.028			
N	222				247			

CDI = Children's Depression Inventory Scores. Set Shifting = TEACH Set Shifting Accuracy.

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 7

Current Depression Moderating Impact of Rumination on Sustained Attention

Predictor	ΔR^2	B	SE	β
Step 1	.053**			
Age		−.87	.23	−.17**
Race(1)		−.55	.32	−.09
Race(2)		−.93	.71	−.06
SES		.16	.31	.03
Gender		.44	.28	.07
Step 2	.007			
Age		−.86	.23	−.17**
Race(1)		−.58	.32	−.09
Race(2)		−.88	.71	−.06
SES		.14	.31	.02
Gender		.46	.28	.08
Current Depression		−.70	.40	−.09
Rumination		.03	.02	.07
Step 3	.026**			
Age		−.91	.23	−.18**
Race(1)		−.54	.31	−.09
Race(2)		−.77	.70	−.05
SES		.19	.30	.03
Gender		.54	.28	.09††
Current Depression		.04	.44	.01
Rumination		.06	.02	.16**
Rumination × Current Depression		−.16	.05	−.23**
Total R^2	.087**			
Adjusted R^2	.071**			

	ΔR^2	B	SE	β
N	470			

Note. CDI = Children's Depression Inventory Scores. Sustained Attention = TEACH Sustained Attention Score.

$^{\dagger\dagger}p < .05$,

$^{\dagger}p < .01$,

$^{*}p < .008$,

$^{**}p < .001$

Table 8

Rumination Predicting Sustained Attention in those with (left) and without (right) Current Depressive Symptoms

	ΔR^2	B	SE	β	ΔR^2	B	SE	β
Predictor								
Step 1	.149†				.044*			
Race(1)		−.40	.77	−.06		−.59	.35	−.10
Race(2)		−2.93	1.49	−.22††		−.28	.81	−.02
Age		−1.64	.59	−.31**		−.72	.25	−.15**
SES		−.02	.74	.00		.17	.34	.08
Gender		.54	.75	.08		.46	.30	.08
Step 2	. 080*				.022*			
Race(1)		−.18	.74	−.03		−.63	.34	−.10
Race(2)		−2.75	1.43	−.21		−.20	.80	−.01
Age		−1.75	.57	−.33**		−.74	.25	−.15
SES		.18	.72	.03		.16	.34	.03
Gender		.96	.74	.14		.44	.30	.07
Rumination		−.11	.04	−.30*		.06	.02	.15**
Total R^2	.228**				.066*			
Adjusted R^2	.166**				.051*			
N	81				389			

CDI = Children's Depression Inventory Scores. Sustained Attention = TEACH Sustained Attention Score.

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$.