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Cognition-Emotion Interaction as a Predictor of Adolescent Depressive Symptoms

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Abstract

Given the sharp increase in rates of depression during adolescence, especially in girls, it is important to identify which youth are at greatest risk across this critical developmental transition. This research examined whether (a) individual differences in cognition-emotion interaction, as reflected in cognitive control (CC) deficits and trait negative emotionality (NE), predict depression levels across a one-year period (6^{th} – 7^{th} grade); and (b) these temperamental traits create a particularly strong risk in girls. Youth (338 girls, 298 boys; *M* age in 6^{th} grade = 11.96, *SD* = .37) reported on their trait NE and depressive symptoms; teachers reported on CC deficits. As hypothesized, compromised CC predicted subsequent depressive symptoms in girls with high, but not average or low, trait NE. This research informs efforts to identify which adolescents will be at heightened risk for depression during the adolescent transition and points to possible candidates for early intervention.

Keywords

cognitive control; negative emotionality; depression; adolescence; gender

Adolescence is a stage of increasing risk for depression, particularly in girls (Rudolph, 2009). During this stage, youth are faced with a range of novel challenges, such as shifts in school organization and expectations, disruptions in friendship groups, and changing family dynamics (Ge, Lorenz, Conger, Elder, & Simons, 1994; Rudolph, 2009; Rudolph, 2014; Steinberg & Morris, 2001). Adolescents' ability to cope with these challenges contributes to their mental health. Whereas some negotiate the shifting social and emotional landscape of adolescence with few adverse effects, others experience an onset or increase in depressive symptoms. Understanding what makes youth more or less vulnerable during this critical developmental juncture is a key goal for early identification and prevention of depression. To better understand this divergence, developmental scientists have become increasingly

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interested in the role of individual differences in temperament, including both cognitive (regulatory) and emotional (reactive) processes, as a predictor of adolescent mental health. The goal of the present research was to examine the interactive contribution of compromised cognitive control (CC) and trait negative emotionality (NE) to depressive symptoms during the adolescent transition. Moreover, we investigated whether this cognition-emotion interaction differentially predicted depressive symptoms in girls and boys. These questions were studied during the first two years of middle school, a transition marked by significant changes that may heighten risk for depressive symptoms in vulnerable youth.

CC is a self-regulatory aspect of temperament involving higher-order executive processes that guide attention and behavior to meet goals (Isquith, Gioia, & Espy, 2004; Rothbart & Bates, 2006; Snyder & Hankin, 2016; Vasey et al., 2014). A key component of cognitive control is its facilitation of intentional, strategic, and problem-solving oriented action (Compas, Connor-Smith, & Jaser, 2004; Gioia & Isquith, 2004). Aspects of CC include inhibition (ability to direct internal resources toward inhibiting behavior), planning/organization (ability to plan and organize actions over time), working memory (ability to hold information in mind for the purpose of manipulating it), and shifting (ability to focus and shift attention as needed) (Gioia, Isquith, Guy, & Kenworthy, 2000a).[1] Having the capacity to address challenges in a strategic, productive way may be essential to youths' ability to effectively navigate the transition to adolescence. For example, engaging in primary control coping strategies such as problem solving requires strong inhibition and planning/organization skills (e.g., overriding prepotent, involuntary responses while planning future effortful responses). Similarly, engaging in secondary control coping strategies such as cognitive reappraisal requires strong working memory and the ability to shift one's mindset. Thus, CC deficits may compromise youths' ability to regulate cognition and behavior aimed at coping effectively with the adolescent transition, thereby increasing risk for depression. CC deficits may be especially problematic in youth with high trait NE, as reflected in a susceptibility to experiencing high aversive arousal (i.e., higher reactivity), difficulty being soothed once aroused (i.e., slower return to baseline), and general sensitivity to negative environmental cues (Rothbart & Bates, 2006). If youth with CC deficits experience intense emotional arousal when exposed to the challenges of adolescence, they may have even greater difficulty planning and executing complex strategies for coping with stressors, instead perseverating on negative mind-sets and aversive mood states that leave them vulnerable to depressive symptoms.

A few recent longitudinal studies provide preliminary support for this interactive contribution of CC and NE to depressive symptoms[2] (for similar findings in cross-sectional studies of early to mid-adolescents, see Muris, 2006; Muris, Meesters, & Blijlevens, 2007; Verstraeten, Vasey, Raes, & Bijttebier, 2009; Yap et al., 2011). One study of early adolescents revealed that the interaction between effortful control (EC) and NE (i.e.,

[1]We use the term cognitive control to refer to a general self-regulatory construct that involves multiple higher-order cognitive processes. This construct overlaps with the temperamental dimension of effortful control (which typically is operationalized in terms of attentional control, inhibitory control, and activation control), but also includes working memory and planning/organization.
[2]These studies test a similar hypothesis but use NE as the independent variable and CC as the moderator. Because we view CC as reflecting core abilities that enable one to cope effectively with challenge, in the present study we operationalize CC at the independent variable and NE the moderator.

fearfulness) at 11 years predicted internalizing symptoms at 13 ½ years, such that fearfulness predicted subsequent internalizing symptoms for adolescents with low but not high EC. However, this effect held only when prior internalizing symptoms were not controlled (Oldehinkel, Hartman, Ferdinand, Verhulst, & Ormel, 2007). In a series of papers, Vasey and colleagues (Vasey, Harbaugh, Lonigan et al., 2013a; Vasey, Harbaugh, Mikolich, Firestone, & Bijttebier, 2013b; Vasey et al., 2014) examined the joint effects of CC, NE, and positive emotionality (PE) as a predictor of concurrent or future depressive symptoms in multiple age groups (children through young adults). Although a significant three-way interaction generally emerged, the nature of this interaction (or the joint effects of CC, NE, and PE) differed. In some cases, NE predicted depressive symptoms for individuals with low but not high EC at **high** levels of PE (Samples 1–3 in Vasey, Harbaugh, Lonigan et al., 2013a; Vasey et al., 2014; see also Van Beveren, Mezulis, Wante, & Braet, in press), but in other cases NE predicted depressive symptoms for individuals with low but not high EC (or predicted depressive symptoms more strongly for those with low than high EC) at **low** levels of PE (Samples 4–5 in Vasey, Harbaugh, Lonigan et al., 2013a; Vasey, Harbaugh, Mikolich et al., 2013b). Moreover, some studies reveal the opposite pattern of effects such that NE predicted depressive symptoms for individuals with high but not low EC (or predicted depressive symptoms equally/more strongly for those with high than low EC) (Sample 5 at **high** PE and Samples 1–3 at **low** PE in Vasey, Harbaugh, Lonigan et al., 2013a; at **low** PE in Vasey et al., 2014; at **low** PE in Van Beveren et el., in press; at high stress levels in Gulley, Hankin, & Young, 2016). Overall, prior findings suggest that the cognition-emotion interaction plays a robust role in predicting risk for depressive symptoms during adolescence but the nature of this effect is complicated.

Along with differences in sampling procedures, age of samples, measures, and study design (concurrent vs. longitudinal), differing findings to date may result in part from potential gender differences in the interactive contribution of CC and NE to depressive symptoms. Prior relevant research rarely has examined gender differences (for two exceptions, see Gulley et al., 2016, who found no evidence for a four-way (CC × NE × PE × Gender) interaction; Oldehinkel et al. 2007, who found no evidence for a three-way (CC × NE × Gender) interaction). During adolescence, girls are faced with particularly elevated levels of social stress (Rudolph, 2009), which may place heightened demands on their cognitive resources and increase the likelihood that those with compromised CC and high levels of NE develop depressive symptoms. Indeed, social stress is more likely to predict depressive symptoms in girls than boys with CC deficits (Agoston & Rudolph, 2016) and with heightened NE (Sugimura & Rudolph, 2012). Thus, we hypothesized that the joint contribution of CC deficits and NE to depressive symptoms would be amplified in girls relative to boys.

The aim of this study was to extend a limited but growing data base by examining gender differences in the interactive contribution of CC and trait NE to depressive symptoms. CC was assessed using teacher reports of observed deficits in everyday life, reflecting the allocation of CC in real-life situations when cognitive resources may be taxed (Denckla, 2002; Muris et al., 2008). Trait NE was assessed using self-reports of arousal and emotionality. We used a two-wave longitudinal design focused on early adolescence (6^{th} –

7^{th} grade) given the challenges youth face during this time along with the emerging risk for depressive symptoms.

Method

Participants and Procedures

Participants were 636 youth in a longitudinal study (338 girls, 298 boys; *M* age in 6^{th} grade = 11.96, *SD* = .37). The sample included youth from various ethnic groups (66.7 % White, 21.7 % African American, 7.1 % Asian American, 4.5 % other) and socioeconomic backgrounds (34.7% received a subsidized school lunch). Most youth were recruited in 2^{nd} grade with an additional 60 of their classmates joining in 3^{rd} grade. Consent forms were sent home with youth. In addition, project staff attended school registrations, open houses, and parent-teacher conferences to meet directly with parents and obtain consents. Parents provided written consent, and children provided oral assent. Of the 2^{nd} graders targeted for recruitment, 80% received consent and participated; participants and nonparticipants did not differ in age, $t(723) = .63$, *ns*, gender, $\chi^2(1) = .15$, *ns*, ethnicity, $\chi^2(1) = .59$, *ns*, or school lunch status (full pay vs. subsidized), $\chi^2(1) = .35$, *ns*. Thus, this sample was representative of the students from which it was drawn. Of the original 636 participants, 548 had 6^{th} grade teacher reports of CC, 532 had 6^{th} grade self-reports of NE, 532 had 6^{th} grade self-reports of depressive symptoms, and 475 had 7^{th} grade self-reports of depressive symptoms. Youth with complete versus incomplete data did not significantly differ in gender, $\chi^2(1; N = 636) = .64$, *ns*, or ethnicity, $\chi^2(1; N = 636) = .04$, *ns*. Youth with complete data were somewhat more likely than youth with incomplete data to receive subsidized school lunch, $\chi^2(1; N = 631) = 3.93$, $p = .05$. All participants ($N = 636$) were included in analyses; missing data were estimated using multiple imputation. Youth self-reports were collected during classroom administration sessions. Teacher surveys were distributed and returned at school. Youth received a small gift, and teachers received a monetary reimbursement.

Measures

Table 1 presents descriptive and psychometric information.

Cognitive control—In 6^{th} grade, teachers completed four subscales of the Behavior Rating Inventory of Executive Function (BRIEF; Gioia et al., 2000a), which were selected based on hypotheses about relevant aspects of CC: inhibition (10 items; e.g., “Has trouble putting the brakes on his/her actions.”), planning/organization (12 items; e.g., “Does not plan ahead for school assignments.”), working memory (10 items; e.g., “Has trouble with chores or tasks that have more than one step.”), shifting (8 items; e.g., “Tries the same approach to a problem over and over, even when it does not work.”). Teachers rated each item on a 3-point scale (1 = Never a Problem to 3 = Often a Problem). Because of the high intercorrelations among the subscales (*r*s = .60 – .91, *p*s < .001), a mean composite CC score was calculated as the average of the subscale scores, with higher scores reflecting more CC deficits. The BRIEF shows strong internal consistency (Gioia & Isquith, 2004), inter-rater and test-retest reliability, and construct validity (Gioia, Isquith, Guy, & Kenworthy, 2000b). CC scores deviated from normality, $D(548) = .20$, $p < .001$, with skewness of 1.25 (SE = .10) and kurtosis of .70 (SE = .21).

Negative emotionality—In 6th grade, youth completed the NE subscale of the Temperament in Middle Childhood Questionnaire (Simonds & Rothbart, 2004), which includes 25 items assessing the tendency to experience intense negative emotions, including anger (e.g., "I get irritated when I have to stop doing something I am enjoying.") and sadness (e.g., "I sometimes feel sad for no reason.") as well as low soothability (e.g., "I have a hard time calming down when I am upset."). Youth checked a box indicating how true each item was on a 5-point scale (1 = Almost Always Untrue to 5 = Almost Always True). Scores were computed as the mean of the items, with higher scores reflecting more NE. The NE subscale shows strong reliability and construct validity (Rothbart, Ahadi, Hershey, & Fisher 2001; Sugimura & Rudolph, 2012). Confirmatory factor analyses support the unitary structure of the NE subscale and its distinction from depressive symptoms (Sugimura & Rudolph, 2012). NE scores deviated from normality, $D(532) = .06$, $p < .001$, with skewness of 0.47 (SE = .11) and kurtosis of −0.13 (SE = .21).

Depressive symptoms—In 6th and 7th grade, youth completed the Short Mood and Feelings Questionnaire (Angold, Costello, Messer, & Pickles, 1995), which includes 13 items assessing recent depressive symptoms (e.g., "I felt unhappy or miserable."). The response format was modified from a 3- to 4-point (1 = Not at All to 4 = Very Much) scale. Scores were computed as the mean of the items, with higher scores reflecting higher levels of symptoms. This measure shows strong convergent (Angold et al., 1995), and divergent (Thapar & McGuffin, 1998) validity. Depressive symptoms scores deviated from normality, *D*s(475–532) = .19–.20, *ps* < .001, with skewness of 2.20 (SEs = .11) and kurtosis of 6.18–6.65 (SEs = .21–.22).

Results

Data Imputation

Missing values were estimated using multiple imputation in *SPSS Statistics Version 21* which uses the fully conditional specification method. The imputation model included all the variables used in the regression analyses, as well as the interaction terms (Enders, 2010). Possible values for missing data were generated, creating five imputed datasets. Analytic procedures conducted using these datasets yield pooled estimates that account for the variability in estimates between and within the imputed datasets. For estimates not automatically pooled by SPSS, Rubin's method for combining point estimates was applied (Enders, 2010; Rubin, 1987). The results from the original data using listwise deletion and the pooled estimates from the imputed data were very similar and yielded the same conclusions.

Gender Differences and Intercorrelations

T-tests were conducted to examine gender differences (Table 1). Boys showed significantly more CC deficits than did girls ($t = 4.75$, $p < .001$). Girls showed significantly higher levels of NE ($t = -4.07$, $p < .001$) as well as 6th ($t = -2.15$, $p = .032$) and 7th ($t = -3.19$, $p = .001$) grade depressive symptoms than did boys. As anticipated, in both girls and boys, higher levels of CC deficits and NE were associated with depressive symptoms.

Contribution of CC Deficits and NE to Subsequent Depressive Symptoms

A hierarchical multiple regression analysis was conducted to examine the independent and interactive contribution of 6^{th} grade CC deficits and 6^{th} grade NE to 7^{th} grade depressive symptoms, adjusting for 6^{th} grade depressive symptoms. All continuous variables in the regression model were standardized, and therefore the unstandardized regression coefficients approximate standardized betas. Interaction terms were computed as the product of the variables. Gender (−1 = boys, 1 = girls) and the main effects of 6^{th} grade depressive symptoms, CC deficits, and NE were entered at the first step, the two-way interactions (CC Deficits × NE, CC Deficits × Gender, and NE × Gender) were entered at the second step, and the three-way interaction (CC Deficits × NE × Gender) was entered at the third step. To probe significant three-way interactions with gender, results for each group were estimated by running the model with gender centered at values corresponding to girls or boys. Specifically, the CC Deficits × NE interaction within girls was estimated by running the model with gender coded as boys = −1, girls = 0 and then the CC Deficits × NE interaction was estimated within boys by running the model with gender coded as boys = 0, girls = 1. To probe significant CC Deficits × NE interactions, simple slopes were estimated at low (−1 *SD*), moderate (mean), and high (+ 1 *SD*) levels of NE (Aiken & West, 1991). A regions of significance test (Preacher, Curran, & Bauer, 2006; Roisman et al., 2012) was used to determine the values of NE at which CC deficits had a significant effect on depressive symptoms.[3]

The regression analysis revealed significant effects of 6^{th} grade depressive symptoms and NE, a significant NE × Gender interaction, and a significant CC Deficits × NE × Gender interaction (Table 2). Decomposition of this interaction revealed that, in girls, there was a significant CC Deficits × NE interaction (B = .14, SE = .05, $t = 3.00$, $p = .003$). As shown in Figure 1a, CC deficits predicted changes in depressive symptoms in girls with high (B = .12, SE = .06, $t = 2.04$, $p = .042$) but not average (B = −.02, SE = .06, $t = -.24$, $p = .811$) or low (B = −.14, SE = .10, $t = -1.48$, $p = .145$) levels of NE. Regions of significance tests indicated that CC deficits had a significant positive effect on depressive symptoms when NE was > .72 SD above the mean. Of the girls in the sample, 30.6% had NE scores in this range. CC deficits had a significant negative effect on depressive symptoms when NE was < −1.52 SD below the mean. Of girls in the sample, 3.1% had NE scores in this range. In boys, there was a nonsignificant CC Deficits × NE interaction (B = −0.05, SE = .06, $t = -0.90$, $p = .372$; Figure 1b).

Discussion

This study examined whether individual differences in regulatory (i.e., CC) and reactive (i.e., NE) aspects of temperament make an interactive contribution to longitudinal changes in adolescent depressive symptoms. Consistent with our hypotheses, compromised CC predicted higher subsequent depression levels in youth with high, but not average or low, trait NE; moreover, this pattern emerged in adolescent girls but not boys.

[3]Results from the original rather than imputed data are reported for the regions of significance test, as this test requires estimates of coefficient covariances, which are not produced with pooling.

Girls with fewer top-down CC resources and a high susceptibility to experiencing emotional arousal may have particular difficulty coping with the transition to adolescence, which requires successful negotiation of diverse physical, psychological, and social challenges. These girls may have trouble generating productive coping strategies, may be prone to adopting negative mind-sets (e.g., ruminating about minor stressors, blaming themselves for difficulties), and may be unable to effectively regulate the emotional arousal accompanying the adolescent transition. Indeed, cognitive inflexibility, difficulty shifting attention, and associated CC deficits predict perseveration (e.g., dwelling on unpleasant thoughts and events) and more intense and prolonged emotional and physiological arousal (Joormann & Vanderlind, 2014; Whitmer & Gotlib, 2012), which may put adolescent girls at risk for depression. These effects may be particularly potent in females relative to males because girls face more stress, particularly complex interpersonal stressors, than do boys during adolescence (Rudolph, 2009), and maladaptive responses to stress predict subsequent depression in adolescent girls but not boys (Agoston & Rudolph, 2011).

Of note, this gender difference differs from Oldehinkel et al. (2007) and Gulley et al. (2016), who found no evidence for three-way (CC × NE × Gender) or four-way (CC × NE × PE × Gender) interactions, respectively. This discrepancy may be due to differences in the time frames of the studies, sample sizes, and ages of the samples as well as variations in the measures and informants used to assess CC (teacher report of CC deficits vs. parent report of EC), NE (self-report of general NE vs. parent report of fearfulness/frustration and parent report of general NE), and symptoms (self-report of depressive symptoms vs. multi-informant report of internalizing symptoms and parent report of depressive symptoms). Moreover, detecting a four-way interaction likely requires greater power than available in the Gulley et al. (2016) study. Future research will need to consider the sensitivity of various measures to gender differences and to determine the generalizability of the observed gender differences across developmental stages.

It is also worth noting that although the nature of our CC × NE interaction (i.e., CC deficits predict elevated depression in girls with high but not low NE) is consistent with the general pattern of findings in much of the prior research in adolescents (e.g., Muris et al., 2007; Oldehinkel et al., 2007; Vasey et al., 2013b in the presence of low PE; Vasey et al., 2013a in the presence of high PE in three samples and low PE in two samples; Vasey et al., 2014 in the presence of high PE), other research also reveals different patterns of cognition-emotion interaction (e.g., Gulley et al., 2016; Van Beveren et el., in press Vasey et al., 2013a; Vasey et al., 2014), particularly when examining three-way interactions with other variables (e.g., the pattern observed in this study most consistently emerges at high levels of PE). Thus, it will be important for future research to elucidate precisely how temperamental aspects of adolescent cognition and emotion interact to predict depressive symptoms and how these effects might vary according to other characteristics or experiences of youth. Nevertheless, this research confirms that individual differences in the strength of adolescent CC (regulatory) systems and in the sensitivity of adolescent emotion (reactive) systems can help explain which adolescent girls are at greatest risk for depressive symptoms during this developmental stage.

Despite its contribution, this research does not identify the mechanisms underlying the interactive effect of CC deficits and NE on depressive symptoms. One important direction for future research will be to determine whether individual differences in the neural systems involved in cognitive regulation, emotionality, and their connectivity serve as one pathway through which this interactive effect operates. Moreover, both compromised CC and heightened NE are linked to diverse factors that may contribute to depression, such as attentional bias to threat (Lonigan & Vasey, 2009), maladaptive stress responses (Lengua & Long, 2002; Oldehinkel, Hartman, Nederhof, Riese, & Ormel, 2011), emotion regulation difficulties (Yap et al., 2011), and social impairment (Snyder et al., 2015), each of which may help explain why adolescents with dual risks in these systems are particularly vulnerable to depression. Understanding the mechanisms involved in cognition-emotion interactions can inform early intervention efforts aimed at reducing risk in vulnerable youth prior to the adolescent transition. For example, growing evidence suggests that mindfulness-based interventions may improve CC (Chambers, Lo, & Allen, 2008), reduce maladaptive responses to emotion (Hilt & Pollak, 2012; Mendelson et al., 2010), and alter neural systems involved in attentional control and emotion regulation (Tang, Holzel, & Posner, 2015; Lutz et al., 2014), suggesting their potential utility for youth demonstrating compromised CC and/or high trait NE prior to adolescence.

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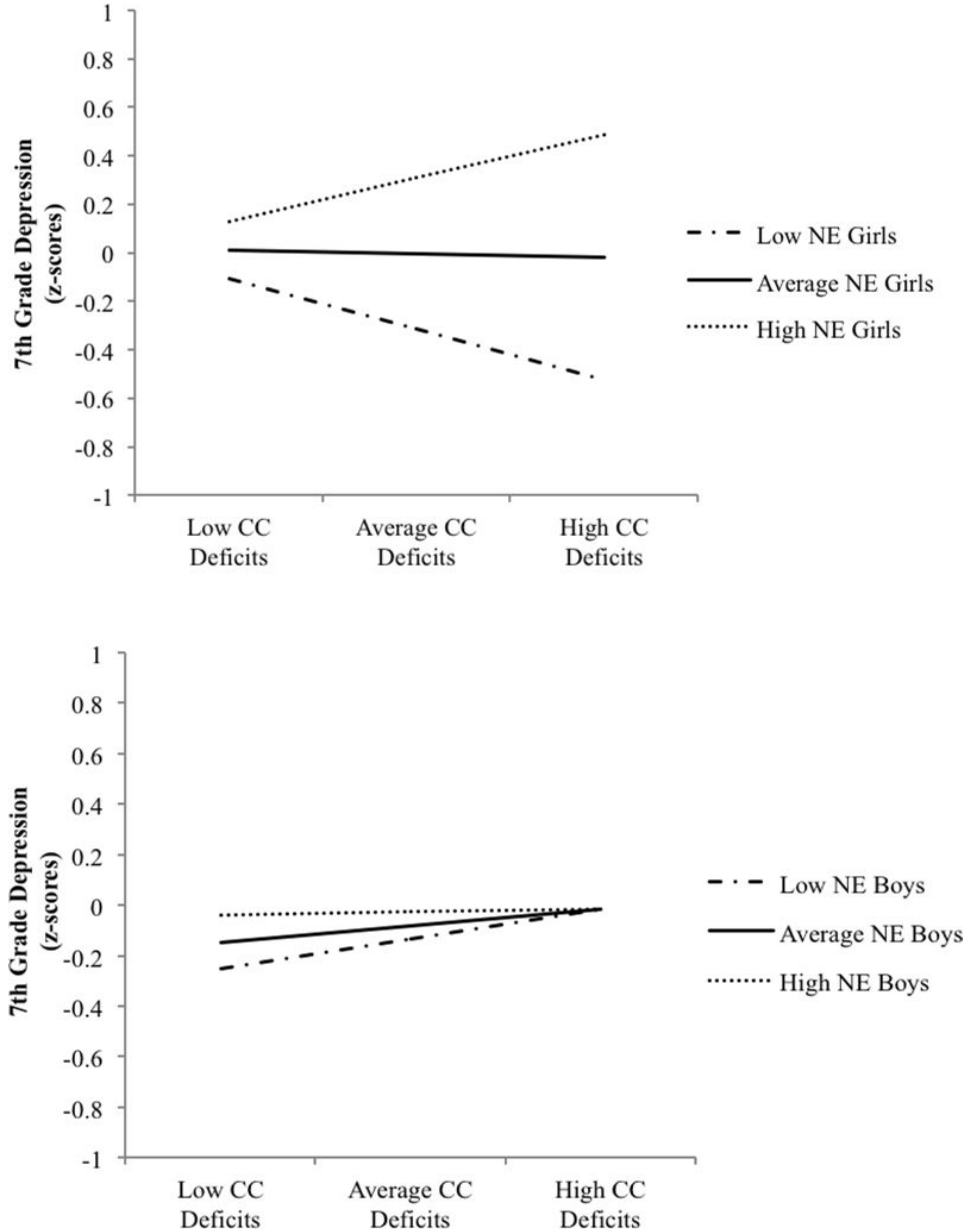

Figure 1.

Predicting 7th grade depressive symptoms from the interactive contribution of 6th grade cognitive control and negative emotionality, adjusting for 6th grade depressive symptoms, in (a) girls and (b) boys.

Table 1

Descriptives and Intercorrelations Among the Variables

	Girls		Boys						
Measure	***M***	***SD***	***M***	***SD***	***a***	**1**	**2**	**3**	**4**
1. 6th Grade Depressive Symptoms	1.49[a]	.53	1.39[a]	.45	.90	–	.19***	.62***	.56***
2. 6th Grade CC Deficits	1.32[b]	.41	1.47[b]	.46	.98	.21**	–	.26***	.18**
3. 6th Grade Negative Emotionality	2.58[b]	.72	2.34[b]	.65	.92	.52***	.24***	–	.50***
4. 7th Grade Depressive Symptoms	1.43[b]	.51	1.32[b]	.36	.89	.42***	.18**	.29***	–

Note.

** $p < .01$.

*** $p < .001$.

[a] Means differ between gender by $p < .05$.

[b] Means differ between gender by $p < .001$. Correlations above the diagonal are for girls; correlations below the diagonal are for boys.

Table 2

Predicting 7th Grade Depressive Symptoms from 6th Grade Cognitive Control Deficits, Negative Emotionality, and Gender

Predictors	*B*	*SE*	*t*	95% Confidence Interval	ΔR^2
Step 1					.30
6th Grade Depressive Symptoms	.40	.05	8.80***	[.31, .48]	
6th Grade CC Deficits	.05	.04	1.37	[−.02, .13]	
6th Grade NE	.19	.05	3.63***	[.08, .29]	
Gender (−1 = Boys, 1 = Girls)	.06	.04	1.42	[−.02, .14]	
Step 2					.02
6th Grade Depressive Symptoms	.38	.05	8.17***	[.29, .47]	
6th Grade CC Deficits	.05	.04	1.12	[−.04, .13]	
6th Grade NE	.17	.05	3.22**	[.06, .27]	
Gender (−1 = Boys, 1 = Girls)	.06	.04	1.57	[−.02, .15]	
6th Grade CC Deficits × NE	.05	.04	1.39	[−.02, .13]	
6th Grade CC Deficits × Gender	−.02	.04	−0.48	[−.10, .06]	
6th Grade NE × Gender	.14	.04	3.22**	[.05, .23]	
Step 3					.01
6th Grade Depressive Symptoms	.38	.05	8.48***	[.29, .47]	
6th Grade CC Deficits	.03	.04	0.63	[−.06, .11]	
6th Grade NE	.18	.05	3.44**	[.08, .29]	
Gender (−1 = Boys, 1 = Girls)	.04	.04	0.85	[−.05, .13]	
6th Grade CC Deficits × NE	.05	.04	1.23	[−.03, .12]	
6th Grade CC Deficits × Gender	−.04	.04	−1.03	[−.12, .04]	
6th Grade NE × Gender	.13	.04	2.96**	[.04, .22]	
6th Grade CC Deficits × NE × Gender	.10	.04	2.52*	[.02, .18]	

Note.

^ $p < .10$.

* $p < .05$.

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** $p < .01$.

*** $p < .001$. All continuous variables were standardized and thus unstandardized Bs approximate standardized betas.