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Rejection Reactivity, Executive Function Skills, and Social Adjustment Problems of Inattentive and Hyperactive Kindergarteners

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Abstract

This study examined emotional reactivity to rejection and executive function (EF) skills as potential mediators of the social behavior problems of inattentive and hyperactive kindergarteners. Participants included 171 children, including 107 with clinical levels of ADHD symptoms, 23 with sub-clinical levels of ADHD symptoms, and 41 typically-developing children (63% male; 73% Caucasian, 11% African American, 4% Latino/Hispanic, 1% Asian, and 11% multiracial; M_{age} = 5.2 years). Inattention (but not hyperactivity) was uniquely associated with poor EF, social withdrawal, and aggression. In structural equation models, EF skills mediated the associations between inattention and both aggression and social withdrawal. Hyperactivity (but not inattention) was uniquely associated with rejection reactivity and each contributed uniquely to aggression. Findings suggest that difficulties with emotion regulation may warrant more attention in early interventions planned for children with high levels of ADHD symptoms.

Children who enter school exhibiting high rates of inattention and hyperactivity often find it difficult to make friends and get along with their classmates, leading to significant social impairment (Gagnon, Craig, Tremblay, Zhou, & Vitaro, 1995; Hoza, 2007). A recent set of studies suggests that difficulties with emotion regulation may play an important role in the genesis of the social difficulties that accompany high levels of inattention and hyperactivity (Barkley, 2010; Melnick & Hinshaw, 2000; Nigg & Casey, 2005). Theorists have suggested that two partially separable but interactive processes affecting emotion regulation may be involved: 1) heightened emotional reactivity in the face of provocation, and 2) deficits in the capacity to modulate emotional arousal (Barkley, 2010; Maedgen & Carlson, 2000; Nigg & Casey, 2005). Different neural pathways may underlie these two processes, with emotional reactivity more linked with deficits in behavioral inhibition and associated with hyperactivity, and emotion modulation (e.g., capacity to refocus attention away from the threat, self-soothe, and reappraise the situation) more linked with deficits in executive function [EF] skills and associated with inattention (Nigg & Casey, 2005).

Studies examining the social difficulties of children with ADHD often focus on middle childhood, given the increasing prevalence of ADHD diagnoses peaking around age 8 (Sonuga-Barke, Auerbach, Campbell, Daley, & Thompson, 2005). This study focused on

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younger children just entering kindergarten (age 5) with elevated (sub-clinical and clinical) levels of ADHD symptoms, given evidence that the developmental difficulties associated with emerging ADHD, including EF deficits and social adjustment difficulties, are typically evident by age 5 (Sonuga-Barke et al., 2005). At the point of kindergarten entry, children are faced with a host of new social and behavioral demands that challenge their capacity for emotion regulation and social integration (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008). This study examines the link between ADHD symptoms (inattention, hyperactivity) and social difficulties (aggression, social withdrawal) at school entry and the degree to which this link may be mediated by two processes affecting emotion regulation (reactivity to rejection, and EF skills). A key goal was to improve the understanding of the social difficulties associated with elevated ADHD symptoms at school entry to inform early intervention and prevention efforts (Ciairano, Visu-Petra, & Settanni, 2007; Gaynes et al., 2014).

Inattention and Hyperactivity: Associations with Social Adjustment Difficulties

Children rated high on inattention by parents and teachers appear forgetful and easily distracted and frequently have difficulties listening, following directions, and sustaining attention on tasks (APA, 2013). Inattention symptoms and the inattentive subtype of ADHD (ADHD-IA) are often associated with higher levels of social withdrawal as compared to hyperactive symptoms and the hyperactive (ADHD-HI) or combined subtype of ADHD (ADHD-C; Gaub & Carlson, 1997; Hodgens, Cole, & Boldizar, 2000; Maedgen & Carlson, 2000). For example, in a meta-analysis of 546 studies, Willcutt and colleagues (2012) found an average correlation between inattention and social withdrawal of moderate size ($r = .37$), in contrast to a significantly lower average correlation between hyperactivity and social withdrawal ($r = .18$).

Children rated high on hyperactivity are characterized by under-controlled motor activity (e.g., fidgeting, talking excessively, always “on the go”) and poor behavioral inhibition (e.g., frequently interrupts, blurts out answers, has trouble waiting; APA, 2013). Hyperactivity is often associated with elevated rates of aggressive and oppositional behaviors (e.g. Hodgens et al., 2000; Maedgen & Carlson, 2000; Willcutt et al., 2012). For example, in a longitudinal study of over 1,000 boys, hyperactivity in kindergarten predicted aggression at the end of elementary school whereas inattention did not (Gagnon et al., 1995).

The elevated social withdrawal and aggression that accompany high rates of inattention and hyperactivity, respectively, may make it difficult for young children to establish positive peer relationships when they enter kindergarten (Gagnon et al., 1995; Hoza, 2007). Poor social integration and early peer rejection may then create a negative cascade in which inattentive and hyperactive children experience reduced opportunities for normative peer socialization and frequent hostile peer encounters, fueling distress and social dysfunction that often persist into adolescence and even adulthood (Barkley & Fischer, 2010; Hoza, 2007). Although inattention and hyperactivity may directly undermine positive social behavior, accumulating research suggests that poor emotion regulation, including a tendency to be

both emotionally reactive and to have difficulty modulating emotional arousal may mediate the link between ADHD symptoms and associated social withdrawal and aggression (Maedgen & Carlson, 2000; Melnick & Hinshaw, 2000). This study built on this research by explicitly testing these mediational links with both of these pathways in the same model predicting social behavior.

Heightened Emotional Response to Provocation: Rejection Reactivity Pathway

Conceptually, one key factor often contributing to difficulties with emotion regulation consists of the "bottom up" tendency to respond to threatening events with heightened negative reactivity (Martel, 2009; Nigg & Casey, 2005). Empirical research suggests stronger associations between negative emotional reactivity and hyperactivity than inattention (see review by Martel, 2009). For example, during a frustrating task in which 8–11 year-old children did not get the prize they desired, children with ADHD-C displayed more intense signs of emotional frustration (e.g., frowning, grimacing, becoming tense) immediately following the task than did children with ADHD-IA (Maedgen & Carlson, 2000). Consistent with these findings, Nigg and Casey (2005) describe shared neural pathways for behavioral inhibition and emotional reactivity and note that, in comparison to inattentive children, hyperactive-impulsive children show overreactivity in the fronto-limbic loops which is an area associated with approach-avoidance behavior in response to emotionally salient events.

Hyperactive children often elicit rejection from peers, making it especially important to understand how young children with elevated hyperactivity react emotionally in situations involving peer rebuff (Erhardt & Hinshaw, 1994). Prior research suggests that, compared with normative peers, children with ADHD are more likely to perceive ambiguous social experiences as ostracizing, attribute hostile intent to their peers, and respond with aggression (Johnson & Rosen, 2000; King et al., 2009). To examine the possible contribution of heightened emotional reactivity to this process, this study examined children's tendency to experience intense emotional arousal under conditions of peer rebuff, termed here *rejection reactivity*.

The specific role that rejection reactivity may play in triggering aggressive behaviors has not yet been studied in young children with elevated ADHD symptoms. However, in older children and adolescents, the tendency to feel intense emotional distress in reaction to perceived social ostracism is a core feature of rejection sensitivity (Ayduk, Gyurak, & Luerssen, 2008; Canu & Carlson, 2007). Over time, older children and adolescents with elevated rejection sensitivity anticipate and perceive social rejection more readily than other children, and experience heightened social anxiety and personal distress, as well as exhibit increased aggression and social withdrawal (Downey, Lebolt, Rincón, & Freitas, 1998). Rejection reactivity may thus create particular problems at school entry when young children must establish new friendships and navigate a large peer group for the first time.

Deficits in Modulating Emotions: EF Pathway

In addition to “bottom up” processes of emotional reactivity, emotion regulation is affected by “top down” processes involving the modulation of emotional arousal, which utilize EF skills (Barkley, 2010). EF skills develop rapidly between the ages of 3 and 7 and include three inter-related cognitive skill sets: working memory, inhibitory control, and attention set-shifting (Blair, Zelazo, & Greenberg, 2005; Garon, Bryson, & Smith, 2008). EF skills measured with cognitive performance tasks are strongly (inversely) correlated with teacher and parent ratings of inattention (e.g., Castellanos & Tannock, 2002; Martel, 2009). Once the severity of inattention is controlled for, hyperactivity tends to show little to no unique association with EF among elementary and kindergarten age children (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005).

In recent years, researchers have begun to consider the ways in which EF deficits may affect the social-emotional development of young children, perhaps by reducing their capacity to navigate social interactions and control aggressive impulses effectively (Bierman et al., 2008; Garon et al., 2008). Each component of EF is thought to contribute to the capacity to modulate emotional arousal and thereby regulate emotion effectively (Bierman et al., 2008). For example, working memory (e.g., the ability to hold and act on mental representations) may help children create and retain mental templates for ways to regulate emotions (e.g., remember to count to 10 or take a deep breath when upset) and social scripts (e.g., turn-taking, negotiating, and resource sharing). Inhibitory control (e.g., the ability to interrupt an emotionally reactive response to provide a more appropriate response) and attention set-shifting (e.g., the ability to strategically focus and disengage attention while resisting interference and distractions, including emotionally frustrating ones) may help children delay responding and allow them to generate, consider, and select appropriate responses with peers, promoting sensitive social behavior and flexible social problem solving. Empirical studies show that, in pre-kindergarten, EF skills are correlated with prosocial behavior and (inversely) with aggression (Bierman, Torres, Domitrovich, Welch, & Gest, 2009). In addition, predictive links exist between EF skills in early elementary school and social competence one year later (Ciairano et al., 2007), as well as reduced internalizing and externalizing problems two years later, controlling for baseline behaviors (Riggs, Blair, & Greenberg, 2004). In neuroimaging studies, areas of the brain associated with EF have been implicated directly in the “top-down” regulation of emotional arousal, for example with activation of the anterior cingulate cortex associated with the process of shifting attention to an object of interest to avoid distress (Bush, Luu, & Posner, 2000).

The Present Study

This study included measures of core processes associated with emotion regulation, including the tendency to react intensively to perceived threat (rejection reactivity) and cognitive skills to support the modulation of emotional arousal (EF skills; Barkley, 2010; Nigg & Casey, 2005). Associations between rejection reactivity and EF skills and concurrent symptoms of ADHD (inattention, hyperactivity), as well as social behavior problems (social withdrawal, aggression), were examined among children entering kindergarten. Three hypotheses were tested regarding these associations. First, it was hypothesized that unique

direct links would emerge between inattention and social withdrawal, and between hyperactivity and aggression, consistent with past research documenting these links (e.g., Maedgen & Carlson, 2000). Second, given past studies demonstrating the association between EF and inattention (e.g., Martel, 2009), we expected to replicate unique direct association between inattention and poor EF skills with rejection reactivity in the same model. We also expected a unique direct association between hyperactivity and rejection reactivity, based on prior research suggesting that hyperactive children often elicit rejection and interpret it as having hostile intent (Erhardt & Hinshaw, 1994; King et al., 2009). Third, in a comprehensive model, this study extended prior research by examining rejection reactivity and EF as mediators of the links between ADHD symptoms and social withdrawal (Ciairano et al., 2007) and aggression (Downey et al., 1998). Specifically, direct associations were expected between poor EF skills and social behavior, with poor EF skills mediating the association between inattention and social withdrawal. In addition, direct associations were expected between rejection reactivity and social behavior, with rejection reactivity mediating the association between hyperactivity and aggression. Figure 1 summarizes the expected associations tested in this study.

Method

Participants

One hundred-seventy-one children ages 5–6 were recruited for an intervention study from 46 kindergarten classrooms in four Pennsylvania school districts. Brochures describing the study were distributed to parents of all children in the participating kindergarten classrooms in the fall of two successive years. Interested parents of qualifying children were visited at home and provided their informed consent for child participation. This study used data from the pre-test assessments, prior to any intervention activities.

A multi-gate process was used to determine eligibility for inclusion in the sample of children with elevated ADHD symptomatology. First, at kindergarten entry, teachers completed two behavioral rating scales: Conners' ADHD Rating Scale—Revised, Short Form (Conners, 2001) and the DuPaul ADHD Rating Scale (ADHD-RS; DuPaul, 1991) on children with parental permission to participate in the screening (N = 714). Children with three or more inattentive or hyperactive symptoms, or four or more total symptoms moved to the second gate, and their parents completed a structured diagnostic interview (the Diagnostic Interview Schedule for Children, DISC-IV; Shaffer, Fisher, Lucas, Dulcan, & Schwab-Stone, 2000) and parent-report rating forms, the Conners' Parent Rating Scale—Long Form—Revised (Conners, 2001) and the Behavioral Assessment Scale for Preschool Children, 2nd Edition (BASC-2, Reynolds & Kamphaus, 2004). The highest rating by either a teacher or parent was used to identify children for inclusion in the study. Children who had six or more inattention or hyperactivity symptoms based on parent or teacher report met study criterion for a DSM-IV ADHD diagnosis. Given that ADHD symptoms are still emerging at this age, children were also included if they had five inattention or hyperactivity symptoms or a T-score over 60 on parent or teacher ratings, representing sub-threshold levels of ADHD (Sonuga-Barke et al., 2005). Of the children who met these criteria, 30 were screened out of the study for having a sensorimotor disability, neurological disorder, or psychosis as

reported by their parents, or being unable to complete the assessments due to low levels of English proficiency.

These procedures resulted in a final sample for the current study of 171 children, including 107 children who met criteria for a DSM-IV ADHD diagnosis (21% predominantly inattentive, 18% predominantly hyperactive, and 62% both), 23 children with sub-threshold ADHD, and 41 typically-developing children randomly selected from the same classrooms. Demographically, the final sample was 63% male, 73% Caucasian, 11% African American, 4% Latino/Hispanic, 1% Asian, and 11% multiracial, with an average age of 5.2 years old (SD = .4). Four percent of the children (N = 7) were taking medication for ADHD symptoms at the time of the assessments. Given prior research suggesting that medication for ADHD alone rarely normalizes children's concurrent social adjustment, these children were retained in the study (Pfiffner, Calzada, & McBurnett, 2000).

Child assessments—Approximately a month after the screening process was completed and the sample identified, children participated in two assessment sessions. Trained examiners individually administered a set of tasks, including tests of children's rejection reactivity and EF skills. The examiners also provided ratings of children's aggression and social withdrawal based on their observations during the assessment. Both testing sessions were completed at the school less than within a week of each other, in a quiet room outside of the classroom setting. Approximately a month later, teachers returned completed additional ratings to describe children's aggression and social withdrawal.

Measures

ADHD—As part of the screening process, hyperactivity and inattention were assessed by teacher and parent ratings using a 4-point Likert scale ("not true at all" to "very much true") on the Conners' ADHD Rating Scale-Revised, a commonly used assessment used as a valid measure of childhood ADHD (Pelham, Fabiano, & Massetti, 2005). A short form version of the Conners was used with teachers to reduce the classroom burden, whereas a long form was used with parents. The teacher's short form consisted of 5 cognitive problems/inattention items ("short attention span," "lacks interest in school;" α = .93) and 7 hyperactivity items (e.g., "restless," "has difficulty waiting his/her turn;" α = .95). The parent's long form consisted of 12 cognitive problems/inattention items ("forgetful in daily activities," "loses things necessary for tasks or activities;" α = .90) and 9 hyperactivity items (e.g., "hard to control in malls or while grocery shopping," "will run around between mouthfuls at meals;" α = .88). Prior research has demonstrated similar internal reliability (.73 – .95) and strong test re-test reliability for these scales (r = .72 – .92 over 2 months; Conners, 2001). For analyses, teacher and parent T-scores were averaged for each symptom subscale (inattention and hyperactivity).

Rejection reactivity—The tendency to react to peer rejection with strong negative emotion was assessed with the Social Cognitive Interactive Task (SCIT; Powers & Bierman, 2011). This computer-game measure, modeled after Williams and Jarvis's (2006) Cyberball, exposed children to an ambiguous threat of peer rejection. First, children customized a shape (triangle, square, or circle) character to represent themselves. They then watched as their

shape happily played ball with another shape. A third shape then joined the group, and the two shapes played ball with each other, leaving out the child's shape, who stood at the side jumping up and down to indicate a desire for inclusion. The scene ended with the two other shapes going off together with the ball, leaving the child's shape behind. At the end of this scene, the research assistant asked the children, "when the purple and orange shapes walked away, did you feel: happy, sad, mad, or scared." After the child verbally indicated one of the four feeling options, the research assistant asked, "did you feel a little bit (restated feeling), or a lot (restated feeling)." Children were scored *reactive to rejection* if they chose a distressed emotion (i.e., sad, mad, or scared feelings) and reported feeling that emotion "a lot"; children who did not report a distressing emotion (i.e., happy) or only mild ("a little") distress were scored as non-reactive to rejection. This task modeled the peer rebuff experience created in the Cyberball game designed for older children, tapping the child's initial emotional response to being left out of peer play.

Executive function skills—Four cognitive performance tasks were used to assess EF. *Finger Windows forwards*, a subset of the Wide Range Assessment of Memory and Learning, was administered to assess visuospatial working memory (Adams & Sheslow, 1990). This task has shown strong internal consistency and convergent validity (α = .86; Sheslow & Adams, 2001). A backwards version developed by Bedard, Jain, Hogg-Johnson, and Tannock (2007) was also administered. In the Finger Windows forwards task, children watched the examiner place a pencil into a series of holes in a plastic card, and then tried to repeat the sequence exactly. In the backwards version, children repeated the sequence in backwards order. Trials presented increasingly long sequences and testing was discontinued following three consecutive errors. Each trial was scored correct (1) or incorrect (0), and the child's score was the average correct across the forwards and backwards administrations (α = .86).

Backward Word Span (Davis & Pratt, 1996) assessed verbal working memory by having children listen to a list of words, and then repeat the list in reverse order. Starting with two words, children were allotted two practice attempts to master the task and if they were unable to repeat the words in reverse order the assessment was not administered. One word was added to the list after each successful trial until the list consisted of five words. Children's score represented the highest number of words they were able to repeat correctly (α = .58).

Heads-Toes-Knees-Shoulders (HTKS) assessed working memory, inhibitory control, and attention set-shifting and has been shown to be significantly associated with traditional measures of these constructs (McClelland et al. 2014; Ponitz, McClelland, Matthews, & Morrison, 2009). In this task, children were first asked to focus their attention on the examiner's instructions and copy the examiner, touching their head and touching their toes. Then, they were asked to play a silly game and touch their toes when the examiner said "touch your head" and vice versa, constantly shifting their attention from each of the examiner's instructions to doing the opposite action. In a second training sequence, children touched their knees when the examiner said to touch their shoulders and vice versa. After four practice trials of each training sequence, there were 10 scored trials of each. Children earned two points for a correct response, zero for an incorrect response, and one if they

made any motion toward the incorrect response but then self-corrected. The outcome variable used was the total number of correct points, with a maximum of 40 points possible. Scored trials had strong internal consistency (α = .96). In past studies, the HTKS task has also demonstrated strong internal consistency (α = .90) and good validity when compared to other measures of executive functions in kindergarteners (McClelland et al. 2014; Ponitz et al., 2009).

Peg Tapping was administered to assess inhibitory control. It required children to tap a peg once when the interviewer tapped twice and vice versa (test-retest reliability over a 2-week period r = .80 and α = .84 in past studies; Diamond & Taylor, 1996; Meador, Turner, Lipsey, & Farran, 2013). This task required children to inhibit a strong tendency to imitate the examiner, remember what the examiner tapped, and follow the rule of tapping the opposite number. The total score was the number of correct trials (out of 16 trials). The four EF measures (finger windows, backward word span, HTKS, peg tapping) were significantly correlated, supporting their validity as measures tapping into EF (r = .30 to .55, ps < .05).

Social adjustment—Social withdrawal was assessed with teacher and examiner ratings. Teachers rated children on two items drawn from the TOCA-R (Teacher Observation of Classroom Adaptation—Revised; Werthamer-Larsson, Kellam, & Wheeler, 1991) social contact scale (e.g., “avoids playing with other children”) and four items from the anxiety/withdrawal subscale of the Revised Behavior Problem Checklist (e.g., “keeps to him/herself, tends to withdraw”). Both scales used a 6-point Likert scale (1 = almost never to 6 = almost always). Test examiners rated children on one 4-point item (reverse-scored) reflecting social withdrawal (“Alert and interactive; is not withdrawn”). Ratings were averaged across the two examiner ratings and combined with teacher’s rating. Items had adequate internal consistency (α = .69).

Aggression was also assessed using teacher and research assistants’ ratings. Teachers rated children on the Authority Acceptance scale of the Teacher Observation of Child Adaptation-Revised (TOCA – R), using 7 items (e.g., “fights with other children,” “knowingly breaks rules”) rated on a 6-point Likert scale (1 = almost never to 6 = almost always). After each testing session, examiners completed the Adapted Leiter-R Assessor Report (Roid & Miller, 1997). Four of these items reflected oppositional-aggressive behavior (e.g., “defiant,” “careless or destructive with test materials”), rated with a 4-point scale. Ratings were averaged across the two testing sessions. Items had strong internal consistency (α = .83).

Results

Descriptive Analyses

Descriptive statistics for all study variables are presented in Table 1. Data were missing for 1–2 children on five measures. Maximum likelihood estimation methods were used to impute missing data in the analyses.

Correlations among study variables are shown in Table 2. Hyperactivity was positively associated with inattention, rejection reactivity, aggression, and social withdrawal. Inattention was inversely associated with EF skills and positively associated with social

withdrawal and aggression. The EF measures were inversely associated with aggression, social withdrawal and hyperactivity. Rejection reactivity was associated with aggression and the HTKS task.

Measurement Model

Before testing the hypotheses, a measurement model was estimated. Domain representative parceling was used to create three indicators for aggression and three for social withdrawal in order to reduce the measurement error due to either teacher or research assistant rating bias (see Little, Rhemtulla, Gibson, & Schoemann, 2013 for a description of this method and its application to reducing measurement error). This measurement model is presented in Figure 2. A model is generally considered to have good fit if CFI > .96 and RMSEA < .05 and acceptable fit if CFI > .92 and RMSEA < .08 (Bentler & Bonett, 1980; Browne & Cudeck; 1993, Hu & Bentler, 1999). Chi-square is not considered a good indicator of model fit for large samples, so it was not used in this study (Hu & Bentler, 1999). The measurement model was judged to satisfactorily fit the data based on the pattern of fit indices CFI = .94 and RMSEA = .06; all indicators were significantly related to their respective latent constructs (*ps* < .05). Thus, it was deemed appropriate to proceed with structural equation modeling.

Structural Equation Models

Structural equation models were estimated to test the three hypotheses and systematically build a final model examining the associations among ADHD symptoms (inattention, hyperactivity), the hypothesized mediators (rejection reactivity, EF skills) and social behaviors (social withdrawal, aggression). Per Muthén and Muthén's (2010) recommendations for testing mediation with dichotomous hypothesized mediators (i.e., rejection reactivity), robust weighted least squares were used to estimate paths using MPLUS. Separate models were estimated to test each hypothesis. Children's gender and age, and school district geography (rural vs. urban) served as control variables in all structural equation models.

Hypothesis 1—The first structural model tested the hypothesis that, with ADHD symptoms and social behaviors included in one model, inattention would be associated with social withdrawal whereas hyperactivity would be associated with aggression. As expected, inattention was significantly associated with social withdrawal, $\beta = .58$, $p < .001$, and hyperactivity was significantly associated with aggression, $\beta = .60$, $p < .001$ (not pictured). Contrary to expectations, inattention was also significantly associated with aggression ($\beta = .18$, $p = .03$).

Hypothesis 2—The second structural model tested the hypothesis that, when the dimensions of ADHD symptoms were entered in the same model as rejection reactivity and EF skills, inattention would be linked with EF and hyperactivity would be linked with rejection reactivity. As hypothesized, in this model, hyperactivity was significantly associated with rejection reactivity, $\beta = .27$, $p = .04$, and inattention was significantly associated with poor EF, $\beta = -.64$, $p < .001$ (not pictured).

Hypotheses 3—The third comprehensive model tested the hypothesis that EF would mediate the association between inattention and social withdrawal, whereas rejection reactivity would mediate the association between hyperactivity and aggression. This final model with standardized path coefficients is presented in Figure 3 and was judged to have acceptable fit, with CFI = .93, and RMSEA =.06. In this model, EF was significantly associated with inattention, $\beta = -.65$, $p < .001$, social withdrawal, $\beta = -.40$, $p < .001$, and aggression, $\beta = -.29$, $p = .001$. Bootstrapping of 5000 samples was used to test for mediation. MPLUS uses the delta method to test for mediation, which is similar to (and often equivalent to) the Sobel method (Muthén & Muthén, 2010). The test includes confidence intervals; if zero is not in the interval, it indicates that the indirect effect is different from zero. The effect of EF mediating the association between inattention and social withdrawal was estimated to be .26 with a 95% confidence interval of .05 to .47. The estimated effect of EF mediating the association between inattention and aggression was .19 with a 95% confidence interval of .05 to .32, and the link between inattention and aggression became non-significant when EF was in the model ($\beta = .00$). As the 95% confidence interval for the mediated effect did not include zero, EF mediated the association between inattention and social withdrawal. Additionally, EF mediated the association between inattention and aggression.

Rejection reactivity was significantly associated with hyperactivity, $\beta = .27$, $p = .04$, and aggression, $\beta = .19$, $p = .02$. Contrary to expectations, rejection reactivity was not significantly associated with social withdrawal ($\beta = -.12$, $p = .16$). Bootstrapping of 5000 samples was used to test for mediation. The estimated effect of rejection reactivity mediating the association between hyperactivity and aggression was .05 with a 95% confidence interval of −.02 to .13. Hence, rejection reactivity did not mediate the association between hyperactivity and aggression. Instead, because rejection reactivity was associated with aggression after accounting for hyperactivity in the model, rejection reactivity had an additive effect, contributing to aggression in ways that extended beyond the association between hyperactivity and aggression.

Discussion

Theorists have suggested that difficulties regulating emotion may play an important role in the social impairments of children with elevated ADHD symptomatology (Barkley, 2010; Nigg & Casey, 2005). Prior research has established significant links between inattention and social withdrawal, as well as between hyperactivity and aggression (e.g., Maedgen & Carlson, 2000; Willcutt et al., 2012). However, the role that emotion regulation may play in mediating these associations is not well understood and has not been studied in young children who are making the initial transition into elementary school. This study makes a unique contribution to understanding these associations by testing the hypothesis that negative emotional reactivity (indexed by rejection reactivity) and reduced capacity to modulate such emotion arousal (indexed by EF skills) would contribute to aggressive and socially withdrawn behavior and mediate the associations between ADHD symptomatology and social behavior problems.

Replicating prior research, hyperactivity was associated with aggression, and inattention was associated with social withdrawal (Maedgen & Carlson, 2000; Willcutt et al., 2012). Inattention was also associated with elevated aggression. Extending beyond prior research, EF deficits not only significantly predicted elevated aggression and social withdrawal but also mediated the association between inattention and aggression and mediated the association between inattention and social withdrawal. Rejection reactivity was associated with hyperactivity and aggression, but did not mediate the association between hyperactivity and aggression. Instead, hyperactivity and rejection reactivity both made unique and cumulative contributions to aggression.

Overall, although only EF served as a mediator, the study results provide new additional support to the importance of both rejection reactivity and EF as factors associated with ADHD symptomatology and implicated in the development of aggression and social withdrawal in young vulnerable children making the transition into kindergarten. The findings validate the conceptualization of two processes contributing to emotion regulation, one “bottom up” (indexed by rejection reactivity) and another “top down” (indexed by EF), that are differentially associated with hyperactivity and inattention that have implications for children’s social adjustment.

Integrating Reactivity and EF in Models of Social Impairment with ADHD

Deficits in EF skills have been implicated in the cognitive and academic difficulties of children with ADHD; the findings from this study suggest that EF skills (working memory, inhibitory control, attention set-shifting) may play an important role supporting social adjustment as well. Whereas past research on children with ADHD has shown that EF skill deficits account for 40–50% of the variance between inattentive symptoms and impairments in social interactions (Huang-Pollock, Mikami, Pfiffner, & McBurnett, 2009), this study adds to such findings by demonstrating the importance of EF in modulating children’s emotions in social interaction even after accounting for rejection reactivity. EF skills may be enhancing social functioning at school entry by enabling children to strategically deploy attention, reducing emotional arousal by shifting attention from threatening to calming stimuli (avoidance, distraction; Raver, Blackburn, Bancroft, & Torp, 1999), and then reappraising social and affective cues to reframe problems and identify solutions (Gross & Thompson, 2007). EF skills may reduce aggression in children with elevated ADHD symptoms both by enhancing their social skill development (Ciairano et al., 2007), and by facilitating the modulation of emotional arousal associated with rejection reactivity. These findings are consistent with those of Riggs, Greenberg, Kusche and Pentz (2006) who found that increases in EF skills in the early elementary grades promoted later decreases in both internalizing and externalizing problems.

An important novel feature of this study was its concurrent examination of rejection reactivity, assessing children’s emotional reaction to a simulated social exclusion. The SCIT assessment used here was based on Cyberball, a virtual ball-tossing game used to simulate peer rebuff in older children and adolescents (Williams & Jarvis, 2006). Among adolescents, Cyberball has been shown to elicit greater feelings of ostracism and increased arousal when excluded from an on-line ball-tossing game (Boyes, & French, 2009; Ruggieri, Bendixen,

Gabriel, & Alsaker, 2013). In the simplified ball-tossing game used here, most kindergarteners likewise expressed distress about being excluded, with 96% reporting feeling sad, mad or scared after the exclusion manipulation. Parallel to the variation observed in teens' response to Cyberball (Boyes & French, 2009; Ruggieri et al., 2013), variation emerged among the kindergartners in this study, with 62% expressing "a lot" of negative feelings after the game and 38% expressing just "a little" or no distress. This index of rejection reactivity, reflecting the amount of distress felt after a simulated social exclusion, was associated with hyperactivity and uniquely associated with aggression, controlling for concurrent hyperactivity, inattention, EF skills, gender, age and school district geography (rural vs. urban).

It is unclear whether the rejection reactivity that emerged in response to the SCIT task is a precursor of or risk factor for the development of rejection sensitivity, which has been studied among older children, adolescents, and adults. Rejection sensitivity reflects an individual's tendency to anxiously expect, readily perceive, and intensely react to rejection and is associated with elevated levels of reactive aggression that impair social functioning, especially among adolescents (Downey et al., 1998). Developmentally, this study's kindergarteners are less likely to be highly invested in peer relationships relative to older youth, and their capacity for social information-processing is less well-developed as well (Welsh & Bierman, 2003). This study thus documents important individual differences in rejection reactivity that exist by school entry, but additional research is needed to understand whether rejection reactivity is associated with or contributes to the development of social information processing biases, rejection sensitivity, and social anxiety that are often experienced by children with poor peer relations in elementary school (Downey et al., 1998).

The current study also did not examine the mechanisms that might account for the association between hyperactivity and rejection reactivity, but theorists have suggested that this link could reflect shared neural pathways and a common foundation in poor behavioral inhibition, such that children are unable to inhibit their emotional reactivity (Nigg & Casey, 2005). Alternatively, the link may emerge or intensify as a function of developmental experiences. For example, hyperactive children may experience more rejection from peers and adults due to their intrusive and insensitive behavior and may therefore become more sensitive and emotionally reactive to rejection over time (Kim & Yoo, 2013; Niederhofer, 2009; Sonuga-Barke et al., 2005). These are also question for future research.

Limitations and Future Directions

The most important limitation of this study was its cross-sectional design, which limits the ability to draw conclusions about the direction of causality or nature of cross-domain influences over time. For example, it is plausible that social behavior problems contribute over time to greater rejection reactivity and delayed EF skill development, rather than the reverse. The possible causal and temporal explanations of associations amongst constructs included in this study are theory-based and require longitudinal studies to confirm them.

In addition, although rejection reactivity was shown to play an important role in the school adjustment of children with ADHD, it was measured by a single-item dichotomized indicator. The measures of EF were also quite brief, and one (working memory) had

relatively low internal consistency. Future research would benefit from using more extensive measures with more indicators to assess rejection reactivity and EF skills, which might reveal even stronger associations with social adjustment than those found in this study.

Finally, the majority of the children participating in this study were at high risk for emotional and social difficulties due to elevated levels of inattention and hyperactivity at school entry. Hence, the findings may not generalize to other populations. For example, rejection reactivity may play a different role in children without elevated inattention and hyperactivity as these associations may be different in other children (e.g., temperamentally shy boys are more reactive to rejection than non-shy boys; Howarth, Guyer, & Perez-Edgar, 2013).

Implications for Educational and Clinical Interventions

The current findings underscore the importance of addressing the emotional and social problems of young children with high levels of ADHD symptomatology, even though a majority of these children are not diagnosed with ADHD until age 7 or later. Increasingly, researchers are recognizing that ADHD symptoms are best conceptualized as varying along a continuum, and that developmental experiences can play a key role in the emerging severity of those symptoms and the accompanying social and emotional impairment (Sonuga-Barke et al., 2005).

Moreover, this study suggests that tailored interventions may be needed, given the different links between emotional and social problems and the symptom patterns of inattention versus hyperactivity. That is, children with more severe inattention may need interventions focused on fostering EF skills and social initiation skills. For example, targeting older grade school children, Pfiffner and colleagues (2007) found that teaching self-monitoring and social skills improved the social engagement, cooperation, and regulation of children with ADHD-IA. However, further research is needed to determine whether similar skill-training efforts are efficacious with younger children as they enter kindergarten. In contrast, children with more severe hyperactivity may need interventions that target their tendency to react intensely to rejection and to behave aggressively. Social-emotional learning programs that focus on teaching young children how to recognize, label, manage, and reduce negative emotional arousal may be helpful, along with social skills training and behavior management strategies designed to reduce aggression and promote conflict resolution and social problem-solving skills (for a review, see Bierman & Motamedi, 2015). Early intervention during preschool or the early elementary years may be beneficial, in order to avoid or reduce negative socialization experiences at school entry that may compound the social and emotional difficulties of children entering kindergarten with elevated ADHD symptomatology.

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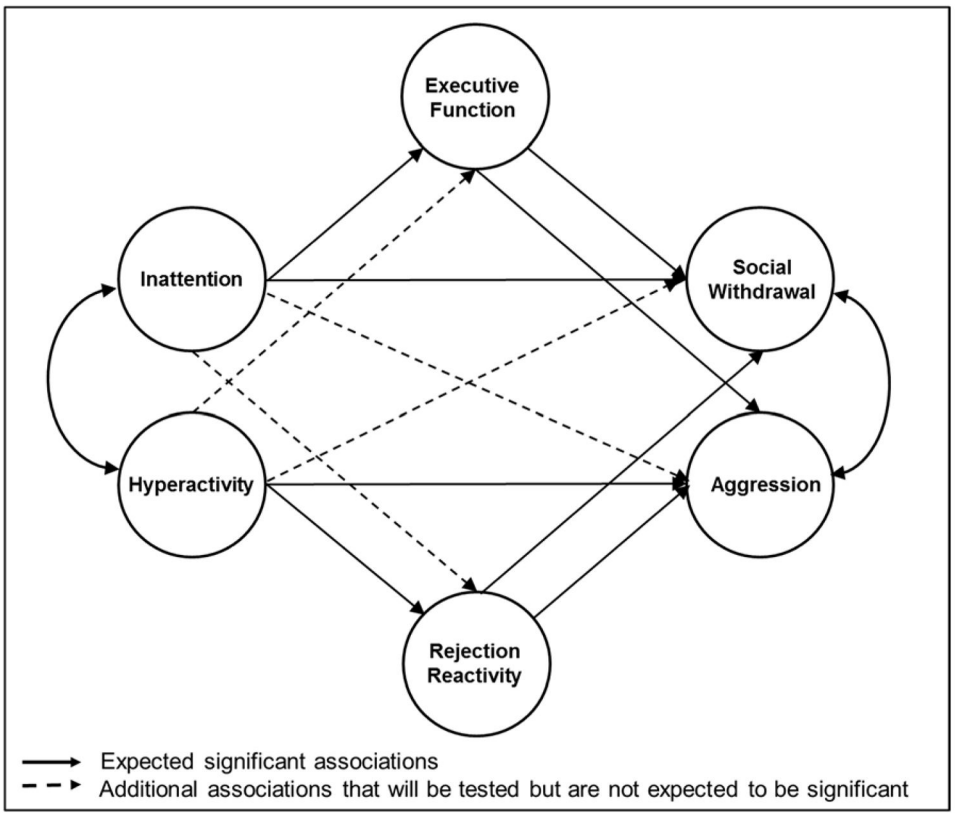

Figure 1.

Hypothesized Model of EF and Rejection Reactivity Mediating the Associations of Social Adjustment with Inattention and Hyperactivity in Kindergarteners

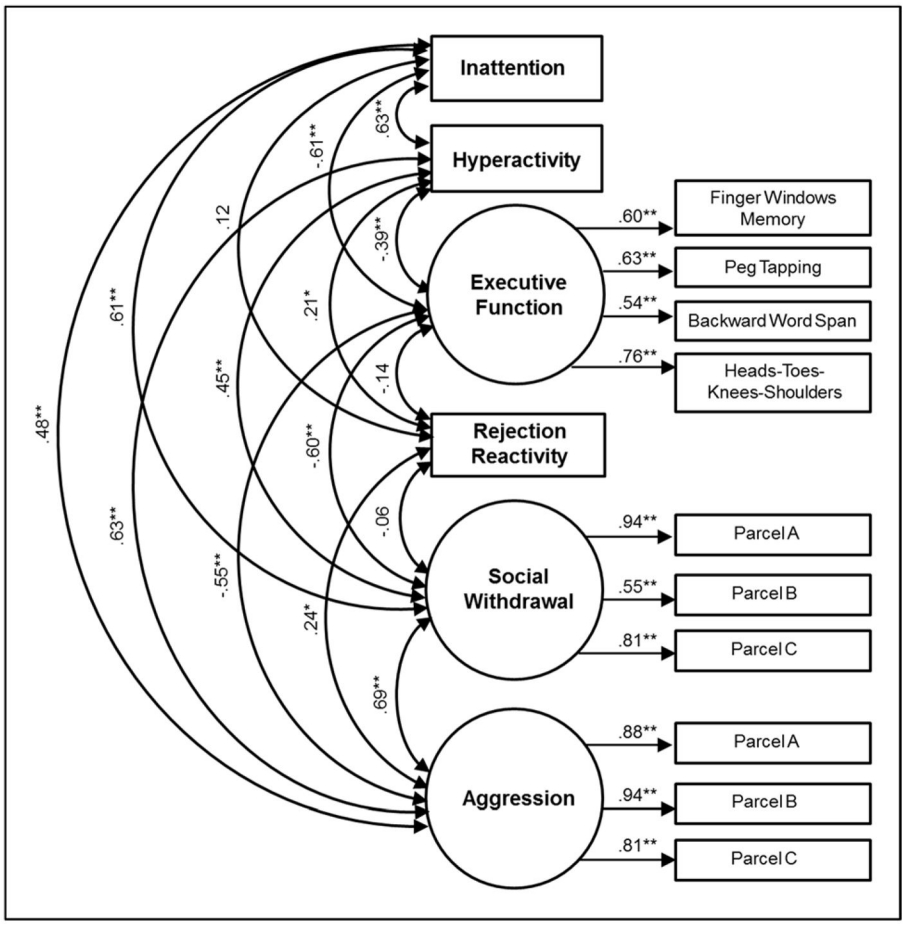

Figure 2.
Measurement Model
** $p < .01$; * $p < .05$

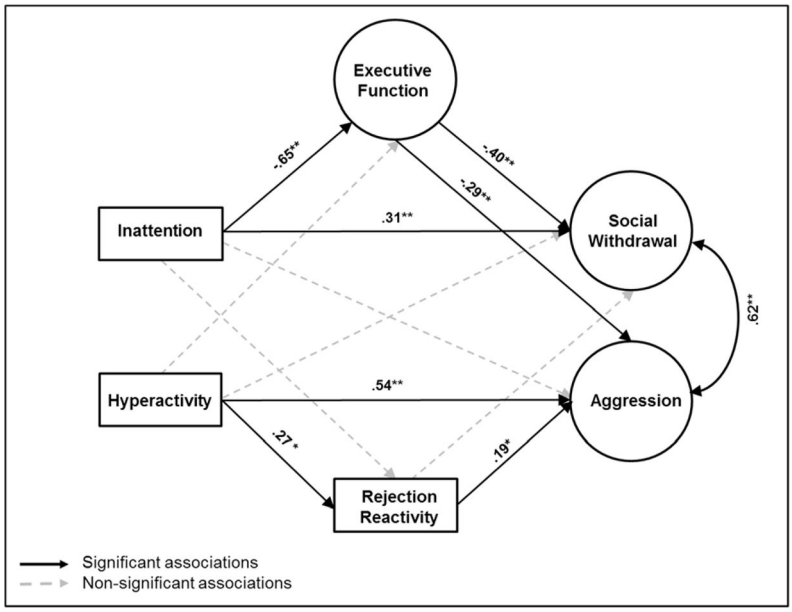

Figure 3.

Structural Equation Model Predicting Social Withdrawal and Aggression

Note. For simplicity, β values for non-significant paths and control variables are not shown. ** $p < .01$; * $p < .05$.

Table 1

Descriptive Statistics

Variables	N	Mean	SD	Min	Max
Inattention	171	58.06	11.91	41.00	87.00
Hyperactivity	171	60.44	11.89	41.00	89.00
Finger Windows	170	0.17	0.12	0.00	0.57
Backward Word Span	170	2.10	0.73	1.00	4.00
HTKS	169	25.39	13.21	0.00	40.00
Pencil Tapping	169	13.73	4.07	0.00	16.00
Proportion Reactive to Rejection (SCIT)	169	0.62	0.49	0.00	1.00
Social Withdrawal [a]	171	0.00	0.64	−1.00	1.87
Aggression [a]	171	0.00	0.66	−0.84	2.90

[a]Average of teacher and examiner standardized ratings.

Table 2

Correlations among Study Variables

Variables	2	3	4	5	6	7	8	9
1. Inattention	.63**	−.41**	−.36**	−.46**	−.33**	.10	.54**	.45**
2. Hyperactivity	--	−.27**	−.22**	−.29**	−.22**	.16*	.40**	.60**
3. Finger Window Memory	--	--	.30**	.55**	.29**	−.02	−.34**	−.28**
4. Backward Word Span	--	--	--	.50**	.38**	−.06	−.26**	−.27**
5. Head-Toes-Knees-Shoulders	--	--	--	--	.46**	−.15*	−.37**	−.36**
6. Peg Tapping	--	--	--	--	--	−.04	−.38**	−.33**
7. Rejection Reactivity	--	--	--	--	--	--	−.02	.21**
8. Social Withdrawal [a]	--	--	--	--	--	--	--	.58**
9. Aggression [a]	--	--	--	--	--	--	--	--

[a] Average of teacher and examiner standardized ratings.

** $p < .01$;

* $p < .05$