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Differentiating Symptoms of ADHD in Preschoolers: The Role of Emotion Regulation and Executive Function

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Abstract

Objective: This study examined the extent to which individual differences in executive function (EF) and emotion regulation (ER) were uniquely associated with inattention and hyperactivity symptoms of ADHD, respectively.

Method: Participants included 249 preschool children with at-risk or clinically elevated levels of externalizing behavior problems (EBPs).

Results: Regression analyses were conducted examining the association between EF and ER—as reported by parents/teachers and assessed via child task performance—and hyperactivity and inattention. Even after accounting for IQ, age, sex, and severity of oppositional defiant disorder, greater levels of parent/teacher-reported EF problems and worse EF performance were associated with greater inattention. In addition, better observed ER was associated with lower inattention. Conversely, greater levels of parent/teacher-reported EF problems and worse parent/teacher-reported ER were associated with greater hyperactivity.

Conclusion: Our findings suggest that underlying deficits in EF and ER do differentially relate to ADHD symptoms.

Keywords

ADHD; executive function; emotional regulation; inattention; hyperactivity/impulsivity

Self-regulation broadly refers to the planning and control of behavioral, emotional, and cognitive skills necessary for optimal functioning (Bandura, 1991; Calkins, 2007; Ponitz et al., 2008). Theoretical models of self-regulation along with neuroscience research support a distinction between top-down (instruction-driven) and bottom-up (stimulus-driven) components to self-regulation (Hugdahl, 2000; Martel et al., 2009; Sergeant et al., 2003). Associated with the top-down processing, executive functioning (EF) encompasses planning and execution of goal-directed behaviors (Barkley, 1997), such as working memory (WM), inhibition, set shifting, planning, contextual memory, and fluency (Pennington & Ozonoff, 1995; Welsh, 2002). Conversely, emotion regulation (ER) is conceptualized as a bottom-

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up process as it entails experiencing, expressing, and modulating emotional experiences (Gross, 1998; McRae et al., 2012). Assessing these interrelated, yet distinct self-regulation processes during the preschool period is especially important given the well-documented links between EF and ER and children's school readiness (Blair & Razza, 2007; Graziano et al., 2007; Welsh et al., 2010).

ADHD is a neurodevelopmental disorder characterized by symptoms of inattention and/or hyperactivity that affects 5% to 7% of school-age children (American Psychiatric Association, 2013; Polanczyk et al., 2014). ADHD is associated with significant impairments across functional domains (Wehmeier et al., 2010), emerging as early as pre-school (American Psychiatric Association, 2013; Connor, 2002; Egger & Angold, 2006; Lavigne et al., 2009) and extending into adulthood (Barkley, 2016; Biederman, 2005; Mash & Barkley, 2003). A significant body of research highlights the heterogeneity of ADHD symptom presentation and associated impairment (Chhabildas et al., 2001; Wåhlstedt et al., 2008). For example, Grizenko et al. (2010) found that children with ADHD combined presentation are more likely to have comorbid internalizing and externalizing problems and be disruptive at school compared to children with ADHD with a predominately inattentive presentation. Martel and colleagues (2008, 2009) found preliminary support that differential underlying processes, such as EF and ER, can partially account for heterogeneity in ADHD symptoms in older children and adolescents. Specifically, inattention symptoms appear to be more closely tied to underlying deficits in EF, while the hyperactive symptoms of ADHD are more closely linked to ER deficits (Martel et al., 2008; Wåhlstedt et al., 2008). However, limited work has examined these associations in the preschool period, despite the significant impact of early EF and ER deficits on children's behavioral, academic, and social functioning (Graziano et al., 2015; Lonigan et al., 1999). The present study sought to examine how individual differences in young children's EF and ER relate to heterogeneity in ADHD symptoms.

ADHD and EF

Theoretical models of ADHD suggest that individuals with ADHD have an underlying deficit in EF that contributes to poorer recall, planning, and anticipatory or preparatory behaviors (Barkley, 1997, 2015; Nigg et al., 2005). Early deficits in EF have also been identified as an etiological risk factor for ADHD (Nigg et al., 2005). These EF deficits found among children with ADHD are documented across observational/neuropsychological and parent/teacher report measures. Mahone and Hoffman (2007) found that 3- to 5-year-olds with ADHD are reported by parents as having significantly poorer EF compared with typically developing children. Moreover, preschool children with ADHD demonstrate deficits in inhibitory control, verbal WM, spatial memory, and verbal fluency on laboratory tasks (Thorell & Wåhlstedt, 2006). Despite robust findings demonstrating EF deficits in individuals with ADHD, less work has examined the association between EF and symptoms of ADHD. Examining such associations is particularly important since EF has been established as one neuropsychological component associated with ADHD, yet not all children with ADHD suffer from EF deficits (Nigg et al., 2005).

One of the few studies to date examining the association between EF and ADHD symptoms in children and adolescents demonstrated that when examining performance on neurocognitive tasks, deficits in EF, but not ER, are significantly associated with inattention symptoms (Martel et al., 2008). Similarly, longitudinal research in preschoolers has demonstrated that early deficits in EF, as measured by task performance, are associated with later reported symptoms of inattention, but not hyperactivity (Wåhlstedt et al., 2008). Given that children with ADHD and EF deficits have significantly worse school outcomes (e.g., repeating a grade, diagnosis of a learning disability) than typically developing children (Biederman et al., 2004), it is important to understand how EF (measured by both rating scales and objective measures) may contribute uniquely to the heterogeneity of ADHD symptoms in preschoolers.

ADHD and ER

A recent meta-analysis found that children with ADHD not only have EF deficits but also, and potentially relatedly, suffer significant deficits across various domain of emotion dysregulation, including one’s ability to recognize and understand emotion, reactivity to emotional events, and ER strategies (Graziano & Garcia, 2016). Deficits in ER are seen across externalizing disorders that are highly comorbid with ADHD (i.e., oppositional defiant disorder [ODD]), highlighting the importance of examining ER as it specifically relates to ADHD (Martel & Nigg, 2006; Nigg et al., 2004). In addition, the behavioral inhibition theory suggests that children with ADHD display a greater dependency on external factors affecting motivation and arousal (Barkley, 1997; Bunford et al., 2015). Empirically, both preschool and elementary children with ADHD demonstrate deficits in ER (measured both at the behavioral and at the biological levels) when compared with typically developing children (Cole et al., 1996; Musser et al., 2011).

When relating ER deficits to symptoms of ADHD, studies with older children demonstrate that only symptoms of hyperactivity are associated with performance on ER tasks (Martel et al., 2008). However, in an adolescent sample, ER was uniquely associated to symptoms of inattention, but not hyperactivity (Martel et al., 2008). These contradicting results suggest that (a) there are differences in the heterogeneity of ADHD symptoms across development and (b) underlying self-regulation processes such as ER may also differentially relate to ADHD symptoms. Indeed, longitudinal studies have shown that children’s ADHD presentation varies tremendously from the preschool to the adolescent years (Lahey et al., 2005; Waschbusch et al., 2007). Conversely, it remains unclear the extent to which individual differences in ER contribute to the heterogeneity in ADHD symptom presentation during the preschool period. Considering the associations between ER and poor academic and social outcomes in kindergartners (Graziano et al., 2007; Rubin et al., 1995), identifying how ER deficits relate to symptom presentation of ADHD may help to identify which children may benefit most from intervention.

Current Study

In summary, it is well established that children with ADHD have significant impairments in both EF and ER (Barkley, 1997; Graziano & Garcia, 2016; Willcutt et al., 2005). Studies with older children and adolescents suggest that EF deficits are uniquely associated with inattention symptoms of ADHD, while deficits in ER are mostly uniquely associated with deficits in ER (Martel et al., 2009; Sonuga-Barke, 2003). In preschoolers, EF performance deficits are predictive of later symptoms of inattention (Wåhlstedt et al., 2008). Given that EF and ER processes are rapidly developing during the preschool period (Denham, 2006; Garon et al., 2008), it is critical to examine their association with emerging symptoms of ADHD. Identifying subgroups of children with the most impairing EF and/or ER deficits may not only provide understanding of the heterogeneity within ADHD, but also yield more personalized treatment (Reid et al., 2005). The goal of the current study was to examine the extent to which individual differences in EF and ER were uniquely associated with symptoms of ADHD (i.e., inattention and hyperactivity). In line with prior research with older children (Martel et al., 2009), it was expected that in preschoolers, deficits in EF would uniquely relate to symptoms of inattention, while deficits in ER would uniquely relate to symptoms of hyperactivity.

Method

Participants and Recruitment

The study was conducted at a large urban university in the Southeastern United States with a large Hispanic/Latino population. Children and their families were recruited from local preschools and mental health agencies through brochures, radio ads, and open houses/ parent workshops to participate in an intensive summer treatment program for children transitioning to pre–K or kindergarten (STP-PreK; Graziano et al., 2014). Participants in the current study met eligibility criteria if they (a) had an externalizing problems composite t-score above 60 on either parent, M = 64.80, SD = 12.35, or teacher, M = 66.75, SD = 13.23, ratings on the Behavior Assessment System for Children–Second Edition (BASC-2; Bird et al., 1992; Piacentini et al., 1992), which was collected during the initial assessment; (b) were enrolled in preschool the previous year; (c) obtained an estimated IQ of 70 or higher, M = 91.58, SD = 14.93, on the Wechsler Preschool and Primary Scale of Intelligence–Third (WPPSI-III) or Fourth Edition (WPPSI-IV; Wechsler, 2002, 2012); and (d) were able to attend an 8-week summer program prior to starting kindergarten.

The final study sample consisted of 249 preschool children (78% males) with at-risk or clinically elevated levels of externalizing behavior problems and whose parents provided consent to participate in the study. The mean age of the participating children was 4.95 years, SD = 0.53 years. In terms of the ethnic and racial makeup, 82% of the children were Hispanic/Latino. All children’s primary language was English, with 56% also being proficient in Spanish. All child assessments were administered in English. Parent measures were administered in the parents’ preferred language (83% English, 17% in Spanish by bilingual staff). Table 1 displays sample demographics including rates of diagnoses. Consistent with recommended practice (Pelham et al., 2005), diagnostic information was obtained through parent structured interviews in conjunction with parent and teacher ratings of symptoms and impairment. The specific interview protocol and rating scales used included the Diagnostic Interview Schedule for Children–Version IV (C-DISC; Shaffer et al., 2000) or Kiddie–Disruptive Behavior Disorder Schedule (K-DBDS; Keenan et al., 2007), the Disruptive Behavior Disorders (DBD) Rating Scale (Pelham et al., 1992), and the Impairment Rating Scale (Fabiano et al., 2006). According to parent report at intake, only 10 children were on any psychotropic medication (e.g., stimulants, non-stimulants).

Study Design and Procedures

The university's Institutional Review Board approved this study. As part of the initial assessment for this study, parents and teachers also completed several questionnaires about the child's behavior and self-regulation skills. Eligible participants were invited to attend the second laboratory visit prior to the start of treatment in which children and their parents were video recorded during various tasks, including an EF battery and two ER tasks, which were administered by trained graduate and undergraduate students, discussed in further detail below.

Measures

ADHD

Inattention and hyperactivity.: To assess children's behavioral functioning, parents and teachers completed the BASC-2 (Reynolds & Kamphaus, 1992). The BASC-2 is a widely utilized tool that allows one to understand several emotional and behavioral domains. Several scales include internalizing, externalizing, and behavior symptom domains, and adaptive/social functioning skills. The attention problems and hyperactivity gender normed *t*-scores were examined in the present study as a proxy for symptoms of inattention and hyperactivity (αs = .80–.91; Pelham et al., 2005). Consistent with prior work (Bird et al., 1992; Martel et al., 2009; Piacentini et al., 1992), the highest *t*-score among parent and teacher reports was used.

EF, top-down processing

Head–toes–knees–shoulders task (HTKS).: The HTKS (Ponitz et al., 2009) is a widely used tool for assessing EF in preschool populations (Graziano et al., 2015; McClelland et al., 2014). The HTKS has well-established internal consistency, reliability, and concurrent/predictive validity (McClelland et al., 2014; Ponitz et al., 2009). During HTKS, children are required to follow a set of behavioral rules, such as "touch your head," that is paired with a conflicting behavioral response. There are two parts to the task with 10 trials each. Prior to each part, children are presented with a set of rules (i.e., head and toes), such that the child is required to do the opposite/different move from what is stated aloud. For example, when the examiner says, "touch your toes" the correct behavioral response would require the child to touch their head. In the second part, a new set of paired rules is added, touching shoulders and knees. The measure is scored by giving the child 0, 1, or 2 points for each response. The child receives 0 points for an incorrect response, 2 points for an immediate correct response, and 1 point for self-corrections. Scores range from 0 to 40, with higher scores indicating better EF.

Automated Working Memory Assessment (AWMA).: Children were individually administered four subtests of the AWMA (Alloway et al., 2004). Subtests included the following: (a) Word Recall (auditory short-term memory), (b) Listening Recall (auditory

WM), (c) Dot Matrix (visuospatial short-term memory), and (d) Mister X (visuospatial WM). In the Word Recall task, children are required to remember a sequence of words and repeat them back to the examiner. The Listening Recall subtests require children to determine the validity of a sentence, then repeat the last word of the sentence with increasing difficulty. During Dot Matrix, children must recall the location of dots on a 4 × 5 grid, in the order. In the Mister X task, two similar figures are next to each other, each holding a ball in its hand. One of the figures is rotated between 45 and 315 degrees. The child is required to determine spatial orientation (i.e., "Are they holding the ball in the same hand or different hands?") and recall the location of the ball from six different possibilities. Raw scores from the subtests are converted to standard scores according to gender and age norms. Scores from the AWMA show adequate test–retest reliability and has established convergent validity (Alloway et al., 2008). Due to the moderate to high correlation among the four subtests, $r = .30–.50$, $p < .01$, an average standardized score was calculated and used for the analyses in the current study. Due to the strong correlation between performance on HTKS and AWMA, $r = .50$, $p < .01$, both measures were standardized and averaged to create an EF performance composite.

Emergent Metacognition—BRIEF.: Parents and teachers completed the Behavior Rating Inventory of Executive Function–Preschool Version (BRIEF-P; Gioia et al., 2000). The BRIEF-P yields five nonoverlapping clinical scales (inhibit, shift, emotional control, WM, and plan-organize). The BRIEF-P has well-established internal consistency, reliability, and validity (Ezpeleta et al., 2015; Isquith et al., 2004). For the purpose of the present study, the emergent metacognition index *t*-score, which focuses on the cognitive aspects of self-regulation and is comprised of the WM and plan/organize subscales, was used as a measure of EF. Consistent with prior work, the highest report between parent and teacher report was used, $\alpha = .93–.92$, with higher scores indicating greater EF problems.

ER, bottom-up processing

Emotion Regulation Checklist (ERC).: To assess for children's ER skills, parents and teachers completed the ERC (Oades-Sese et al., 2011; Shields & Cicchetti, 1997). The ERC yields two scales: Negativity/Lability and Emotion Regulation Scale. The Negativity/Lability scale is composed of 10 items that capture negative affect and mood lability. The Emotion Regulation scale is composed of 14 items that assess adaptive regulation. To more comprehensively assess emotion dysregulation and consistent with prior work (Graziano et al., 2014; Ramsden & Hubbard, 2002), both scales were transformed to *z*-scores. The Negativity/Lability scale was then divided by negative one to produce its inverse. The inverse Negativity/Lability *z*-score and the Emotion Regulation *z*-score, $rs = .20–.23$, $p < .01$, were then averaged for a standardized mean Emotion Regulation score, $\alpha = .76–.78$, with higher scores indicating better ER. To ensure we capture the highest level of impairment, the lowest report between teacher and parent was used.

Laboratory Temperament Assessment Battery (Lab-TAB).: To elicit frustration, two frustration tasks adapted from the Lab-TAB (Goldsmith & Rothbart, 1996) were administered: *I'm Not Sharing* and *Impossibly Perfect Circles*. In the *I'm Not Sharing* task, an assistant brings a container of candy and tells the experimenter to share it equally with the child. The experimenter begins by equally dividing the candy with the child, but slowly begins to take more than the child, eat a piece of the child's candy, takes more than given to the child, and eventually takes all the child's candy without allowing the child to eat any of the candy. In the *Impossibly Perfect Circles* task, children were asked to draw circles repeatedly. After each one, the examiner criticizes something minor about the circle (e.g., too small) and tells the child to draw another. The tasks were discontinued if the child was highly distressed or cried for more than 30 s. The global measure of regulation was coded on a scale from 0 (*dysregulcited*) to 4 (*well regulated*). For each code, 20% of the videos were coded for reliability. The reliability Kappas for global regulation codes in this study were all above .80. For data reduction purposes, the most severe rating of dysregulation between the two tasks was used for the current study.

Measures: Covariate

ODD.: Parents and teachers completed the DBD Rating scale (Pelham et al., 1992). Each symptom of ODD on the DBD Rating Scale is rated on a 4-point frequency scale (*not at all, just a little, pretty much*, or *very much*). The DBD Rating Scale was adapted to reflect the newest edition of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; *DSM-5*; American Psychiatric Association, 2013). For this study, the highest mean item severity of ODD symptoms between parent and teacher report was used, α = .85–.88.

Data Analytic Plan

All analyses were conducted using Statistical Package for the Social Sciences, version 20 (SPSS 20). For the measures used, there was some missing data for parent and teacher report measures, 11% and 22% respectively, and EF task performance, 11%. According to Little's missing completely at random test, the missing data were missing completely at random, $\chi^2(320) = 320.69$, $p = .22$. There were no significant differences between children with complete versus partial data in terms of any demographic variables or any outcomes examined in the current study. Multiple imputation was conducted with five imputations, which is a sufficient estimate for the given sample size (Rubin, 1987). Preliminary analyses were conducted to examine the associations between demographic variables and the study variables. Multiple hierarchical regression equations were conducted to examine the association between EF and ER and symptoms of ADHD.

Results

Preliminary Analyses

Preliminary analyses examined any potential associations between demographic variables and any of the study's outcomes (see Table 2). Children's age was significantly associated with EF performance, $r = .39$, $p < .001$, indicating that older children performed better on the EF battery. Age was also significantly associated with observed ER, $r = -.20$, $p < .05$, such that older children displayed poorer regulation. Child sex was significantly associated with parent/teacher-reported hyperactivity and attention problems, $r = -.15$, $p < .05$; $r = -.23$, $p < .001$, respectively, such that males had less reported hyperactivity and attention problems than females. In addition, child IQ was significantly associated with attention problems, $r = -.24$, $p < .001$, and both parent/teacher-reported EF and EF performance,

$r = -.31$, $p < .001$; $r = .59$, $p < .001$, respectively. Children with higher IQ had less attention problems and better EF. Furthermore, parent/teacher-reported symptoms of ODD were significantly associated with observed EF, $r = .18$, $p < .01$; parent/teacher-reported ER, $r = -.57$, $p < .001$; and observed ER, $r = -.17$, $p < .05$. Specifically, children with higher levels of ODD had significantly better performance on EF tasks, and worse reported and observed ER. No other demographic variables were associated with ADHD symptoms, EF, or ER. Therefore, subsequent analyses included IQ, age, sex, and symptoms of ODD as covariates.

Bivariate correlations were examined between EF and ER and ADHD symptoms (see Table 2). Both parent/teacher-reported EF and EF performance were significantly associated with parent/teacher-reported inattention, $r = .58$ $p < .001$, $r = -.22$ $p < .001$, respectively. Children with greater parent/teacher-reported EF deficits and poorer performance on the EF battery were rated by parents/teachers as having higher levels of inattention. In addition, observed ER was significantly associated with inattention, $r = -.20$, $p < .05$. Children who displayed greater regulation were rated by parents/teachers as being less inattentive. Parent/teacher-reported ER and EF was also significantly associated with hyperactivity, $r = -.57$ $p < .001$, $r = .25$ $p < .001$, respectively. Children rated by parents/teachers as having poorer ER and greater EF problems demonstrated higher levels of hyperactivity.

Regression Analyses

Hierarchical regression analyses were conducted to examine the unique associations between top-down and bottom-up regulatory processes (i.e., EF and ER) and symptoms of ADHD. Both regression analyses (i.e., inattention and hyperactivity) were conducted with separate EF and ER models, and the results were consistent. Therefore, the combined models are presented below. As seen in Table 3, IQ and sex were both significantly associated with inattention, $\beta = -.23$, $p < .001$ and $\beta = -.23$, $p < .001$, respectively, while age and ODD severity were not, ps > .05. Children with higher IQ were less inattentive, and males were rated as having less attention problems than females. In addition, EF and ER accounted for a significant portion of variance in parent/teacher-reported inattention, $R^2 = .45$, $\Delta R^2 = .34$, $p < .001$. EF and ER account for 34% of the variance in inattention, above and beyond IQ, age, sex, and symptoms of ODD. More specifically, higher parent/teacher-reported EF problems, $\beta = .55$, $p < .001$, and worse performance on an EF battery, $\beta = -.20$, $p < .05$, were significantly associated with inattention, even when controlling for IQ, age, sex, and symptoms of ODD. Children rated by parents and teachers as having more EF problems and demonstrating worse EF performance had higher levels of inattention. In addition, observed ER was significantly associated with inattention, $\beta = -.12$, $p < .05$, such that children who were more regulated were rated by parents and teachers as being less inattentive. Parent/teacher-reported ER was not significantly associated with inattention, $p > .05$.

In terms of hyperactivity, sex and ODD severity were significantly associated with hyperactivity, $\beta = -.16$, $p < .01$ and $\beta = 49$, $p < .001$, respectively, while IQ and age were not, ps > .05. Males were less hyperactive than females. In addition, children with more severe ODD were rated as being more hyperactive. In addition, EF and ER accounted for a significant portion of variance in parent/teacher-reported hyperactivity, $R^2 = .35$, $\Delta R^2 = .10$, $p < .001$. EF and ER account for 34% of the variance in hyperactivity, above and beyond IQ, age, sex, and symptoms of ODD. More specifically, parent/teacher-reported ER was significantly associated with hyperactivity, $\beta = -.17$, $p < .05$, even when controlling for IQ, age, sex, and ODD severity. Children rated by parents and teachers as being more regulated demonstrated lower levels of hyperactivity. Observed ER was not significantly associated with reported hyperactivity, $p > .05$. In addition, parent and teacher–reported EF problems were significantly associated with hyperactivity, $\beta = .27$, $p < .001$, even when controlling for IQ, age, sex, and ODD severity. Children with greater reported EF problems were more hyperactive. There were no significant interactions for either inattention or hyperactivity; therefore, they were not included in Table 3.

Discussion

This is one of the first studies to examine the extent to which individual differences in preschoolers' EF and ER are uniquely associated with inattention and hyperactivity symptoms of ADHD. Findings from this study suggest that over and above IQ and symptoms of ODD, deficits in EF, as measured by both parent/teacher reports and performance on an EF battery, are significantly associated with inattention symptoms of ADHD. Observed ER was also significantly associated with inattention, over and above IQ and symptoms of ODD. Conversely, both parent/teacher-reported ER and EF were significantly associated with symptoms of hyperactivity, while neither observed ER nor performance on an EF battery was associated with hyperactivity. These findings are discussed in further detail below.

The associations found in this study between deficits in EF and greater symptoms of inattention are consistent with prior conceptualizations of top-down processes that require the ability to focus on task-relevant stimuli (Gazzaley & Nobre, 2012). More specifically, both selective attention and WM involve top-down modulation of the prefrontal and parietal cortices as demonstrated by performance on neuropsychological tests, electroencephalography (EEG), and functional imaging studies (Gazzaley & Nobre, 2012; Sergeant et al., 2003). Greater activity in the prefrontal cortex, near the precentral sulcus, is associated with filtering and attending to only relevant stimuli, along with activation in the medial and lateral prefrontal cortex areas when focusing attention (Gazzaley & Nobre, 2012). Given the similar underlying processes, children demonstrating deficits in EF are likely to demonstrate deficits in attention as well. Empirical research has supported this with both cross-sectional and longitudinal studies. Martel and colleagues' (2008) work in older adolescents found that poor performance on neurocognitive EF tasks is uniquely associated with inattention, while Wåhlstedt and colleagues (2008) demonstrated longitudinally that early deficits in EF are associated with later symptoms of inattention. Our findings support the findings of previous studies, suggesting that deficits in EF relate to symptoms of inattention, as early as preschool. Consistent with prior work, IQ accounted for some of the variance in inattention (Wåhlstedt et al., 2008). This may be indicative of the correlation between IQ and deficits in EF (Ardila et al., 2000; Mahone et al., 2002).

In addition to EF, the results from the current study indicated that children who were less regulated during the frustration tasks had higher levels of inattention. While this was contrary to the hypotheses predicting that ER would uniquely be associated with hyperactivity, it is important to note the potential role of EF in ER (Blair & Ursache, 2011). While ER is usually conceptualized as a bottom-up process, literature has identified that there are also top-down processes that occur (Graziano & Garcia, 2016; Gross, 1999). Gross's (1999) emotion generation process model states that emotions begin with a cue that provokes an emotional response, which may be modulated. As part of the modulation process, an individual may engage in situation selecting, situation modification, attentional deployment, cognitive change, or response modification (Gross, 1999). EFs, such as alerting, orienting, and executive attention, may be especially critical in these situations for the regulation of both behavior and emotions as early as preschool (Blair & Ursache, 2011). More specifically, research has demonstrated the importance of controlling attention in distracting oneself from distress (Kopp, 1989). It is possible that in the current study, children with ADHD were not able to shift attention as an effective distraction or coping technique in response to frustration. However, subsuming the association between ER and inattention in the current study as a related function of EF is only one possible explanation. As the current study's observed global regulation measure does not disentangle bottom-up ER from top-down ER, one should exercise caution when considering the impacts of EF on ER.

When examining the associations between self-regulation deficits and symptoms of hyperactivity, the findings were mixed. On one hand, parents/teachers reported that children with poorer ER demonstrated greater levels of hyperactivity. However, observed ER was not significantly associated with hyperactivity. These null findings may be a result of the standardized tasks used in the current study. Due to the time-limited nature of the frustration tasks used in the current study, the standardized assessment used may not have captured broader trait-like characteristics related to ER, such as reactive control or surgency (Martel et al., 2008). Alternatively, parent/teacher-reported self-regulation might be more indicative of these broader, more chronic trait-level dimensions of self-regulation. This could explain why parent/teacher ER was significantly associated with hyperactivity, while observed ER was not.

In addition to poorer parent/teacher-reported ER, children who were rated as having more EF problems had significantly greater levels of hyperactivity in the current study. As previously mentioned, it is possible that this reflects the role of top-down EF processes in the modulation of emotions (Blair & Ursache, 2011). However, our findings align largely with the findings of Martel and colleagues' (2008) work examining differential associations between top-down and bottom-up traits and symptoms of ADHD, such that hyperactivity was related to both bottom-up and top-down traits. The current study contributes to the existing literature as one of the strongest studies examining the associations between self-regulation deficits and symptoms of ADHD, given the utilization of both report measures and standardized/observed tasks for both EF and ER. Our findings, in combination with the previous literature, suggest that top-down EF processes may be more important than bottom-up reactivity during the preschool years. Therefore, interventions that target deficits in EF may yield better long-term outcomes for children in terms of both inattention and hyperactivity.

Limitations and Future Directions

While major strengths of this study include a multi-informant, multi-method approach to understanding differential associations between symptoms of ADHD and self-regulation (while controlling for ODD), some limitations should be addressed. The global codes used to code ER were not specific enough to examine which strategies of ER children may be employing (Gross, 1999), or the extent to which EF may be related to ER (Blair & Ursache, 2011). To further explore the extent to which hyperactivity or inattention/attention shifting occurred during EF and ER tasks, future research should include observation, report, and physiological measures. More specifically, for inattention, observing whether a child is attending away from a frustrating or stressful task in vivo may provide further clarification as to whether attention shifting is being used to regulate emotions in a time of distress. In addition, physiological measures (e.g., respiratory sinus arrhythmia and pre-ejection period) could further our understanding on the non-observable, biological processes underlying inattention and hyperactivity. Finally, additional tasks should be considered, such as the Gift Wrap, Gift Bow task (Kim et al., 2013), or other Lab-TAB frustration tasks.

Within the EF domain, though the HTKS task has been validated as a measure of EF, it encompasses both EF and behavioral regulation (Graziano et al., 2015; McClelland et al., 2014). Thus, due to the complex nature of the task, it is difficult to disentangle which aspects of self-regulation are being employed throughout. Some literature has even distinguished between “hot” EF (i.e., top-down cognitive processing in emotional contexts) and “cool” EF (i.e., top-down cognitive processing in neutral contexts; Zelazo & Carlson, 2012). Future research should examine the extent to which these distinctions in EF may contribute to ER development. In addition, even though the EMC scale of the BRIEF was used, the BRIEF has been criticized for measuring self-regulation more globally, and being associated with a wide range of behavior problems (Mahone & Hoffman, 2007). However, Toplak et al. (2013) demonstrated that despite tapping into different constructs, there is utility in both performance-based and rating measures of EF. This study showed that higher levels of inattention were associated with deficits in EF across measures, potentially supporting the use of the HTKS task, and the EMC as valid measures of EF.

The measures used for this study may not represent all components of ER. Previous meta-analysis identified four distinct constructs of ER: emotion recognition/understanding, emotion reactivity/negativity/lability, ER, and empathy/callous-unemotional traits (Graziano & Garcia, 2016). More specifically, the ERC primarily represents emotional negativity/lability and global regulation, while the global regulation codes are primarily assessing overall ER. Future research should examine other measures assessing all domains of ER, such as an emotion recognition task and a measure of empathy and callous/unemotional traits. However, this study is among the first to our knowledge to use multiple reports, both parent/teacher and laboratory task observation when examining ER in preschoolers.

Another limitation is the cross-sectional design of the study. It is unclear if changes in self-regulation results in a change in symptoms of ADHD, or conversely, if a change in symptoms of ADHD results in changes in EF and ER. Given that the symptom presentation of ADHD changes throughout the lifespan, future research should examine the development of the associations between self-regulation processes and symptom domains across the lifespan (Chhabildas et al., 2001; Wåhlstedt et al., 2008). Because this study was not longitudinal, it is not possible to disentangle the development of ER as it potentially relates to EF. For example, if the ability to learn coping skills is imperative in effectively modulated emotional responses, then deficits in EF could have compounding effects on the development of effective ER strategies. Longitudinal research would be able to disentangle the directionality in the parallel associations found between EF/ER and symptoms of ADHD, as well as the potential effects of EF on ER.

Furthermore, the primarily Hispanic/Latino sample in this study limits the interpretations of the results found in a preschool sample to preschoolers of other racial/ethnic backgrounds. However, previous work was limited to in generalizability to Caucasian populations. The present study expanded upon the population for which results from previous research may apply. Given that Hispanic/Latino children are the fastest growing minority in the United States (La Greca et al., 2009), it is important to examine self-regulation processes in this population.

Conclusion

Despite the limitations, the current study provides initial evidence that deficits in EF differentially relate to symptoms of inattention, while deficits in both EF and ER predict symptoms of hyperactivity. This study addresses a gap in the literature, examining the association between self-regulation processes and symptoms of ADHD in preschoolers. Although work with older children and adolescents has established unique associations between EF and inattention, and ER and hyperactivity (Martel et al., 2009), this study was the first to our knowledge to examine underlying self-regulations in preschoolers with ADHD. The findings from this study may aid in identifying subgroups of children with EF and/or ER impairments to better understand heterogeneity within ADHD. One proposed suggestion given the results of the current study is for interventions to target EF deficits in preschoolers, such as circle time games (Tominey & McClelland, 2011). This would not only yield improvements in attention but also potentially improve the ability to learn effective coping skills to modulate bottom-up processes as well. Future research should examine the parallel associations between self-regulation processes and symptoms of ADHD with (a) observed measures of hyperactivity and inattention, (b) neurobiological measures (e.g., fMRI) to examine biological underpinnings of self-regulation profiles in children with ADHD, and (c) most importantly, longitudinal studies to better understand if changes in EF/ER predict changes in symptoms of ADHD, or if changes in symptoms of ADHD predict changes in EF/ER.

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Table 1.

Descriptive Statistics.

Screening measures	Mean (SD)
Child sex (% male)	78
Child age	4.96 (0.52)
Hollingshead SES	43.63 (12.63)
Child ethnicity (% Hispanic/Latino)	82
Child full scale IQ	91.64 (14.93)
BASC-2 Externalizing *t*-score (P)	64.87 (12.32)
BASC-2 Externalizing *t*-score (T)	66.75 (13.23)
ADHD-only diagnosis (%)	32
ODD-only diagnosis (%)	14
ADHD + ODD diagnosis (%)	43
ADHD symptoms	
BASC-2 Hyperactivity *t*-score (P)	68.95 (12.41)
BASC-2 Hyperactivity *t*-score (T)	66.45 (11.98)
BASC-2 Attention Problems *t*-score (P)	64.66 (8.02)
BASC-2 Attention Problems *t*-score (T)	60.70 (7.73)
Executive Function	
BRIEF—EMC *t*-score (P)	71.42 (14.69)
BRIEF—EMC *t*-score (T)	68.53 (13.67)
HTKS and AWMA *z*-score composite (O)	0.00 (0.88)
Emotion Regulation	
ERC *z*-score (P)	0.00 (0.77)
ERC *z*-score (T)	0.00 (0.78)
Lab-TAB—*I'm Not Sharing*, Global Regulation (O)	2.43 (1.15)
Lab-TAB—*Circles*, Global Regulation (O)	2.76 (0.87)

Note. SES = socioeconomic status; BASC-2 = Behavior Assessment System for Children–Second Edition; P = parent report; T = teacher report; ODD = oppositional defiant disorder; BRIEF—EMC = Behavior Rating Inventory of Executive Function—Emergent Metacognition; HTKS = head–toes–knees–shoulders task; AWMA = Automated Working Memory Assessment; O = observed/standardized measure; ERC = Emotion Regulation Checklist; Lab-TAB = Laboratory Temperament Assessment Battery; *Circles = Impossibly Perfect Circles* task.

Table 2.

Variable Correlations.

Variable Name		1	2	3	4	5	6	7	8	9	10
1.	Age	1									
2.	Sex	−.09	1								
3.	IQ	.04	.02	1							
4.	$ODD^{P/T}$	−.02	.03	.16*	1						
5.	$BASC\text{-}H^{P/T}$	−.01	−.15*	.06	.48***	1					
6.	$BASC\text{-}I^{P/T}$	.04	−.23***	−.24***	−.03	.46***	1				
7.	EF^{O}	.39***	−.02	.59***	.18*	.09	−.22**	1			
8.	$EMC^{P/T}$	.07	.00	−.31***	−.02	.25***	.58***	−.19*	1		
9.	ER^{O}	−.20*	−.11	.06	−.17*	−.15	−.20*	−.05	−.18*	1	
10.	$ERC^{P/T}$	.11	−.08	.04	−.57***	−.41***	−.11	−.02	−.20**	.18*	1

Note. ODD = oppositional defiant disorder; P/T = Parent/Teacher report; BASC = Behavior Assessment System for Children; EF = Executive Functioning; O = observed/standardized measure; EMC = Emergent Metacognition; ER = Emotion Regulation—*I'm Not Sharing* and *Impossibly Perfect Circles* tasks; ERC = Emotion Regulation Checklist.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3.

Dimensions of Self-Regulation on ADHD.

Outcome Variable	β	*t* value	Model R^2	ΔR^2	ΔF
Inattention (P/T)					
Step 1					
IQ	−.23***	−3.72	.11	.11	7.59***
Age	.09	1.35			
Sex	−.23***	−3.76			
ODD (P/T)	.02	0.36			
Step 2					
EF Performance (O)	−.20*	−2.34	.45	.34	36.24***
EF Problems (P/T)	.55***	10.11			
Observed ER (O)	−.12*	−2.12			
Reported ER (P/T)	−.04	−0.55			
Hyperactivity (P/T)					
Step 1					
IQ	−.02	−0.39	.25	.25	20.78***
Age	.03	0.47			
Sex	−.16*	−2.81			
ODD (P/T)	.49***	8.47			
Step 2					
EF Performance (O)	−.01	−0.14	.35	.10	8.99***
EF Problems (P/T)	.27***	4.39			
Observed ER (O)	−.02	−0.32			
Reported ER (P/T)	−.17*	−2.16			

Note. EF = Executive Functioning; P/T = parent–teacher report; EF Performance = head–toes–knees–shoulders task and Automated Working Memory Assessment composite; O = observed/standardized measure; EF Problems = Behavior Rating Inventory of Executive Functioning–Preschool Version, Emergent Metacognition index; ER = Emotion Regulation; Observed ER = Laboratory Assessment of Temperament Battery, Global Regulation; Reported ER = Emotion Regulation Checklist; ODD = oppositional defiant disorder.

* $p < .05$.

** $p < .01$.

*** $p < .001$.