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Permalink

https://escholarship.org/uc/item/0br1w15p

Journal

Journal of Child and Family Studies, 31(9)

ISSN

1062-1024

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Publication Date

2022-09-01

DOI

10.1007/s10826-022-02296-z

Peer reviewed

Relationships between Depression and Executive Functioning in Adolescents: The Moderating Role of Unpredictable Home Environment

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Abstract

Although researchers have explored the link between depression and executive functioning (EF), the influence of early-life environmental and relational instability on this association has not been comprehensively assessed in adolescents. This cross-sectional study examined whether unpredictability of home environment in childhood moderated the relationship between depression and EF in adolescents. Participants were 138 adolescents aged 13 to 17 years (72% female; 47.8% White; 47.1% Hispanic). Diagnostic status (major depression versus healthy control) and depression severity were assessed using psycho-diagnostic interviews and self-reports from parents and adolescents. Participants also completed the Questionnaire of Unpredictability in Childhood (QUIC). EF was assessed using self-report (Behavior Rating Inventory of Executive Function, Second Edition; BRIEF2) and a battery of performance-based measures. Results showed that QUIC scores moderated the relationship between depression and BRIEF2 scores, such that high unpredictability was associated with poorer EF for adolescents exhibiting low depression severity. Participants with the highest levels of depression exhibited the poorest EF ratings, regardless of childhood unpredictability. Unpredictability was moderately associated with performance-based measures, but did not interact with depressive symptoms to predict complex performance-based EF. Recommendations include assessing for unpredictable childhood environment and acknowledging this risk factor for poor EF in youth with sub-threshold depression. Treatment implications are discussed with respect to family systems/parenting interventions, as mildly depressed adolescents growing up in unstable homes may be vulnerable to EF difficulties. Further, this study adds to the EF measurement literature by examining

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associations between self-report and performance-based EF instruments in a diverse sample of adolescents.

Extant research has explored the various factors impacting cognitive development in children and adolescents, including psychological determinants (e.g., depression), early-life influences (e.g., parenting practices), and environmental variables (e.g., socioeconomic status, chaos in the home). However, the majority of studies examining these constructs focus on young children, and none have comprehensively analyzed the relationships among depression, childhood unpredictability, and executive functioning (EF) during the vulnerable developmental period of adolescence. The present study adopts a bioecological framework to understand these complex processes, as EF has primarily been examined within biological models, which can overlook important ecological and interpersonal influences (Hughes & Ensor, 2009).

Executive Functioning and Depression

According to bioecological theory (Bronfenbrenner & Evans, 2000), cognitive processes develop in the context of proximal factors (e.g., relationships with parents, peers, and teachers) that interact with each other over time. EF, specifically, develops across childhood and adolescence and broadly captures cognitive control comprising higher-order self-regulation processes, including problem-solving, decision-making, planning, self-regulation, inhibition, cognitive flexibility, shifting, and working memory, which are managed by the prefrontal cortex (Anderson et al., 2002; Karbach & Unger, 2014). In adolescence, a period of growing independence whereby one's behaviors have more lasting consequences, EF continues to evolve and is implicated in every-day management of emotions and behaviors, goal-setting, maintenance of relationships, and basic processing of information and attentional control (Diamond, 2013; Lezak, 2004).

This is also a period of great vulnerability whereby major depressive disorder (MDD) emerges as one of the most common mental illnesses diagnosed in adolescence (Merikangas et al., 2010). Meta-analytic data suggest that adolescents with MDD exhibit significantly poorer EF compared to their counterparts without psychiatric history, with behavioral inhibition and planning abilities strongly impacted by the disorder (Wagner et al., 2015). This association is not surprising when considering the detrimental impact that MDD symptoms, such as diminished concentration, emotional dysregulation, and slowed thinking, can have on cognitive functioning (Gonda et al., 2015). Moreover, other depressive symptoms, such as cognitive distortions, may further hinder mental flexibility and enhance cognitive difficulties. The maladaptive processes associated with depression, such as extensive negative ruminations that monopolize the central executive resources of the brain, could lead to problematic cognitive styles (e.g., perseveration) and subsequent EF deficits (Kavanaugh et al., 2019; Visted et al., 2018). Moreover, cognitive flexibility is dependent upon the development of the frontal lobe (Casey, 2000), which may be impacted by

depression (Bos et al., 2018). During a time when youth depend upon EF skills to succeed academically and socially, and indeed at an age when they are primed to exert more agency and self-regulation within their environments, depression in adolescence can be particularly harmful to successful achievement trajectories and broad socioemotional adjustment (Best & Naglieri, 2011).

Executive Functioning and Environmental Influences

When examining macrosystemic influences (e.g., poverty) that interact with biological variables, the development of frontal systems and emerging EF abilities are certainly vulnerable to early-life environmental factors (Davis et al., 2017; Diamond, 2006). Growing up in institutional/transitional settings (Fisher et al., 2013; Merz et al., 2013), in families with low socioeconomic status (SES; Lawson et al., 2018) or being exposed to childhood maltreatment (Su et al., 2019) has been found to impact EF and broad cognitive abilities. Particular emphasis has also been placed on the role of parenting, attachment, and family ecology in shaping EF in children (Bernier et al., 2015; Blair et al., 2014; Zebdi et al., 2016). The limited research on the association between negative parenting practices and cognitive functioning suggests that various maladaptive parenting behaviors are linked to poor global EF and low inhibition (Valcan et al., 2018). However, there is significant measurement heterogeneity within and across studies that include negative parenting constructs, and many combine behaviors characterized as controlling and engaging (e.g., intrusiveness, harsh discipline, and hostility; e.g., Halse, 2019), as well as neglectful and disengaged (e.g., rejection and detachment; e.g., Fatima et al., 2016), which can result in diverse findings. Further, most of these studies use younger samples and more adolescent-based research is needed to distinguish these parenting dynamics at different developmental stages of the offspring.

Despite the recent focus on the complexities involved in measuring the influence of parenting on EF (Fay-Stammbach et al., 2014), there is a gap in the literature regarding the construct of *unpredictability* in parenting behavior. Parent-child attachment research has indicated that consistently negative/rejecting parenting, which contributes to insecure-avoidant attachment, is less detrimental than inconsistent or unpredictable parenting, which in turn contributes to insecure-ambivalent/resistant or disorganized attachment (Cassidy and Berlin, 1994; Menon et al., 2020); cognitive development is likely to be impaired when youth cannot effectively adapt to and cope with an environment and/or relationship that is constantly changing (Bronfenbrenner & Evans, 2000; Davis et al., 2019; Glynn & Baram, 2019). However, severity of negative parenting (e.g., abuse) may also be an important factor to consider when weighing the salience of consistency versus unpredictability in parenting, which is beyond the scope of the current paper. Nonetheless, the ability to foresee the potential consequences to one's behavior, which is a core feature of EF regarding planning and organizing, is likely rooted within the consistency experienced at home through predictable patterns of rewards and punishment, and dyadic regulation (Andrews et al., 2021; Bernier et al., 2015). Indeed, predictable limit-setting with young children has been observed to lead to better effortful control (i.e., self-regulation) over time (Lengua et al., 2007), whereas inconsistent discipline has been associated with poorer EF task performance in children and younger adolescents (Sosic-Vasic et al., 2017).

In addition to unpredictability in parenting behavior, youth may be negatively impacted by uncertainty experienced in the broader home environment. From a bioecological framework, the family microsystem and associated proximal factors, such as parent-child interactions and home environment, significantly shape cognitive developmental trajectories (Bronfenbrenner & Evans, 2000). Some literature has been dedicated to the cognitive cost attached to household chaos (e.g., lack of routine, crowding, instability; Ackerman & Brown, 2010; Marsh et al., 2020), which may be considered a proxy for some aspects of childhood unpredictability. Indeed, a recent meta-analysis found robust associations between household chaos and EF problems in children (Andrews et al., 2021). Predictability in the home, such as having family meals or traditions, consistent discipline, and housing stability, is essential to the development of self-regulation and EF, as children are able to predict the consequences of their actions and begin to establish self-reliance in their abilities to contribute to the family environment in a positive way (Martin et al., 2012).

Executive Functioning, Depression, and Unpredictable Environments

Although a few studies have examined how unpredictable environments are associated with adolescent depression (e.g., Bakker et al., 2012; Fowler et al., 2015; Glynn et al., 2019), none explored how these constructs may interact to contribute to EF difficulties. Children living in unstructured home environments have a tendency to disengage from their overstimulating family interactions rather than investing adequate regulation skills to cope with unpredictability (Vernon-Feagans et al., 2016). Within the context of habitual family instability and uncertainty, depressed adolescents may be more likely to withdraw and exhibit symptoms of anhedonia compared to youth without internalizing problems faced with similar stressful situations (Glynn et al., 2019). The level of severity of the youth's unpredictable environment (e.g., consistent instability versus sporadic disorganization in the home environment) may differentially impact the relationship between depression and EF (Andrews et al., 2021). In summary, depression can lead to and/or compound the effects of EF deficits – experiencing pervasive unpredictability in childhood (e.g., lack of routines and consistency in the home), as opposed to less severe forms of uncertainty, could further strengthen this association.

A Note on EF Measurement

The Behavior Rating Inventory of Executive Function, Second Edition (BRIEF2; Gioia et al., 2015), including its previous iteration, is one of the most commonly used EF rating scales in the adolescent literature (Nyongesa, 2019). However, this measure has not strongly related to performance-based EF assessments in previous investigations (Andrews et al., 2021; Bodnar et al., 2007; Kavanaugh et al., 2019), with modest correlations reported in studies that did find associations (Miranda et al., 2015; Toplak et al., 2013). EF researchers contend that the BRIEF has greater ecological validity (i.e., responses on the rating scale have a functional resemblance to real-world behaviors, such as social adjustment), is more likely to predict future outcomes (e.g., academic functioning) and captures the wider range of broad EF abilities (Isquith et al., 2013) compared to performance-based assessments. In contrast, performance-based measures, which are collected in structured, artificial environments whereby youth are cued with detailed instructions, are more likely to capture

individual cognitive components of the broader EF constructs (Isquith et al., 2013; Miranda et al., 2015). Neuroimaging studies have also differentiated brain regions implicated in predominantly cognitive aspects of EF compared to the behavioral components (Anderson et al., 2002). As these two modalities hone in on different underlying mechanisms, we used both aspects to measure EF in the current study. Prior EF research on proxies of unpredictability in childhood (Andrews et al., 2021; Marsh et al., 2020) and on depression (e.g., Wagner et al., 2015) primarily relied on performance-based measures. Studies that have used both EF modalities have shown associations between parent-rated EF and parent-rated adolescent depression scores and between youth performance on EF tasks and self-reported depression severity (Kavanaugh et al., 2019).

Current Study

The current investigation tested the hypothesis that unpredictability in the home environment would moderate the association between depression and EF difficulties, such that EF would be poorer for depressed youth who report unpredictability in their childhoods. As with the majority of samples included in the aforementioned literature on EF and depression, we utilized a convenience sample of community-recruited adolescents with varying levels of psychosocial treatment history. As the core study aimed to recruit youth with and without depression and was primarily focused on assessing outcomes (e.g., EF) for this vulnerable population, we were interested in environmental/parental factors that influence the relationship between depression and cognitive abilities. We further add to the neuropsychological assessment literature by using multi-modal EF assessments with the BRIEF2 self-report and a battery of performance-based assessments commonly used with adolescents (Nyongesa, 2019). Exploratory analyses test our hypothesis using diagnostic groups (i.e., adolescents with MDD versus healthy controls) to supplement the analyses using continuous depression measures.

Materials and Methods

Participants

Participants included 138 adolescents recruited from various community organizations and healthcare facilities throughout Southern California via advertisements and recruitment events between 2017 and 2020. Adolescents were between ages 13 and 17 years (M=15.91, SD=1.46), predominantly female (71.7%), and non-Hispanic (52.9%). Race was reported separately from ethnicity, and participants identified as White (47.8%), Multiracial (23.9%), Black (11.6%), Asian (10.2%), American Indian/Alaskan Native (5.1%), or Native Hawaiian/Pacific Islander (1.4%). Nearly half of the sample reported earning $70,000 and above in annual family income. SES, which was calculated using the Hollingshead (1957) scale based on the educational and occupational status of up to two primary caretakers, ranged from 11 to 61 (M=42.34, SD=11.94). Participants who volunteered for the study reported a wide range of treatment histories (e.g., currently in therapy, no history of psychiatric treatment). Although some participants reported having received MDD diagnoses by their mental health providers, MDD status was determined using psycho-diagnostic batteries described below.

Procedures

Adolescents were recruited as part of a larger neuroimaging study (Anonymous, 2020) and were eligible to participate if they were 13 to 17 years old at recruitment. All participants included herein represent those eligible following phone screening and recruited to-date. Exclusion criteria were based on self-report and included conditions that would affect brain development and EF performance on tasks, such as IQ below 80 and childhood neurological problems, as well as recent use of alcohol and/or drugs in the week before screening and psychotropic medications in the past three months. The protocol was approved by the Institutional Review Board. At the initial visit, youth and their parents completed informed consent/assent procedures and psycho-diagnostic interviews. Parents reported on sociodemographic factors, and youth completed self-report measures on unpredictability, depressive symptoms, and EF. At a subsequent visit shortly thereafter, youth were administered a brief neuropsychological battery (i.e., performance-based measures). Participants were compensated $50 for each of the two visits. Six adolescents who only participated in the initial visit did not complete performance-based EF measures. Three additional participants did not complete one auditory attention-based measure (i.e., Continuous Auditory Test of Attention; CATA) and one participant only completed the CATA at visit two due to equipment problems.

Measures

Appendix A provides an overview of the study measures, including the constructs captured by each score/scale/subscale used to measure EF and unpredictability, and the collection method and mode of inference.

Childhood Unpredictability—The Questionnaire of Unpredictability in Childhood (QUIC) was developed by Glynn and colleagues (2019) to comprehensively examine the impact of early-life physical, emotional, and relational unpredictability on adolescent and adult mental health. The QUIC was designed to excavate the unique influence that childhood unpredictability can have on developmental trajectories. Respondents are instructed to answer "yes" or "no" to 38 items for experiences occurring prior to age 18 (29 items) or experiences more likely to occur prior to age 12 (9 items across two subscales; e.g., parents late picking up from school), which comprise the following subscales (see Appendix A): Parental Monitoring and Involvement (9 items), Parental Predictability (12 items), Parental Environment (7 items), Physical Environment (7 items), and Safety and Security (3 items). Higher scores, which include reverse-scoring of some yes/no answers, indicate greater perceived unpredictability. The QUIC total score was used in the current study's primary analyses and exploratory analyses examined subscale scores. The QUIC was validated in a sample of 175 adolescents, with good internal consistency reported for the total scale (α=0.84). The current sample's Cronbach's alpha was acceptable (α=0.72).

Depression—All psycho-diagnostic assessments were conducted by a licensed child and adolescent psychiatrist or clinical psychologists supervised by the aforementioned psychiatrist. Adolescents and a primary caregiver were separately administered the computerized Kiddie Schedule for Affective Disorders and Schizophrenia for School-Aged Children (K-SADS-COMP V2.0; Townsend et al., 2020) and consensus ratings were used

to determine MDD criteria. This instrument has good psychometric properties (interrater agreement=0.94 to 0.98; and strong convergent validity with other depression scales) and was used in the current study to compare adolescents with MDD (*n*=63) to healthy controls (HC) with no lifetime psychiatric history (*n*=75) on variables of interest.

Depression severity was assessed using the 17-item Children's Depression Rating Scale–Revised Version (CDRS-R; Poznanski, 1996), a clinician-rated, semi-structured interview used to ascertain impairment level of several domains of functioning (e.g., schoolwork, sleep disturbance, morbid ideation) over the past month, including three observational scales (i.e., depressed facial affect, listless speech, and hypoactivity). The measure was originally developed for 6-12-year-old children and was validated in an adolescent sample meeting/not meeting criteria for MDD (Cronbach's α=0.74 to 0.94; Mayes, 2010); similarly, our sample exhibited good internal consistency (α=0.95). Total scores range from 17 to 117, with 28 or below indicating mild or minimal symptoms and 40 and above suggesting significant symptomology.

Lastly, participants completed the 21-item Beck Depression Inventory (BDI-IA; Beck, 1961) to report on depression severity over the past week using a 4-point scale (0=low to 4=extreme symptom severity). This inventory demonstrated good internal consistency in the current sample (α=0.95) as have previous validation studies (α=0.73 to 0.93; Beck, 1988). Total scores range from 0 to 63, with 16 and below indicating minimal to mild symptoms and scores 17 and above indicating moderate to severe depression.

Self-reports of Executive Functioning—Adolescents completed the 55-item BRIEF2 (Gioia et al., 2015), which assesses for problems with school- and home-based behaviors over the past six months (rated on a 3-point scale as "never, sometimes or often"). Three main EF indices are calculated, including the Behavior Regulation Index (BRI; difficulty inhibiting impulses and self-monitoring consequences of behavior on others; e.g., "I am unaware of my behavior when I am in a group"), the Cognitive Regulation Index (CRI; difficulty with planning, problem-solving, learning, task completion; e.g., "I don't think ahead about possible problems"), and the Emotion Regulation Index (ERI; difficulty flexibly shifting emotional control; e.g. "My eyes fill with tears quickly over little things"). Higher T-scores indicate greater impairment (i.e., T=60-64 mildly elevated; T=70+ clinically elevated) and scoring protocols provide age- and sex-normed T-scores (*M*=50, *SD*=10). A Global Executive Composite (GEC) yields a summary score by incorporating all clinical scales and is the primary self-report EF measure used in the current study. The BRIEF2 was validated with a large, nationally stratified sample and displayed good internal consistency; Cronbach's alphas in the current sample yielded similar coefficients to those found in the validation studies (GEC α=.97; BRI α=.88; CRI α=.96; ERI α=.92). The original measure and its revision have been widely used to examine associations between EF and various mental health problems, including depression, in various clinical and non-clinical adolescent samples (Kavanaugh, et al., 2019; Peters, 2019).

Performance-based Executive Functioning—The following tasks were administered by staff who were trained by clinical psychologists. The Conners' Continuous Performance Test, 3rd edition (CPT-3; Conners, 2014a) and the Continuous Auditory Test of Attention

(CATA; Conners, 2014b) are computerized, validated assessments of sustained attention used with ages 8 years and older. For the CPT-3, participants are required to respond to the letter "X" (targets) presented on a screen by pressing a button and to refrain from responding to other letters (non-targets). Each of the 360 targets are presented for 250ms with 1, 2, and 4 second interstimulus intervals. Similarly, for the CATA, respondents are asked to press a button when hearing a high-tone sound when it is preceded by a low-tone sound, and to refrain from responding to high tones when they are presented by themselves.

Both tasks are 14 minutes in length and scoring protocols yield age-and sex-normed T-scores (M=50, SD=10), with higher scores indicating greater impairment. The three scores used in the current study represented inattention (i.e., missed targets; *Omissions*), impulsivity/ behavioral inhibition (i.e., incorrect responses to non-targets; *Commissions*), and problems with sustained attention (i.e., discrimination between targets and non-targets; *Detectability*). These indices are commonly selected to examine EF abilities in adolescents and young adults, have shown discriminant validity when comparing individuals with Attention-Deficit/ Hyperactivity Disorder (ADHD) to the general population (Conners, 2014a and 2014b; Wang et al., 2019), and also have been used in studies examining EF in depressed adolescents (e.g., Sommerfeldt et al., 2016).

Participants also completed the Color-Word Interference (CWIT) subtest of the Delis-Kaplan Executive Function System (Delis et al., 2001), a well-validated measure commonly used to assess EF in adolescents (Nyongesa, 2019). This stroop-like task, which presents 50 stimuli of "red, blue, and green" on each of the four conditions, requires participants to name the colors of squares presented on page with speed and accuracy (Condition 1: *Color Naming*), read aloud "red, blue, green" words presented in black print (Condition 2: *Word Reading*), read aloud color-words presented in incongruent colors (e.g., "blue" printed in green; Condition 3: *Inhibition*), and alternate between reading the words regardless of the print color or to say the color in which that word is printed based on a predetermined rule (i.e., when there is a box around that word; Condition 4: *Inhibition/Switching*). Conditions 1-4 performance scores are calculated based on completion time regardless of errors and yield age-corrected standard scores (M=10, SD=3), with higher scores indicating better ability. Conditions 1 and 2 represent more basic attention and language skills, whereas Conditions 3, and particularly 4 represent higher-order cognitive flexibility and inhibition (Fatima et al., 2016). Inhibition/Switching was therefore used as the primary performance-based EF measure.

Social Functioning—The 21-item Social Adjustment Scale-Self-Report for Youth (SAS-SR-Y; Weissman et al., 1980) was administered to measure degree of functioning, communication, and support within school, friends/spare time, and family contexts. Adolescents rate items on a 5-point scale whereby higher scores indicate greater social impairment over the last two weeks. The SAS-SR-Y exhibited good psychometric properties in depressed/healthy adolescent samples (e.g., Stice et al., 2008) and the total score used in the present sample exhibited good internal consistency (α=.87). This measure was used in the current study to examine the ecological validity of scores on the BRIEF2, such that greater EF impairments were expected to coincide with greater social functioning problems.

Analytic Plan

Analyses were conducted using SPSS Version 24.0. Participants with one or more missing performance-based measures (n=10) did not significantly differ on sociodemographic variables or on primary variables of interest (i.e., CDRS, BDI, QUIC total, and BRIEF GEC) compared to participants with complete data (n=128). Further, results from Little's MCAR test indicated that data were missing completely at random, X^2(10, N=132)=8.763, p=.56 (Schlomer et al., 2010). Therefore, models were computed with all available data (FIML). Skewness and Kurtosis, which were examined by transforming coefficients to z-scores (Kim, 2013), indicated that Spearman correlations were warranted as most indices went beyond the threshold of normality (z=1.89 to 17.22); partial correlations controlled for confounding variables associated with primary outcomes. However, assumptions for linear regressions were met based on normality of variable residuals.

Our primary hypothesis was tested using hierarchical linear regressions, which included covariates (step 1), predictor variables (steps 2 and 3), and an interaction term (step 4), computed by mean centering predictor variables and multiplying the centered depression and unpredictability terms for interaction. Conditional effects were probed by calculating simple slopes at the mean, low (−1 SD of the mean), and high (+1 SD of the mean) values of the moderator. Regression models were repeated using self-reported and clinician-rated measures of depressive symptoms separately. As multiple performance-based EF indices were collected, in order to reduce multiple comparisons and limit Type-I error for our primary hypothesis, CWIT Inhibition/Switching was pre-selected as the performance-based EF index most closely representing higher-order cognitive flexibility and interpretations were limited to a more conservative threshold of significance at p<.01 based on Bonferroni correction.

Exploratory analyses included diagnostic group (MDD vs. HC) comparisons of both BRIEF GEC scores and performance-based measures, which were conducted using analysis of covariance (ANCOVA) with QUIC scores included as a predictor and a group*QUIC interaction term; covariates included SES and age. Chi-squares were also conducted to compare the groups on clinical range categories of EF measures. To explore all components of basic attention and inhibition, each performance-based measure was included as an outcome using similar regression models as primary hypothesis-testing. Lastly, associations between QUIC and BRIEF subscales were explored using partial correlations.

Results

Descriptive Statistics and Preliminary Analyses

Means, standard deviations, and correlations of demographic and outcome variables are presented in Table 1 (primary and self-report variables) and Table 2 (performance-based EF variables). Sociodemographic characteristics were examined in relation to the primary variables of interest; t-tests revealed no differences between sexes or racial groups (dichotomized as White and non-White due to small subgroup samples), and age correlated modestly with CDRS (r=.20, p<.05) and BDI scores (r=.23, p<.01). Primary variables differed by ethnicity, such that Hispanic participants exhibited poorer

EF scores (e.g., BRIEF GEC: $t(136)=4.57$, $p<.01$), and higher depressive symptom (e.g., CDRS: $t(136)=3.06$, $p<.01$) and childhood unpredictability ($t(135)=2.72$, $p<.01$) scores. Hispanic families also reported significantly lower SES, $t(135)=-5.38$, $p<.01$, and SES was significantly associated with primary variables of interest (see Table 1). As ethnicity and SES co-occurred, SES, rather than ethnicity, was selected as a covariate in the analyses alongside age. Moreover, similar results yielded when replacing ethnicity for SES in our models. Given the well-established link between SES and EF (Lawson et al., 2018), and as depression and EF both vary with age, we carefully selected these two variables as covariates in all models, including all correlations. With respect to clinical range of EF abilities, adolescents in our sample predominantly exhibited average BRIEF GEC scores (62%), with the remainder scoring in the mildly elevated (20%) and clinically elevated (18%) range.

Associations between Study Variables

All primary study variables were moderately to strongly associated with each other after accounting for age and SES (Table 1). Expectedly, the clinician-rated and self-reported depression measures were highly correlated, and greater childhood unpredictability was associated with greater depression severity. As expected, poorer self-reported EF on the BRIEF was associated with poorer social adjustment on the SAS. Partial correlations controlling for age and SES showed strong associations between depression scores and the BRIEF. Further, greater childhood unpredictability was associated with poorer EF on the BRIEF.

No associations were found between performance-based and self-report EF measures, nor between depression and EF task performance (Table 2). QUIC scores yielded associations with some performance-based measures, with coefficients ranging from .21 to .28. Specifically, greater childhood unpredictability was associated with poorer visual and auditory attention skills (CATA Detectability; CWIT Color Naming), and poorer impulse-control on visual and auditory attention tasks (CPT and CATA Commissions).

Hypothesis Testing

Hierarchical linear regressions showed that childhood unpredictability significantly moderated the association between depression and self-reported global EF (Table 3, step 4). Graphical representations of the data demonstrate that a high depression score was significantly linked to greater EF difficulties (i.e., exhibiting the worst BRIEF scores within the sample) regardless of QUIC scores (Figures 1a & b). Decomposition of the simple slopes indicated that increases in childhood unpredictability led to increases in EF difficulties for adolescents exhibiting low symptoms of depression for both CDRS (Figure 1a) and BDI (Figure 1b), although only the BDI was significant at the $p<.01$ level. QUIC scores did not significantly interact with either self-reported or clinician-rated depression scores when testing moderation with the same hierarchical models for performance-based EF, using CWIT Inhibition/Switching as an outcome (Table 4, step 4).

Exploratory Analyses

Diagnostic Group Comparisons

Tables 1 and 2 present means, standard deviations, and t-test comparison results of all study variables for the MDD and HC groups. Consistent with the associations observed between sociodemographic factors and continuous depression measures, participants diagnosed with MDD were older, came from lower SES backgrounds, and were more likely to be Hispanic (62%) compared to HC (35%), X^2=10.20, p<.01. Further, the groups differed on one performance-based measure of basic attention (CWIT Color Naming; Table 2).

After adjusting for age and SES, there was a main effect of diagnostic status on BRIEF scores, F(3,134)=76.53, p<.01, indicating significantly poorer self-reported EF in depressed adolescents (M=65.74, SD=1.30) compared to HC (M=49.92, SD=1.18). An additional ANCOVA was conducted to examine whether unpredictability moderated the effect of depression diagnosis on EF, and no moderating effect was found for either the BRIEF, F(5,131)=1.76, p=.19, or CWIT Inhibition/Switching, F(5,126)=0.03, p=.85. Table 5 presents group comparisons on BRIEF clinical range categories, which revealed that MDD participants were significantly more likely to score in the mildly-to-clinically elevated ranges on all BRIEF subscales compared to HC. Of note, all 25 adolescents scoring in the clinically elevated range on the BRIEF GEC were diagnosed with MDD.

When exploring other performance-based measures as outcomes using this model, there were no main effects of diagnostic status, but diagnosis and unpredictability interacted to predict CPT Omissions scores, F(5,126)=7.87, p<.01, such that MDD participants exhibited lower scores (i.e., better performance; M=47.15, SD=1.10) than did HC youth (M=50.43, SD=1.05) when accounting for unpredictability. However, these scores do not denote clinically significant differences in visual attention, as both groups performed in the average range (i.e., normative sample T-scores M=50, SD=10). Additionally, chi-square analyses, whereby T-scores were categorized as average (<60) or elevated (60), revealed no group differences for CPT Omission scores (X^2=1.73, p>.05). No main effects of unpredictability were observed for these measures, and depression diagnosis and unpredictability did not interact to predict other performance-based EF.

Performance-based EF Regressions

As with the models conducted for our primary hypothesis testing, hierarchical linear regressions were conducted with each of the other nine performance-based EF measures as outcomes and with BDI and CDRS included as interaction terms with childhood unpredictability in separate models. Tasks that did not meet regression assumptions (i.e., non-normality of variable residuals) were winsorized; namely, CPT Omissions and CATA Omissions and Commissions. Although no significant interactions were found, marginal findings show that youth with low depression, but not high depression severity, performed worse on visual attention tasks when they reported greater levels of childhood unpredictability. Similar to patterns observed using the BRIEF, adolescents with high depression severity performed poorly on performance-based EF measures regardless of unpredictability level, although mean EF scores were not in the impairment range.

Decomposition of the simple slopes graphs for marginal findings at $p<.05$ are included in Appendix B and the exploratory regression tables are included in Appendix C.

Associations between BRIEF and QUIC subscales

Correlation results for all BRIEF and QUIC subscales revealed similar patterns to those found with total scores for each index in relation to depression ratings. All BRIEF and QUIC subscale associations yielded significant values ($p<.01$) ranging from .21 to .48, with the QUIC Parental Predictability subscale showing the strongest correlations and Parental Environment exhibiting the smallest associations. The BRIEF Emotional Regulation Index, expectedly, exhibited the strongest correlation with self-reported depression ratings (r=.73). Most QUIC subscales yielded small to moderate correlation values with depression scores (r=.24 to .47).

Discussion

The present study explored the complex relationships between executive functioning and depression, and the systemic influence of home environment unpredictability from a bioecological perspective. We hypothesized that EF would be poorer for adolescents with depression and unpredictable childhoods. Results showed that unpredictability in childhood may incur risk for poorer broad EF abilities for adolescents reporting *milder* symptomology. However, for youth reporting high levels of depression in the current sample, broad EF deficits were observed regardless of childhood unpredictability, which suggests that biological influences may overshadow ecological risk factors that exist beyond individual-level variables. No such interaction between depression and childhood unpredictability was observed for the more specific cognitive components measured by performance-based EF tests, and visual attention diagnostic group differences did not denote clinically significant distinctions (i.e., scores for both groups did not significantly differ from average scores in the normative population used in standardization samples).

When examining relationships between pairs of key constructs, depression and unpredictability were individually associated with youth EF ratings after accounting for the influence of age and SES. The diagnostic groups differed on all BRIEF indices with respect to clinical range categories, with greater EF impairment found in adolescents meeting MDD criteria compared to healthy controls. These results correspond to findings from a recent study by Kavanaugh and colleagues (2019), which found some associations between BRIEF2 parent ratings and both depressive symptoms and diagnosis in a clinical sample of youth spanning childhood and adolescence.

The domain of unpredictability in the home environment measured in the current study has not been previously explored in the literature in a comprehensive manner; however, household chaos and inconsistent parenting behaviors/relationships can be considered adequate proxies for the various uncertainties experienced in early life. The relationship between QUIC scores and EF observed herein is generally consistent with research on household chaos and young children's cognitive development (Andrews et al., 2021; Marsh et al., 2020), as well as emerging work on perceived low maternal care and poor parent-child relationships predicting EF difficulties in adolescent boys (Harwood-Gross et al.,

2020). When examining relationships between specific QUIC subscales in the current study, exploratory analyses revealed that poorer Parental Predictability (e.g., inconsistent punishment, parent mood lability, uncertainty of parental presence, lack of family activities) showed the highest correlation with all BRIEF indices. Indeed, bioecological theory eloquently explains this association, with unpredictability (i.e., interruption of important environmental patterns) contributing to developmentally-disruptive cognitive outcomes (Bronfenbrenner & Evans, 2000).

Overall, our results suggest that adolescents who report milder depressive symptoms and who report childhoods marked by uncertainty, such as tenuous parental relationships (e.g., inconsistent punishment), may struggle to regulate their behaviors and emotions across several settings. This is consistent with meta-analysis findings showing links between disorganized attachment and internalizing and externalizing behaviors throughout childhood for community samples of adolescents (Madigan et al., 2016). In addition to the influence of distal and proximal factors such as genetics and early-life attachment, it may be that youth who have been habitually exposed to uncertainty within their environments, perhaps observing and learning from mercurial parental figures, may essentially begin to emulate those maladaptive behaviors (Bandura, 1977), thus placing them at risk for depression and cognitive difficulties. Further, these individuals may not have had the opportunity to benefit from parent-child co-regulation and may now be inefficient at coping with the stress of unpredictable environments (Vernon-Feagans et al., 2016), thereby compounding the effect of depressive symptoms on EF. Ample research shows the link between depression and broad cognitive difficulties, but less is known about adolescents exhibiting milder symptoms, as studies tend to solely focus on diagnostic categories or may overlook gradations in symptoms (e.g., Wagner et al., 2015). Indeed, one of the strengths of the current study is our inclusion of diagnostic distinctions in addition to continuous measurements of depression, without which we would not have observed how unpredictability significantly changes the relationship between depression and EF. Youth who do not meet full MDD criteria may be vulnerable to negative outcomes due to high familial/socioecological risk factors, such as living in chaotic homes. These environmental stressors should not be overlooked as they are an essential component contributing to the bioecological framework.

Clinical Implications

Our findings have some potential assessment and treatment implications. First, given the link between high levels of depression and EF difficulties, evidence-based psychosocial and pharmacological treatments for depression may improve EF through symptom reduction (Biringer et al., 2005; Gonda et al., 2015). Second, as youth exhibiting more severe symptomology are more likely to seek treatment and receive a higher level of care compared to those with milder symptoms (Mendenhall et al., 2012), adolescents with sub-threshold depression may not be referred for mental health services or neglected in this system if they are referred. Therefore, providers based in schools or primary care may be more optimally slated to intervene. Living in a chaotic versus stable environment appears to matter greatly to the cognitive functioning of youth experiencing low levels of depressive symptomology. Hence, care providers working with adolescents seeking help for broad EF-related problems

(e.g., academic and/or social adjustment problems) may consider systematically assessing for key ecological factors, such as early-life environment and parent-child relationships. As early-life stress has been linked to myriad negative outcomes in childhood (Oh et al., 2018), healthcare best practices and recommendations are emerging which include screening pediatric populations for adverse childhood experiences (ACEs; Shonkoff & Garner, 2012), using a measure which taps into some constructs of unpredictability (Felliti et al., 1998).

To the best of our knowledge, no interventions have been identified for specifically addressing household chaos, as also recognized by others (Marsh et al., 2020). However, speaking to the more nuanced construct of unpredictability of the home environment, most family-centered adolescent therapies target various aspects of unpredictable parenting, such as helping caregivers implement routines and use consistent contingencies (e.g., Multisystemic Therapy: Henggeler & Schaeffer, 2016; behavioral management strategies: Johnson et al., 2014). For adolescents with subthreshold depression living in unstable environments, increasing consistency in the home may yield the greatest positive change on broad EF skills. Establishing daily routines has the potential to significantly improve self-regulation in younger children (Martin et al., 2012); such approaches may also be beneficial to adolescents, particularly those who may have disengaged from the family system due to unpredictability.

With respect to addressing the link between depression and unpredictability, some interventions aiming to enhance family cohesiveness and routines by increasing meals eaten together have led to reductions in adolescent depression (Fulkerson et al., 2009). Moreover, a systematic review of the depression intervention literature indicates that targeting both symptom reduction and the parent-adolescent relationship by methodically involving parents in treatment maximize positive outcomes (Dardas et al., 2018). Stability in the home environment, including financial stability, as well as family cohesion, belonging, and supportive parent-child relationships, have been highlighted as protective factors leading to positive adolescent outcomes (Murray & Monson, 2013).

Intervening in chaotic households may be most impactful earlier in development for youth exhibiting early signs of internalizing problems (Bakker et al., 2012). The influence of specific parenting behaviors on child EF, such as scaffolding and sensitivity, has been comprehensively studied in younger samples (e.g., Fay-Stammbach et al., 2014), and has been identified as the primary focus of parenting interventions. For example, Parent-Child Interaction Therapy (McNeil & Hembree-Kigin, 1995), which was developed from attachment and social learning theories, promotes consistent communication, and targets parent-child co-regulation, has been effective in enhancing consistency in discipline for families living in unstable environments (e.g., Herschell et al., 2017). In summary, strengthening parent-child/adolescent relationships and increasing consistency in the home through behavior management approaches may be the best course of treatment to strengthen cognitive functioning for mildly depressed youth reporting unpredictable childhoods and interrupt the vicious cycle of worsening depressive symptoms, EF deficits and parent-child relationship.

Contribution to the EF Measurement Literature

This study adds to the body of literature utilizing the BRIEF to measure EF with adolescents diagnosed with MDD in addition to examining depressive symptoms and, to the best of our knowledge, this is the first investigation to implement the revised BRIEF2 *self-report* measure in this manner. Our correlations showed no uniform associations between depression severity/diagnostic status and performance-based measures, which captured basic attention, inhibition, and cognitive flexibility (i.e., CPT, CATA, or CWIT scores). With the exception of converging evidence on basic/selective attention remaining equal among adolescents with and without depression (Baune et al., 2014; Vilgis et al., 2013; Wagner et al., 2015), the literature on this topic is mixed. When parsing out the specific domains measured with various performance-based tasks, some large-scale reviews failed to find differences in set shifting abilities and inhibition when comparing adolescents and young adults with and without MDD (Baune et al., 2014; Vilgis et al., 2013), whereas meta-analytic data with children and adolescents showed opposite results (Wagner et al., 2015). Contradictory findings are likely, in part, due to sample heterogeneity, such that both clinical and community samples of youth with varying levels of depression and diagnostic comorbidity are often included, as well as the confounding impact of medication on neuropsychological functioning. Lastly, when comparing findings from previous literature using heterogenous age groups, we should note the unique characteristics of our participants, as adolescents may be markedly more self-aware of their emotional states and exhibit greater cognitive self-regulation than do younger children and may exhibit less cognitive control compared to young adult samples (e.g., Casey et al., 2019).

Additionally, we did not find any associations between our EF rating scale (BRIEF2) and performance-based measures, which is generally consistent with the literature (e.g., Bodnar et al., 2007; Stichter et al., 2016) – however, most rating scales examined have typically been limited to parent reports (Kavanaugh et al., 2019) and studies have primarily used ADHD samples (Isquith et al., 2013). Although some researchers have noted a few relationships between the BRIEF and stroop-like tasks (e.g., Anderson et al., 2002), again, parent reports of EF were typically used; adolescents' perceptions of their own behavioral problems likely capture more socially-based, goal-directed regulation, whereas parent observations may converge more strongly with performance-based tasks of behavioral inhibition. Even investigators finding small correlations between the two types of measures have noted salient differences in the two constructs (Miranda et al., 2015; Toplak et al., 2013), noting that broad EF is a more nuanced estimate of emotional and behavioral responses (Anderson et al., 2002). Indeed, BRIEF scores were strongly associated with social adjustment scores in the current sample, which further supports the ecological validity of the BRIEF and bases the functioning captured in the measure within real-world domains.

Limitations and Future Directions

The primary limitation of the current study is the use of a cross-sectional design, which restricts the predictive interpretation of the results. We conceptualized EF as a functional outcome of depression based on prior literature (e.g., Jeon & Kim, 2015) and we were interested in EF outcomes within our recruited sample of adolescents with depression. Further, notwithstanding that one of the study strengths is the inclusion of

a medication-naïve, racially/ethnically diverse sample of adolescents, it should be noted that youth volunteered to participate in a study focusing on depression. A further limit to generalizability, stringent diagnostic and exclusion criteria were implemented, thereby excluding adolescents with ADHD, a condition that has significant overlap with EF difficulties, and those engaging in substance use. Further, participants were not generally representative of the surrounding urban setting, and included significantly more female, Black, and Multiracial adolescents than the general population of Orange County, California (e.g., U.S. Census Bureau, 2019). Comparable to other studies on EF and depression, our convenience sample of community-based participants included youth with varying levels of treatment/diagnostic history for depression. Also, important developmental differences should be considered across the age group of the current sample (13-17 years old); to address this limitation, age was included as a covariate in all models.

Although we conceptualize unpredictability of the home environment as being linked to the development of EF difficulties in adolescence, it is important to note that most QUIC items inquired about experiences occurring throughout childhood, past and present, reports of which may have been influenced by the presence of depressive symptoms. Indeed, variations in how childhood unpredictability is measured, and from whom reports on adolescent problems are obtained, may lead to divergent findings. For instance, such differences in reporters have been found in the literature linking attachment to internalizing behaviors (Madigan et al., 2016). It is also important to account for potential shared-informant bias when interpreting results herein, which were mostly based on self-reports measures (with the exception of clinician-rated depression). Similarly, although QUIC parent unpredictability and BRIEF indices were highly correlated, the specific nature of this link is not well understood, as youth with various dysregulation behaviors may engender poor parenting practices, and vice versa (Halse, 2019). Future investigations should consider implementing longitudinal designs to examine causal relationships and the temporal presentation of symptomology, environmental factors and EF, and simultaneously consider implementing multi-modal assessments to comprehensively capture these interconnected constructs. With respect to additional environmental variables to consider, exploring educational contexts would further our understanding of how supportive or hostile school environments may play a role in the development of EF for these adolescents (e.g., teacher support enhancing student emotional regulation; see Romano et al., 2021). Lastly, as home environment unpredictability and associated internalizing and externalizing problems are overrepresented in adolescent populations with a history of out-of-home placements (e.g., residential care; Muzi & Pace, 2020), who are already vulnerable to disruptions in EF development (Carrera et al., 2019), future research should expand to such high-risk samples.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Funding:

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Highlights

- First investigation to examine how unpredictability of home environment moderates the link between depression and executive functioning (EF) in adolescents.

- High scores on childhood unpredictability were associated with poor EF for adolescents exhibiting low scores on depression severity.

- Adolescents with high depression scores exhibited poor EF regardless of childhood unpredictability.

- Methodology contributions include examining associations between self-report and performance-based EF measures.

- Early-life environment and parent-child relationships should be assessed to help guide clinical assessment and treatment.

Figure 1a. The Interaction Between Depression (CDRS) and Unpredictability (QUIC) Predicts BRIEF GEC Scores

Note. QUIC low score=2.15, mean score=9.38, high score=16.61; CDRS low score=29.67 and high score=68.40; CDRS 27 indicate minimal/mild depression and 41 indicate severe depression; Higher BRIEF scores indicate poorer EF
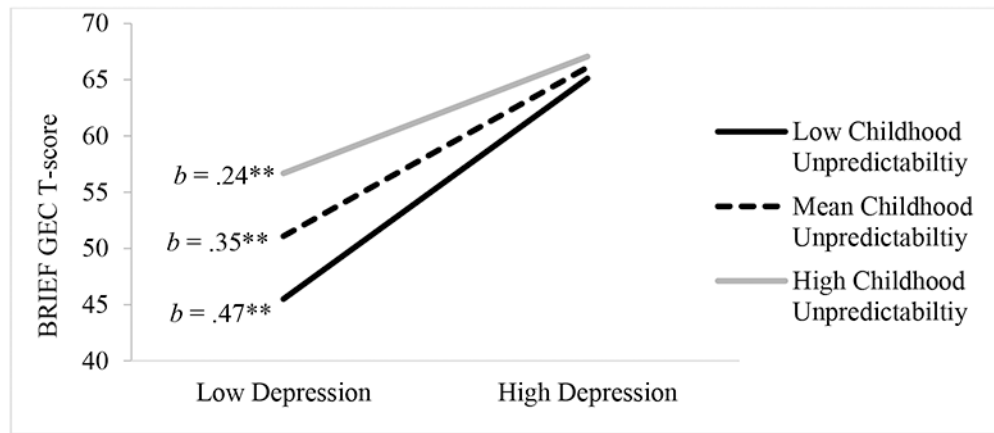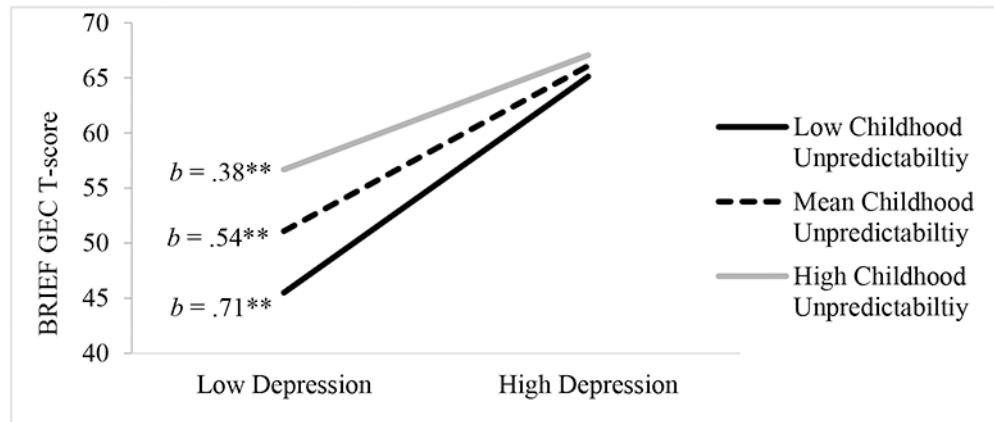
**p < .01

Figure 1b. The Interaction Between Depression (BDI) and Unpredictability (QUIC) Predicts BRIEF Scores

Note. QUIC low score=2.15, mean score=9.38, high score=16.61; BDI low score=1.16 and high score=27.60; BDI 16 indicate mild/minimal depression and 17 indicate moderate to severe depression; Higher BRIEF scores indicate poorer EF.

**p < .01

Table 1

Descriptive Statistics, Partial Spearman Correlations Among Primary Study Variables, and Group Comparisons

Variable	1	2	3	4	5	6	Total (N=138) M (SD)	MDD (n=63)	HC (n=75)	t
1. Age	--						15.91 (1.46)	16.28 (1.40)	15.60 (1.45)	−2.79 **
2. SES	--	--					42.34 (11.98)	39.38 (13.15)	44.83 (10.26)	2.68 **
3. CDRS	.20 *	.28 **	--				49.04 (19.36)	68.06 (10.55)	33.05 (5.82)	−23.51 **
4. BDI	.23 **	.27 **	.77 **	--			13.43 (14.16)	24.75 (12.840)	3.93 (5.73)	−11.91 **
5. BRIEF	.13	.28 **	.62 **	.71 **	--		57.14 (13.07)	66.27 (11.50)	49.47 (8.66)	−9.55 **
6. QUIC	.02	.31 **	.41 **	.50 **	.50 **	--	9.38 (7.23)	12.83 (7.61)	6.45 (5.40)	−5.57 **
7. SAS-SR-Y	.18 *	−.32 **	.73 **	.88 **	.74 **	.57 **	42.54 (14.03)	53.17 (12.13)	33.60 (7.98)	−10.97 **

Note. Age and SES are included as control variables in the Spearman correlations 3-6; MDD=Major Depressive Disorder; HC=Healthy Control; t = Independent Samples t-test comparing MDD and HC participants.

SES=Socioeconomic Status using Hollingshead scale; CDRS= Children's Depression Rating Scale–Revised Version; BDI=Beck Depression Inventory; BRIEF= Behavior Rating Inventory of Executive Function Global Executive Composite; QUIC=Questionnaire of Unpredictability in Childhood adolescent total score; SAS-SR-Y= Social Adjustment Scale-Self-Report for Youth;

*
$p < .05$.

**
$p < .01$.

Table 2

Descriptive Statistics, Partial Spearman Correlations Among Neuropsychological Performance Scores and Primary Study Variables, and Group Comparisons

Variable	CDRS	BDI	BRIEF	QUIC	SAS-SR-Y	M (SD)	MDD (n=61)	HC (n=71)	t
CPT detectability	−.04	−.10	−.03	.23*	−.06	47.39 (9.68)	47.13 (8.88)	47.61 (10.37)	0.28
CPT omissions	−.05	−.09	−.05	.16	−.07	47.97 (8.01)	47.28 (6.74)	48.56 (9.07)	0.91
CPT commissions	−.03	−.05	.01	.26**	.01	47.97 (9.23)	48.11 (8.94)	47.85 (9.54)	−0.17
CATA detectability	.12	.10	.05	.28**	.14	52.08 (9.06)	53.05 (8.43)	51.23 (9.55)	−1.14
CATA omissions	.10	.06	.08	.09	.06	46.96 (6.19)	47.15 (5.89)	46.80 (6.47)	−0.32
CATA commissions	.15	.15	.10	.26**	.18*	50.31 (8.62)	50.78 (8.22)	49.90 (8.99)	−0.58
CWIT Color Naming	−.20*	−.19*	−.16	−.25**	−.15	9.27 (2.82)	8.54 (2.75)	9.89 (2.75)	2.80**
CWIT Word Reading	−.16	−.09	−.05	−.16	−.06	10.37 (2.46)	9.89 (2.44)	10.79 (2.42)	2.13*
CWIT Inhibition	−.13	−.09	−.07	−.21*	−.08	10.12 (3.11)	9.64 (3.12)	10.54 (3.07)	1.66
CWIT Inhibition/Switching	−.16	−.14	−.13	−.16	−.07	9.88 (3.12)	9.70 (3.02)	10.03 (3.22)	0.59

Note. Age and SES are included as control variables in the Spearman correlations; Higher CPT and CATA scores indicate poorer performance and higher scores on CWIT indicate better performance; sample sizes vary for some measures.

CPT=Continuous Performance Test; CATA=Continuous Auditory Test of Attention; CWIT=Color-Word Interference; CDRS= Children's Depression Rating Scale–Revised Version; BDI=Beck Depression Inventory; BRIEF=Behavior Rating Inventory of Executive Function Global Executive Composite; QUIC=Questionnaire of Unpredictability in Childhood adolescent total score; SAS-SR-Y= Social Adjustment Scale-Self-Report for Youth; MDD=Major Depressive Disorder; HC=Healthy Control; t = Independent Samples t-test comparing MDD and HC participants.

*
$p < .05.$

**
$p < .01.$

Table 3

Hierarchical Linear Regressions Examining Childhood Unpredictability as a Moderator of the Effect of Depression Severity (Model 1: CDRS; Model 2: BDI) on Self-Reported Executive Functioning

Outcome: BRIEF GEC

Variable	Step 1			Step 2			Step 3			Step 4		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
CDRS												
SES	−0.34 **	0.09	−0.52, −0.16	−0.14	0.07	−0.28, 0.01	−0.09	0.07	−0.24, 0.05	−0.09	0.07	−0.23, 0.05
Age	1.54 *	0.73	0.10, 2.98	0.20	0.59	−0.96, 1.36	0.23	0.56	−0.88, 1.35	0.22	0.55	−0.88, 1.32
CDRS				0.43 **	0.05	0.34, 0.52	0.36 **	0.05	0.27, 0.46	0.36 **	0.05	0.26, 0.45
QUIC							0.43 **	0.13	0.18, 0.67	0.52 **	0.13	0.26, 0.77
CDRS x QUIC										−0.02 *	0.01	−0.03, −0.01
Adj. R^2			.10			.45			.49			.51
F			8.71 **			87.42 **			11.52 **			5.87 *
BDI												
SES	−0.34 **	0.09	−0.52, −0.16	−0.13	0.07	−0.27, 0.01	−0.10	0.07	−0.24, 0.04	−0.08	0.07	−0.22, 0.05
Age	1.54 *	0.73	0.10, 2.98	0.20	0.57	−0.93, 1.33	0.25	0.56	−0.86, 1.35	0.23	0.54	−0.85, 1.30
BDI				0.60 **	0.06	0.48, 0.72	0.52 **	0.07	0.39, 0.65	0.54 **	0.07	0.41, 0.67
QUIC							0.35 **	0.13	0.10, 0.60	0.46 **	0.13	0.21, 0.72
BDI x QUIC										−0.02 **	0.01	−0.04, −0.01
Adj. R^2			.10			.48			.50			.53
F			8.71 **			97.77 **			7.56 **			8.83 **

Note. QUIC, CDRS, and BDI are mean-centered.

BRIEF= Behavior Rating Inventory of Executive Function; GEC=Global Executive Composite; SES = socioeconomic status; CDRS=Children's Depression Rating Scale–Revised; BDI = Beck Depression Inventory; QUIC = Questionnaire of Unpredictability in Childhood (Total Score).

*
$p < .05$.

**
$p < .01$.

Table 4

Hierarchical Linear Regressions Examining Childhood Unpredictability as a Moderator of the Effect of Depression Severity (Model 1: CDRS; Model 2: BDI) on Performance-Based Executive Functioning

Outcome: CWIT Inhibition/Switching

Variable	Step 1			Step 2			Step 3			Step 4		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
CDRS												
SES	0.04	0.02	−0.01, 0.08	0.03	0.02	−0.02, 0.08	0.03	0.02	−0.02, 0.07	0.03	0.02	−0.02, 0.07
Age	0.28	0.18	−0.08, 0.65	0.35	0.19	−0.02, 0.73	0.35	0.19	−0.02, 0.73	0.35	0.19	−0.03, 0.73
CDRS				−0.02	0.02	−0.05, 0.01	−0.02	0.02	−0.05, 0.01	−0.02	0.02	−0.05, 0.01
QUIC							−0.02	0.04	−0.10, 0.07	−0.02	0.05	−0.11, 0.07
CDRS x QUIC										0.01	0.01	−0.01, 0.01
Adj. R^2	0.03			0.03			.03			0.02		
F	2.95			0.90			1.40			0.01		
BDI												
SES	0.04	0.02	−0.01, 0.08	0.03	0.02	−0.01, 0.08	0.03	0.02	−0.02, 0.08	0.03	0.02	−0.02, 0.08
Age	0.28	0.18	−0.08, 0.65	0.31	0.19	−0.07, 0.69	0.30	0.19	−0.07, 0.69	0.30	0.19	−0.07, 0.68
BDI				−0.01	0.02	−0.05, 0.03	−0.01	0.02	−0.05, 0.04	−0.01	0.02	−0.05, 0.04
QUIC							−0.04	0.04	−0.12, 0.05	−0.05	0.05	−0.14, 0.04
BDI x QUIC										0.01	0.01	−0.01, 0.01
Adj. R^2	0.03			0.02			0.02			0.03		
F	2.95			0.30			0.62			2.04		

Note. QUIC, CDRS, and BDI are mean-centered.

CWIT=Color-Word Interference; SES = socioeconomic status; CDRS=Children's Depression Rating Scale–Revised; BDI = Beck Depression Inventory; QUIC = Questionnaire of Unpredictability in Childhood (Total Score).

*
$p < .05$.

**
$p < .01$.

Table 5

Descriptive Statistics and Group Comparisons on Clinical Range Categories for BRIEF Scores

Variable	MDD (*n*=63)		HC (*n*=75)		X^2
	n	*%*	*n*	*%*	
GEC Average	22	34.9	63	84.0	44.64 [**]
GEC Mild	16	25.4	12	16.0	
GEC Elevated	25	39.7	0	0	
BRI Average	30	47.6	68	90.7	31.13 [**]
BRI Mild	24	38.1	6	8.0	
BRI Elevated	9	14.3	1	1.3	
CRI Average	19	30.2	61	81.3	46.81 [**]
CRI Mild	16	25.4	13	17.3	
CRI Elevated	28	44.4	1	1.3	
ERI Average	16	25.4	64	85.3	52.61 [**]
ERI Mild	24	38.1	9	12.0	
ERI Elevated	23	36.5	2	2.7	

Note. MDD=Major Depressive Disorder; HC=Healthy Control; BRIEF= Behavior Rating Inventory of Executive Function; GEC=Global Executive Composite; BRI=Behavioral Regulation Index; CRI=Cognitive Regulation Index; ERI=Emotional Regulation Index; Average=T-scores below 59; Mild=T-scores 60-64; Elevated=T-scores 70 and above.

[**]
p < .01.