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CHILDREN'S SELF-REGULATION AND THEIR ACADEMIC AND SOCIAL-EMOTIONAL ADJUSTMENT TO SCHOOL: THE ROLES OF EXECUTIVE FUNCTION SKILLS, ATTENTION CONTROL, AND IMPULSE CONROL

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ABSTRACT

Children growing up in poverty are particularly likely to experience delays in both academic and social-behavioral school readiness, a gap that continues to widen over time contributing to several adverse long-term outcomes. Recent research suggests that although these domains appear distinct, the development of early academic and social-behavioral readiness skills may be intertwined and largely dependent upon the development of children's capacities for self-regulation. Although self-regulation skills conceptually underlie children's school readiness and adjustment, studies have rarely examined longitudinal data to examine these hypothesized links from preschool across the transition to school. Collecting direct assessments of children's executive function skills, as well as teacher and assessor ratings of children's attention and impulse control, the current study documented combined and unique contributions of children's preschool self-regulation to their concurrent and later academic and social-behavioral adjustment to school. In addition, the current study applied person-centered analyses (latent profile analysis) and identified four distinct self-regulation profiles among this sample of at-risk children attending Head Start preschools; the study documented group differences in concurrent and later school adjustment outcomes for the profiles. Implications for developmental models, measurement strategies, and intervention designs targeting self-regulatory deficits and school readiness of at-risk children are discussed.

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Introduction

In recent years, driven in part by the enactment of the No Child Left Behind legislation, schools are increasingly concerned about young children's emergent literacy and numeracy skills at entry to kindergarten. Not only have the academic demands of the kindergarten year increased, but school entry signals new expectations for children to listen, follow instructions, complete multi-step tasks, and flexibly shift through a day's worth of structured and unstructured activities (Li-Grining,Votruba-Drzal, Maldonado-Carreno, & Haas, 2010). Because of the increasing expectations facing children at kindergarten, the preschool years represent a critical period to develop competencies necessary for a smooth transition to school. These competencies are referred to collectively as school readiness, and include cognitive and rudimentary academic capacities, as well as the social-emotional and behavioral skills necessary to support learning and more general school success (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Blair, 2002; Campbell & von Stauffenberg, 2008; Raver, 2002). Unfortunately, an increasing number of children lack these competencies at school entry.

Nearly one of every five children are growing up in poverty (Children's Defense Fund, 2011). Children affected by poverty are particularly likely to show delays in school readiness skills, with a substantial achievement gap already apparent at kindergarten between children from low-income families and their middle-income peers (Campbell & von Stauffenberg, 2008). This gap continues to widen over time, contributing to differences in several long-term outcomes, including higher rates of learning difficulties, high school drop-out, and future unemployment among children from economically-disadvantaged families (Ryan, Fauth, & Brooks-Gunn, 2006). With the goal of reducing this gap and improving the long-term outcomes of children growing up in poverty, the promotion of school readiness skills during the preschool

period has become a social and public policy concern (NICHD Early Child Care Research Network, 2003; Shonkoff & Phillips, 2000).

As such, there has been a call for research focused on understanding factors associated with a successful transition to school. Correspondingly, recent years have witnessed a dramatic increase in the availability of interventions designed to promote school readiness by enriching preschool programming (Blair & Diamond, 2008). In terms of early intervention, two different approaches characterize attempts to promote school readiness in children growing up in poverty. One approach focuses on enhanced instructional programming during the pre-kindergarten year, designed to promote emergent literacy or numeracy skills in order to reduce the readiness gap in areas of academic skills (Lonigan, 2006). The other approach utilizes social-emotional curricula and teacher professional development to support children's social-emotional and behavioral readiness for school (Greenberg, Weissberg, O'Brien, Zins, Fredericks, Resnik, et al., 2003). Although seemingly disparate domains of functioning, recent research suggests that the development of academic and social-emotional school readiness may be intertwined, with readiness in both of these domains dependent on the development of self-regulation skills and the capacity for goal-oriented learning.

Grounded in research on neuro-cognitive development during the preschool years, recent research suggests that the neural pathways that support self-regulation develop rapidly between the ages of 3-6, and play a central role in supporting both academic and social-behavior readiness (Blair & Diamond, 2008). The executive regulatory system that develops is characterized by a set of distinct but interrelated cognitive processes that help children to manage their attention, behavior, and emotions (Bierman et al., 2008; Blair, 2002; Li-Grining et al., 2010). These basic skills involve the child's capacity to focus, sustain, and shift attention in order to organize

behavior around goal-oriented activities. Referred to collectively as executive function (EF) skills, these emerging cognitive processes are typically assessed directly with experimental tasks that require the child to inhibit the impulse to repeat a learned or prepotent response and, instead, to adjust attention and behavior in order to follow new or changed task demands. EF capacities develop with age, and this development is associated with school success. However, the development of these processes is negatively impacted by adverse family environments (e.g., Bierman et al., 2008) and is delayed among children growing up in poverty (Li Grining, 2007), leading to new speculation that interventions focused on promoting EF skill development might enhance the school readiness of children growing up in poverty by promoting their academic learning and their social-behavioral control at school (Blair & Diamond, 2008).

However, longitudinal research is needed to test the hypothesized links between the development of self-regulation skills in pre-kindergarten and initial school adjustment after the transition to kindergarten. And although EF skills may play a critical role in promoting academic and social-behavioral readiness and adjustment, it is also possible that other individual differences in areas of attention and impulse control affect school readiness and the child's capacity for goal-oriented learning. EF skills and attention have been referred to as "top down" regulatory skills, in that they develop over time and allow children to modulate their activity level and reactivity. It is also recognized that individual differences exist in impulsivity, described as "bottom up" processes. These individual differences affect the child's activity level, response to environmental stimuli, and behavioral functioning (Kochanska, Murray, Jacques, Koenig, & Vendegeest, 1996; Rothbart, 2004). Hence, impulse control may also play an important role in determining the child's capacity for self-regulated behavior in the classroom.

A broader, multi-method assessment of the development of self-regulation skills is needed, combined with a longitudinal scope that covers the transition into elementary school, in order to better understand how the development of EF skills, as well as attention functioning and impulse control in the pre-kindergarten classroom promote early school success.

The proposed study will contribute to the literature on this topic by examining the development of three indicators of self-regulation skill development during the pre-kindergarten year. It will utilize both direct assessments of children's EF skills, and teacher and observer ratings of attention functioning, and teacher ratings of impulse control. It will examine the inter-relations among these indicators of self-regulation during the pre-kindergarten year and examine their unique and combined prediction of early school adjustment by including outcome measures assessing academic and social-behavioral adjustment in kindergarten and first grade.

Self-Regulation: Executive Function Skills

Conceptually, children's capacity for self-regulated learning depends heavily on the maturation of the executive regulatory system and the development of EF skills. This section briefly reviews the definition and assessment of EF skills, and outlines research evidence linking EF with academic and social-behavioral school readiness and later adjustment.

Definition and assessment. EF skills refer to a set of complex but well-delineated neural and cognitive processes that are activated in the context of novel problem-solving, for example, when a child is trying to accomplish a new task that does not yet utilize automatized skills (Friedman, Miyake, Corley, Young, DeFries, & Hewitt, 2006). Conceptually, EF skills underlie the adaptive, goal-oriented behavior necessary in the school context (Hughes & Graham, 2002). During the preschool years (between the ages of 3 and 6) rapid growth in EF skill corresponds with the development of the prefrontal cortex and with increasing connectivity between neural

systems, resulting in advances in children's abilities to respond flexibly to novel problems, engage in self-regulated, rule-governed behavior, and attend (Barkley, 2001; Clark, Pritchard, & Woodward, 2010; Ruff & Rothbart, 1996).

EF is commonly conceptualized as both a unitary and multicomponent construct (Garon, Bryson, & Smith, 2008; Miyake, Friedman, Emerson, Witzki & Howerter, 2000). In both child and adult samples, factor analytic studies have identified attention set-shifting, working memory, and inhibitory control as the central components of the EF system (Blair & Diamond, 2008; Clark et al., 2010; Garon et al., 2008; Miyake et al., 2000). Despite such findings, researchers have found it difficult to separate these components in children still in the preschool period, when the executive regulatory system is developing rapidly, and development of the component parts is interdependent. For this reason, EF skills in the preschool period are typically conceptualized in terms of their shared, combined variance (e.g., Hughes & Ensor, 2007; Hughes, Ensor, Wilson & Graham, 2010; Welsh, Nix, Blair, Bierman, & Nelson, 2010; Wiebe, Espy, & Charak, 2008).

Attention set-shifting involves the ability to sustain and flexibly shift attention (Blair & Diamond, 2008; Garon et al., 2008; Welsh, et al., 2008). Preschool children often show difficulty thinking about the same things in two different ways or changing from one perspective to another (Diamond, Carlson, & Beck, 2005). However, the ability to sustain and flexibly shift attention likely contributes to children's academic learning and social-behavioral adaptation in the classroom. Activities and interactions throughout the preschool day require children to problem solve and consider multiple perspectives. Many academic tasks require the ability to strategically focus and flexibly shift between different but similar types of problem sets. Attention set-shifting has been measured using tasks such as the Dimensional Change Card Sort

[DCCS] (Frye, Zelazo, & Palfai, 1995). In DCCS, a child is shown cards depicting colored shapes that can be sorted according to color or shape. The child must sort the cards according to one dimension and then is required to shift to sort according to the other dimension.

Working memory involves the ability to hold information in mind, as well as the capacity to update and manipulate information (Garon et al., 2008). Conceptually, working memory skills are related to school readiness. In the service of acquiring academic knowledge, working memory may allow children to hold more information in mind for a longer period of time, thereby increasing opportunity for manipulation of information and consolidation into long-term memory (Bull & Scerif, 2001). Social competence may also be related to working memory, providing children the ability to create mental templates that guide delayed imitation and support rule-governed behavior (Bierman et al., 2008). Working memory can be assessed with cognitive tasks, like the Backward Word Span task (Davis & Pratt, 1996). In Backward Word Span, children are required to repeat lists of words in backward order. As such, the task requires children to hold and manipulate the list of words in mind.

Inhibitory control, which is one of the most frequently studied EF skills, reflects the ability to withhold or restrain a dominant response and engage in a subdominant response (Bierman et al., 2008; Garon et al., 2008). Inhibitory control likely contributes to children's academic learning and social-behavioral adaptation by affording children the ability to consider multiple perspectives and responses to problems as opposed to being "stuck" in a dominant response (Diamond et al., 2005). A common measure of inhibitory control during the preschool period is the Peg Tapping task (Diamond & Taylor, 1996). Peg Tapping task is an anti-imitation task in which children are asked to tap a peg on the table once when the interviewer taps twice, and tap the peg twice when the interviewer taps once.

Relations with academic and social-behavioral readiness. Conceptually, EF skills should be associated with academic and social-behavioral school readiness (Diamond, 2002). Because of the rapid change in EF skills during the preschool period, emerging individual differences in EF skills may begin to shape individual learning trajectories (Clark et al., 2010) and social-emotional competence and behavior (Bierman et al., 2008).

A few studies have examined the contemporaneous association between EF skills and measures of academic learning and social-behavioral adjustment during preschool and the early school years. Bull and Scerif (2001) found that children's performance on measures of working memory, inhibitory control, and attention flexibility at age 7 (e.g., the Stroop test, Wisconsin Card Sort, and a counting span task) was significantly associated with concurrent math ability. The authors hypothesized that children who perform poorly on tasks of inhibitory control and attention flexibility may also have difficulty evaluating performance on math problems and generating alternative approaches to problems. Similar associations have been found earlier in development. Also among typically developing children, Espy and colleagues (2004) found that preschool children's performance on a set of 7 measures tapping inhibitory control and working memory contributed substantively to mathematical performance, after controlling for age, estimated verbal intelligence, and maternal education level.

Preschool EF skills are also associated with later academic learning in the early school years. For example, in a sample of typically developing four-year-old children, Clark and colleagues (2010) measured attention set-shifting and inhibitory control with a selection task that required children to examine an array of three cards that differed on dimensions of shape, size, and color, and identify two different pairs that shared a common attribute. They also assessed inhibitory control using the Shape School (Espy et al, 2004). Performance on these tasks at age 4

accounted for substantial variability in children's math achievement at age 6, after one year of school, even after accounting for individual differences in general cognitive ability and reading achievement. Generally, increased performance on the EF measures was related to a 5- to 10-point boost in math achievement (Clark et al., 2010). Preschool EF skills have also predicted early reading capacities. Bull and colleagues (2008) used growth curve analysis to address whether EF skills specifically predicted math, or whether they would also predict reading. Results indicated that attention shifting and inhibition skills in preschool (as measured by the Shape School) predicted both math and reading. Higher EF skills early on were associated with better academic skill development that was maintained throughout the first three years of schooling.

Similar patterns have been reported with preschoolers from low-income homes. Examining EF skills among children attending Head Start preschools, Blair and Razza (2007) found that inhibitory control at age 3 (measured with the Peg Tapping task) was uniquely related to a range of academic abilities at age 5, including literacy and numeracy skills, even after accounting for concurrent EF and verbal and nonverbal intelligence. In a study using the current sample of children participating in the REDI project, Welsh and colleagues (2010) found that a composite of attention shifting, working memory, and inhibitory control (DCCS, backward word span, and peg tapping) assessed at the start of the pre-kindergarten year significantly predicted growth in children's emergent literacy and numeracy skills over the course of the pre-kindergarten year, after controlling for initial academic skills and language. Growth in these EF skills during the pre-kindergarten year also made unique contributions to kindergarten reading and math achievement.

Others have examined the association of EF skills with social competence and behavior. Among school-aged children, Nigg and colleagues (1999) found associations between poor EF and poor social competence two years later. Studies with school-aged samples also revealed associations between early EF and later behavioral problems (Brophy, Taylor, & Hughes, 2002; Nigg, Quamma, Greenberg, & Kusche, 1999; Riggs, Blair, & Greenberg, 2003). In a sample of Head Start participants, Rhoades and colleagues (2009) found that for children ages 4 to 5 years, inhibitory control (as measured by Peg Tapping) served as a significant, unique predictor of children's social skills. Specifically, children who had greater inhibitory control were more likely to show higher teacher-rated social skills. Additionally, in a sample of preschool children, Hughes and Ensor (2008) found significant links between a composite of EF measures and a measure reflecting problem behavior one year later.

There remains a lack of studies that have examined the cross-domain contributions of EF skills to children's academic and social-behavioral readiness. In one study that has addressed this question, Bierman and colleagues (2008) used the current sample of Head Start REDI participants and found that performance on measures of attention control, working memory, and inhibitory control (DCCS, backward word span, and peg tapping) at the start of the pre-kindergarten year not only predicted significant gains in language and emergent literacy skills over the course of the pre-kindergarten year, but also predicted end of the year behavioral outcomes, including teacher- and observer-rated social competence and observer-rated aggression.

The accumulated findings from these studies support the current scientific interest in the development of EF skills and their role in promoting school readiness, both academic and social-behavioral (e.g., Blair, 2002). However, EF skills are just one of the important contributors to

self-regulation. For instance, attention processes have been studied in many different ways with recognition that a multi-faceted conceptualization and measurement of attention may enhance our understanding of its development and of role of attention in self-regulation and in promoting school readiness (Ruff & Rothbart, 1996). As such, in addition to EF measures, school readiness researchers have been particularly interested in behavioral ratings of children's attention how attention behaviors impact children's academic and social-emotional readiness.

Self-Regulation: Attention Control

Although conceptually intertwined, behavioral ratings of attention control and direct assessments of EF skills are likely to show meaningful differences in predicting academic learning and social-behavioral adaptation. Theory and research with clinical ADHD samples may shed light on the reason for this. As of yet, there is no consensus on the mechanisms responsible for ADHD behaviors, but theory and research have pointed to likely impairments in EF (e.g., Barkley, 1997a, b). Despite considerable research linking children with ADHD to poor EF (see Pennington and Ozonoff, 1996), several studies have failed to find the link (e.g., Kuntis, Oosterlaan, & Stevenson, 2001; Daugherty, Quay, & Ramos, 1993; Kerns, McInerney, & Wilde, 2001). And even when children with ADHD do differ from typically developing children on measures of EF, there is often considerable distributional overlap, suggesting a lack of a clear distinction between the groups (Nigg, 2006). Parallel to these inconsistencies, theories of ADHD behavior have arisen that allow for multiple partially-independent processes to be responsible for ADHD-type behavior, such as breakdowns in the reward/reinforcement response (e.g., Nigg, 2006; Sonuga-Barke, 2002; 2003; 2005). In sum, it is possible that although EF and attention are related, behavioral ratings of attention may also reflect additional information about self-

regulatory processes of the child, particularly in the current sample of children who are at-risk, but who may be showing subclinical levels of inattention and impulsivity.

Research with typically developing children suggests that teacher ratings of inattention predicted uniquely to math outcomes after accounting for EF. For example, in two studies of grade-school children, Fuchs and colleagues found that teacher ratings of attention were relatively robust predictors of math outcomes, even after accounting for the contribution of several EF and related cognitive variables (e.g., working memory, processing speed) (Fuchs, Compton, Fuchs, Paulsen, Bryant, & Hamlett, 2005; Fuchs, Fuchs, Compton, Powell, Seethaler, & Capizzi, 2006). It is possible that behavioral ratings are better indicators of school readiness than direct assessment on EF tasks (or add variance beyond that accounted for by EF task performance), because the multi-task self-regulatory demands of the classroom are more complex than the demands within an experimental performance task, requiring children to effectively coordinate and manage their behavior in academic learning and social situations. As a result, behavioral ratings of attention may also have different utility for early detection and intervention for academic and social-emotional difficulties (Clark et al., 2010; Isquith, Crawford, Espy, & Gioia, 2005).

Definition and assessment. In the area of school readiness research, teacher ratings have been used to assess attention functioning in the classroom. These ratings focus on the child's ability to engage interest, concentrate, avoid distractions, and sustain interest in order to complete learning tasks (Lonigan, Bloomfield, Anthony, Bacon, Phillips, & Sarnwel, 1999). A number of different teacher rating measures have been developed to assess attention, with a range of specific items.

For example, McWayne, Fantuzzo, and McDermott (2004) have focused on children's "approaches to learning" in their Preschool Learning Behaviors Scale, developed to assess children's school readiness. The overall measure includes items describing attention and concentration (e.g., "Easily distracted or seeks distraction," "Doesn't pay attention to teacher/aide"), and also includes items reflecting the child's motivation, perseverance with difficult tasks, flexibility, and problem solving (e.g., "Easily gives up activities," "Displays reluctance to tackle new activities") (Fantuzzo, Perry, McDermott, 2004; McDermott, Leigh, & Perry, 2002). This set of teacher-rated items has been conceptualized as inter-related behaviors that support the child's ability to become engaged in classroom learning activities and thereby succeed at school (Fantuzzo et al., 2004).

Taking a slightly different approach, Cooper and Farran (1991) developed a teacher-rating measure of children's "work-related skills" – also designed to assess young children's ability to organize their attention for goal-oriented learning. Their measure encompasses behaviors like listening, following directions, and staying on task, as well as participating appropriately in groups and organizing work materials. Conceptually, overall ratings of children's work-related skills assess the domains of independence, responsibility, self-regulation, and cooperation (Cooper & Farran, 1991).

Focusing more specifically and narrowly on attention, teacher rating measures have been used to assess children's attention problems during the preschool and early school years, considering these to be premorbid signs or perhaps symptoms of ADHD (Spira & Fischel, 2005). Indeed, when evaluating children for ADHD, heavy emphasis is placed on obtaining teacher reports of children's inattention and impulsivity in the classroom (DuPaul, 1992). Such measures are typically based on the diagnostic criteria of ADHD published in past and current versions of

the Diagnostic and Statistical Manual for Mental Disorders (DSM; American Psychiatric Association, 2000). Studies with subclinical and at-risk samples have also employed these ratings to gauge children's attention (e.g., Merrell & Tymms, 2001; Rabiner, Coie, & Conduct Problems Prevention Research Group [CPPRG], 2000), some with a particular interest in the relation between attention and school readiness (e.g., Lonigan et al., 1999). An example of a rating of children's attention is the ADHD-Checklist developed by DuPaul (1991), which includes a sub-scale assessing attention problems with items such as "Has trouble staying focused" and "Doesn't seem to listen."

Another approach to tapping children's attention has involved the use of assessor ratings of child's behavior during assessment sessions (Bierman et al., 2008; Smith-Donald, Raver, Hayes, & Richardson, 2007). For instance, Smith-Donald and colleagues (2007) adapted the Leiter – R social-emotional scale (Roid & Miller, 1997) for use as an indicator of children's self-regulation. Items on the adapted Leiter – R include "pays attention during instructions" and "remains in seat." Assessors are required to provide a rating of the child's task orientation during the testing. Although these ratings assess children's attention in the controlled context of an assessment session, there is evidence of their validity as a predictor of classroom performance and learning. Specifically, Rhoades and colleagues (2010) found that preschool children with better attention skills, as measured by assessor ratings, showed enhanced academic competence in first grade.

Relations with academic and social-behavioral readiness. A number of studies suggest that behavioral ratings of children's attention explain variance in children's school success. They may be particularly relevant to the acquisition of academic and social skills, as they reflect the degree to which children are able to engage in learning tasks and participate in activities.

Conceptually, better attention in the classroom during the preschool year should be positively associated with later academic progress and social-emotional skills, as children who are attending better are likely to learn from instruction. Conversely, preschool attention problems should be negatively associated with school adjustment.

Consistent with these hypotheses, a number of studies show that teacher-ratings of children's attention are associated with their concurrent academic adjustment throughout the school years. In a large, nationwide sample of students ages 6-17 years, Yen and colleagues (2004) found that teacher ratings of children's "approaches to learning" (i.e., being attentive, persistent, motivated, flexible, etc.) had a unique relationship with concurrent academic achievement over and above cognitive ability. The authors suggested that these findings indicate a need to include an assessment of children's learning behaviors in psychoeducational assessments, in order to identify needs and inform treatment planning, as such skills may be more amenable to intervention than cognitive ability. McClelland and colleagues (2000) found that teacher ratings of children's work-related skills at kindergarten predicted modest but unique variance in concurrent academic outcomes (e.g., general information, math, vocabulary, reading recognition, and alphabet knowledge). Children's work-related skills at second grade also predicted unique variance in concurrent academic outcomes (e.g., reading and mathematics). The researchers also identified a subgroup of children who showed poor work-related skills at kindergarten. This group of children scored lower on academic outcomes at the beginning of kindergarten and the end of second grade, relative to their peers with better work-related skills in kindergarten.

Several studies have revealed significant correlations between teacher ratings of children's attention in the classroom and measures of academic achievement in the early

elementary years (Fuchs et al., 2005; Fuchs et al., 2006; Rabiner et al., 2000; Rabiner, Malone, & CPPRG, 2004). Conversely, children who show attention problems (i.e., high levels of inattention) in school experience underachievement, as assessed by a wide array of measures (see Hinshaw, 1992 for a review). In a comprehensive study using data from six longitudinal, non-experimental studies, Duncan et al. (2007) documented robust associations between teacher-rated attention problems (measured dimensionally) at school entry and subsequent academic achievement, controlling for cognitive skills. These studies suggest that teacher ratings of attention are unique predictors of children's achievement in later elementary school.

Only a few studies have addressed the question of whether teacher ratings of attention during the preschool period would predict later grade school performance. Using a Head Start sample, Blair and Razza (2007) revealed that teacher ratings of children's effortful control (which included an *Attention* subscale with items such as "when practicing an activity, has a hard time keeping her/his mind on it" and "when drawing in a coloring book, shows strong concentration") in preschool were related to children's emergent literacy and math skills in kindergarten. Specifically, teacher-rated effortful control in pre-kindergarten was positively associated with letter knowledge and mathematics ability in kindergarten. On the other hand, among clinical samples, attention problems assessed by teacher ratings in preschool have been associated with reduced academic achievement within the elementary years (Alexander, Entwisle, & Dauber, 1993; Hinshaw, 1992; Spira & Fischel, 2005).

Research with low-income, preschool populations has also yielded links between attention in preschool and social-emotional school readiness. Children who exhibit high levels of attention functioning and associated learning behaviors show low levels of disruptive and disconnected play behaviors with peers (Coolahan, Fantuzzo, Mendez, & McDermott, 2000;

Fantuzzo et al., 2004). Likewise, preschool children who are high on attention functioning and related behaviors have been shown to be correspondingly high on ratings of emotional regulation, suggesting an association between the ability to focus and sustain attention and the ability to control and modulate emotions (Fantuzzo et al., 2004). At present, there remains a lack of research in the school readiness literature examining the possible cross-domain associations of attention with academic and social-behavioral adjustment. Further, no studies have addressed these associations in the context of EF, to determine whether attention has unique associations with adjustment outcomes, after accounting for EF skills.

Self Regulation: Impulse Control

One of the complexities involved in using teacher ratings to assess attention functioning in the classroom is that ratings are often influenced by the child's activity level and impulsivity. However, as outlined above, behavioral ratings of impulsivity may reflect individual differences in a child's temperamental activity level (a "bottom up" regulatory process), compared to EF and attention, which may reflect "top down" regulation (Kochanska et al., 1996). As such, ratings of impulsivity may have different implications for school readiness, as well as different utility for early detection and intervention problems with readiness. As with behavioral ratings of attention, it is also possible that measures of impulsivity in the classroom are better indicators of school readiness than direct assessments of EF because the self-regulatory demands of the classroom are more complex than the demands within an experimental performance task. Furthermore, it is possible that when compared to attention, ratings of impulsivity relate differently to and account for unique variance in school adjustment. For example, impulsivity might have particular relevance to the social-behavioral aspects of school adjustment, such that a child's overactive

and intrusive behavior disrupts activities and impedes social collaboration, alienating teachers and peers (Lonigan et al., 1999).

In examining its link with school adjustment, impulsivity has been assessed using teacher ratings, which typically reflect a child's ability to constrain his or her behavior to meet classroom expectations and teacher directions. Impulsivity often presents as a behavioral or verbal intrusion in classroom activities or the conversations of others. Although inattention and impulsivity are interrelated during early childhood, the two can be separated, even among ADHD samples (DuPaul et al., 1997). In fact, researchers have found that the relationship between ADHD and literacy problems is mediated primarily by inattention, not impulsivity (Spira & Fischel, 2005; Willcutt & Pennington, 2000). Likewise, findings from studies using subclinical samples suggest that inattention is more closely linked than impulsivity to academic performance during the preschool period (Duncan et al., 2007; Friedman-Weineth, Harvey, Youngwirth, & Goldstein, 2007; Lonigan et al., 1999) and early school years (Breslau, Miller, Breslau, Bohnert, Lucia, & Schwietzer, 2009; Hinshaw, 1992; Merrell & Tymms, 2001; Rabiner et al., 2000; Rabiner et al., 2004).

Accumulating evidence supports the appropriateness of examining inattention and impulsivity separately when predicting academic outcomes. For instance, using a longitudinal data set, Breslau et al. (2009) followed children from age 6 to age 17. Results indicated that even when including for a host of covarying factores (including externalizing problems, IQ, neighborhood poverty, maternal education, and single-parent status), teacher ratings of children's attention problems at age 6 accounted for significant, unique variance in academic achievement in math and reading at age 17. Also using a longitudinal sample, Rabiner and colleagues (2000) examined the impact of externalizing and internalizing behaviors of kindergarten children on

later reading achievement in first, third, and fifth grade. Results indicated that of all the behaviors included in the model, teacher-rated inattention was the only one that predicted later reading achievement, after controlling for IQ, prior reading achievement, and parental involvement. In a preschool sample, Lonigan et al. (1999) found similar results. In particular, although conduct problems, hyperactivity, and inattention held negative associations with children's emergent literacy skills, attention problems had the strongest correlation with literacy skills for children in both the low- and middle-income samples of the study. It has been posited that inconsistent attention to classroom lessons where early reading skills were taught, rather than impulsivity or other externalizing problems in the classroom, interferes with the acquisition of important reading skills, resulting in impaired academic functioning over time (Lonigan et al., 1999; Rabiner et al., 2000). It has also been suggested that although young children are frequently observed to be active and impulsive, this does not necessarily mean that they are not learning (Merrell & Tymms, 2001). In sum, research indicates the importance of separating inattention and impulsivity when examining the self-regulatory behaviors as predictors of school readiness and suggests that inattention may be the stronger predictor of academic adjustment. However, there is a lack of research examining pre-kindergarten impulsivity in the context of attention and EF, as well as the combined and unique prediction of academic and social-behavioral adjustment.

Study Aims and Hypotheses

Despite evidence that EF skills, attention, and impulse control are related, yet distinct aspects of self-regulation that affect school adaptation and learning, prior research has not examined these indices concurrently in preschool and tracked their contribution to school adjustment into kindergarten and first grade. The current study contributes to the literature on

this topic by examining associations among the pre-kindergarten self-regulation indices: direct assessments of EF skills, teacher-rated inattention and impulsivity, and assessor-rated attention. It examined the inter-relations among these measures and their combined and unique prediction of school adjustment by including outcome measures assessing both academic (literacy and numeracy) and social-behavioral (social competence and aggression) adjustment at kindergarten and first grade. To provide a fuller understanding of the influence of the self-regulation measures on school adjustment, both variable- and person-centered approaches were utilized in the analyses.

The proposed study utilized data from 164 children attending 22 Head Start classrooms who comprised the "usual practice" control condition of the Head Start REDI program. Assessments tracked the progress of the children over the course of the pre-kindergarten, kindergarten, and first-grade years.

The current project had three aims. The first aim of the study was to examine the inter-relations among the self-regulation indices (direct assessment of EF skills, teacher ratings of inattention and impulsivity, and assessor-rated attention) at the start of the pre-kindergarten year. Preliminary factor analyses documented that preschool teachers can reliably discriminate child inattention from child impulsivity (see Results). Theory and research suggest that direct assessments of EF and teacher-ratings of inattention and impulsivity will be moderately related, but distinct. An additional goal of the first aim was to examine the cross-sectional association of the pre-kindergarten self-regulation indices with measures of academic skill and social-behavioral development. It was hypothesized that although EF would show cross-domain associations with academic and social-behavioral readiness, associations with academics (particularly with emerging numeracy skills) would be stronger than with social-behavioral

readiness. In line with prior research, it was hypothesized that measures of attention functioning (both teacher- and assessor-rated) would also show moderate cross-domain associations. As outlined in the literature, it was hypothesized that teacher-rated impulsivity would be more strongly related to the social-behavioral domains of adjustment than to academic skill development.

The second aim of the study was to utilize a variable-centered approach to examine the longitudinal relation of the pre-kindergarten self-regulation indices with academic and social-emotional adjustment at kindergarten and first grade. The study examined the unique contribution of each measure of self-regulation to children's school readiness and adjustment. Prior research has established links of direct assessments of EF and attention with academic skill development. Because of the shared cognitive demands of the EF tasks and the measures of literacy and numeracy, it was hypothesized that EF would prove to be a unique predictor of academic development. However, it was hypothesized that because ratings of attention assess self-regulation under complex conditions, they would also predict academic development, while the influence of teacher-rated impulsivity would likely fade in the context of these other measures. In predicting social-behavioral adjustment, it was hypothesized that EF skill development and teacher-rated impulsivity would predict social competence and aggression better than measures of attention functioning.

And lastly, the third aim of this study was to utilize a person-centered approach (latent profile analysis) to undertake exploratory analyses examining whether subgroups of preschool children with distinct self-regulation profiles can be identified, and whether those groups are significantly different in terms of their academic and social-behavioral adjustment at kindergarten and first grade. Because these analyses were exploratory, a priori hypotheses

concerning the number of groups and specific profiles were not generated. However, it was anticipated that with direct assessment of EF, teacher-rated inattention and impulsivity, and assessor-rated attention included as continuous predictors, a solution of three or more distinct profiles would result, reflecting more than just level of self-regulation (e.g., high and low), and that these profiles would differ in meaningful ways on measures of academic and social-behavioral school adjustment.

Methods

Participants

Participants included two cohorts of four-year-old children (total N = 164, 14% Latino American, 30% African American, 56% European American; 57% girls) in 22 Head Start classrooms in three counties in Pennsylvania (York, Blair, and Huntingdon). The children were recruited as part of a larger project (Head Start REDI), representing 86% of the initially eligible population, with most of the sample loss due to families who were not available for assessments or who moved prior to the completion of the pre-intervention assessments. Participants were recruited via brochures sent home at the beginning of the pre-kindergarten school year.

At the time of the baseline assessment, children were, on average 4.49 years old (*SD* = 0.31, range = 3.72–5.65). On the Block Design Scale of the Wechsler Preschool and Primary Scale of Intelligence—III, a measure of nonverbal cognitive ability that is highly correlated with full scale IQ (r = .72; Wechsler, 2002), children received an average standard score of 7.92 (SD = 2.64), approximately 0.69 standard deviations below the national mean of 10 (comparable to similar samples of children growing up in poverty).

All families met the requirements for participation in Head Start: 68% had incomes below the national poverty level. Forty percent of the children lived in two-parent families, 43 %

lived with single mothers, and 17 % lived with relatives or foster families. Overall, 33 % of mothers had not completed high school; 46 % had a graduate equivalent degree (GED) or high school diploma; 19 % had some technical training; and 2 % had graduated from college.

Participants in this study were enrolled when they were in their pre-kindergarten year of Head Start (total N= 164). They were followed after they made the transition into kindergarten classrooms, with data collected for 96% of the original sample (N=158), and first grade classrooms, with data collected for 96% of the original sample (N = 157).

Procedures

A multi-method, multi-informant assessment battery included direct assessments of child EF skills, teacher ratings of attention and impulsivity, and assessor ratings of attention. In addition, to assess the dependent measures of school adjustment, direct assessments were collected of child academic skills, and teachers provided ratings of social competence and aggressive behavior. The data used in these analyses were collected at three time points: 1) the beginning of the pre-kindergarten year, as soon as children had acclimated to the Head Start classroom setting, 2) the end of the kindergarten year, and 3) the end of first grade.

Child assessments were conducted at school by trained interviewers during individual "pull-out" sessions. Two assessment sessions were conducted at the beginning of the pre-kindergarten year, and one assessment session was conducted at the end of the kindergarten year and again at the end of first grade. The research assistants participated in a 3-day workshop to learn to administer the measures. They then completed at least two practice assessments in which they were observed by a supervisor and provided with detailed feedback. Assistants had to attain supervisor approval before collecting data on their own. Throughout the data collection periods,

the research assistants were closely monitored to ensure ongoing adherence to the assessment protocol.

In the pre-kindergarten year, one lead and one assistant teacher in each classroom provided independent ratings of child behavior. In April of the kindergarten year and first-grade year, classroom teachers were asked to complete ratings on each child in the study. Teachers were compensated $20 to provide general information about themselves and their classrooms, and they received an additional $7 per child for completing behavioral ratings.

Measures

A multi-method, multi-informant approach was used, including direct assessments conducted with children, teacher ratings, and interviewer ratings.

Self-regulation: EF measures. Four tasks were used to assess EF skills during the pre-kindergarten year. On the *Backward Word Span* task [BWS], which assesses working memory, children were asked to repeat a list of words in backward order (Davis & Pratt, 1996). The practice list and the first list each contained two words, and subsequent lists gradually increased to a total of five words. A child's score represented the highest number of words he/she repeated correctly in backwards order.

In the *Peg Tapping* task [PT] (Diamon & Taylor, 1996), which assessed working memory and inhibitory control, children were required to tap a wooden dowel twice when the experimenter tapped once and to tap once when the experimenter tapped twice. After practice trials, the child was administered a series of 16 mixed one-tap and two-tap trials ($\alpha = .94$). Successful performance of the task requires children to inhibit a natural tendency to imitate the action of the experimenter while remembering the rule for the correct response.

The third EF task, *Dimensional Change Card Sort* [DCCS] (Frye et al., 1995), involved target cards that varied along the dimensions of color and shape (e.g., red and blue, rabbits and boats). After learning to sort the cards according to one dimension (shape or color), the children were asked to sort the cards according to the other dimension. The score represented the number of trials (out of six) in which the child correctly shifted sets after the sorting criteria changed (α = .95). For preschool children, performance on this task reflects their working memory, inhibitory control, and attention-set-shifting abilities (Zelazo, Muller, Frye, & Marcovich, 2003).

Finally, the walk-a-line slowly task [WLS] (Kochanska et al., 1996) assessed inhibitory control. Children were asked to walk along a 6 ft.-long piece of string taped to the floor as the examiner timed them. Children were then asked to repeat the task twice, walking as slowly as they could and even more slowly than they walked in the previous trial. Total scores represented the average percentage by which children were able to reduce their speed on successive trials.

As discussed previously, EF skills are still developing during the preschool period and are often conceptualized in terms of their shared, combined variance in early childhood (e.g., Hughes & Ensor, 2007; Welsh et al., 2010; Wiebe et al., 2008). Exploratory factor analysis of the preschool EF measures revealed a single factor that included significant factor loadings for all four EF measures: BWS (.64), PT (.78), DCCS (.62), and WLS (.61). As such, one composite measure of EF skills was created by standardizing and averaging scores on the four tasks.

Self-regulation: Ratings of inattention and impulsivity. Teacher ratings of inattention were used to assess attention functioning in the classroom, using five items from the inattention subscale of the *ADHD Rating Scale* (DuPaul, 1991; e.g., “Is easily distracted,” “Has trouble staying focused”) and three items from an inventory developed for the larger project to assess learning engagement (e.g., “Is careful with his or her work”; items were reverse scored). Ratings

from lead and assistant teachers in pre-kindergarten (r = .78, p < .001) were averaged and items from the two scales were combined to form a total inattention score (α = .96), reflecting children's preschool attention functioning. Five items from the impulsivity subscale of the teacher-rated ADHD Rating Scale (e.g., "Blurts out answers inappropriately," "Has trouble waiting his/her turn") were used to assess impulsivity. Ratings from lead and assistant teachers (r = .75, p < .001) in pre-kindergarten were averaged and a total impulsivity scale was formed (α = .95).

The final measure of self-regulation at preschool was assessor-rated attention. After administering the child assessment battery, assessors at each testing session rated children's task orientation during the testing. Scores from the two assessment sessions were averaged. Three items reflecting the child's attention capacities (e.g., "pays attention during tasks," "sustains concentration") were averaged and a total score was formed (α = .92).

School readiness and adjustment: Emergent literacy skills. Children's literacy skills develop rapidly during the preschool and early school years. As such, it is necessary for measures to assess developmentally appropriate skills. To assess literacy skills in the proposed study, the assessment battery was adjusted at each time point to accommodate children's increasing skills. The measures used to assess emergent literacy skills at each time point are described below.

Three subscales assessing emergent literacy skills were drawn from the *Test of Preschool Early Literacy* (TOPEL; previously Pre-CTOPP; Lonigan, Wagner, Torgesen, & Rashotte, 2007). The *Blending* and *Elision* subtests were used to assess phonological sensitivity at the pre-kindergarten assessment. On the *Blending* subtest, children were asked to combine different parts of a word, such as "hot" and "dog" or "b" and "air" and point to the correct picture or say the full

word (α = .83). On the *Elision* subtest, children deconstructed compound words and pointed to the correct picture (e.g., Point to "snowshoe" without "snow"; Say "airport" without "air"; α = .80).

In addition, the *Print Awareness* subtest of the TOPEL was administered to assess children's letter recognition and print knowledge skills. On this test, children identified pictures of letters or words and named letters (α = .95 and .98 for pre-kindergarten and kindergarten, respectively). The *Print Awareness* subtest was administered at the pre-kindergarten and kindergarten assessments.

The Letter-Word Identification subtest of the Woodcock-Johnson III Tests of Achievement (Woodcock, McGrew, & Mather, 2001) provided nationally normed and standardized scores reflecting children's decoding skills. The Letter-Word Identification subtest was administered at the kindergarten and first grade assessments.

Two subscales of the Test of Word Reading Efficiency [TOWRE] (Torgensen, Wagner, & Rashotte, 1999) were also administered at kindergarten and first grade. The Sight Word Efficiency scale assessed the number (log-transformed to correct for skewness and kurtosis) of printed words that children identified accurately within 45 seconds (α = >.80 for kindergarten and first grade). The Phonemic Decoding Efficiency scale assessed the number (log-transformed) of non-words that children sounded out accurately within 45 seconds (α = >.80 for kindergarten and first grade).

For the present study, scales of emergent literacy skills will be standardized and averaged into a composite score. In pre-kindergarten, the composite will include Blending, Elision, and Print Awareness. In kindergarten, the composite will include Print Awareness, Letter-Word Identification, and TOWRE. In first grade, the composite will include Letter-Word Identification

and TOWRE. Correlations among the measures administered at pre-kindergarten ranged from .16 ($p < .05$) to .34 ($p. < .001$), at kindergarten from .20 ($p < .05$) to .29 ($p < .01$), and at first grade .732 ($p < .001$).

School readiness and adjustment: Numeracy skills. The Applied Problems scale of the Woodcock-Johnson III Tests of Achievement (Woodcock et al., 2001) was administered at each time point to assess children's emerging numeracy skills. The Applied Problems scale consists of tasks that require children to demonstrate their understanding of numbers and quantity, such as showing two fingers, counting objects, and adding or subtracting small numbers ($\alpha = .82, .78,$ and .84 for pre-kindergarten, kindergarten, and first grade, respectively). The Applied Problems scale is nationally normed and standardized and requires that different items are administered to children according to age and ability level, making it useful in assessing children's early numeracy skills and later achievement.

School readiness and adjustment: Social competence and aggression. Teacher ratings assessed social competence and aggressive-oppositional behavior problems at each time point. The 13 items of the *Social Competence Scale* (Conduct Problems Prevention Research Group [CPPRG], 2003) were rated on a 6-point Likert-type scale (*never* to *always*) and included prosocial behaviors such as sharing, helping, understanding other's feelings, as well as self-regulatory behaviors, such as resolving peer problems independently. Ratings provided by lead and assistant teachers in pre-kindergarten were averaged ($r = .65$, $p < .01$). Internal consistency was high for teachers at pre-kindergarten ($\alpha = .95$). Ratings were provided by classroom teachers at kindergarten ($\alpha = .95$) and first grade ($\alpha = .95$).Seven items from the *Teacher Observation of Child Adaptation – Revised* (TOCA – R; Werthamer-Larsson, Kellam, & Wheeler, 1991) assessed overt aggression (e.g., stubborn, yells, fights). Items were rated on a 6-point Likert-type

scale (*almost never* to *almost always*). Ratings provided by lead and assistant teachers in pre-kindergarten were averaged ($r = .71$, $p < .01$). Internal consistency was high for teachers at pre-kindergarten ($\alpha = .94$). Ratings were also provided by classroom teachers at kindergarten ($\alpha = .89$) and first grade ($\alpha = .90$).

Vocabulary: The *Expressive One-Word Picture Vocabulary Test* (EOWPVT; Brownell, 2000) was used at pre-kindergarten to assess children's vocabulary. In EOWPVT, the assessor points to a picture and the child is required to give the word that best describes the picture (e.g., scissors, bike, train). Past research has demonstrated high levels of internal reliability and predictive validity for this test. The EOWPVT yields raw score, percentile rank, and standard score equivalents. Standard scores will be used for all analyses as a measure of children's expressive vocabulary skills, which will serve as a proxy for intellectual functioning.

Plan of Analysis

First, correlations were conducted to examine associations among the indices of children's preschool self-regulation (EF skills, teacher ratings of inattention and impulsivity, and assessor ratings of attention) and to verify their concurrent associations with measures of child academic and social-behavioral school readiness. These analyses controlled for child age, sex, and vocabulary.

Second, correlations were conducted to examine the longitudinal association between the self-regulation indices of and later academic and social-behavioral adjustment to school in kindergarten and first grade. A set of hierarchical multiple regression analyses were conducted to examine the combined and unique variance in children's kindergarten and first grade academic (literacy and numeracy skills) and social-behavioral adjustment (social competence and

aggression) accounted for by the four indices of self-regulation. These analyses controlled for child age, sex, and vocabulary.

Third, to address whether subgroups of children can be identified based on profiles of preschool self-regulation, latent profile analyses (LPA) were applied using the four indices of self-regulation as predictors. Children were assigned to groups based upon the highest probability of group membership. Then, univariate analyses (ANOVAs) were conducted to compare the groups on academic and social-emotional adjustment at kindergarten and first grade.

Results

Dimensions of Teacher-Rated Self-Regulation

Preliminary analyses were undertaken to document the ability of pre-kindergarten teachers to discriminate behaviors associated with inattention from those associated with impulsivity. It was hypothesized that items would form inter-related but distinct domains according to the degree to which the items reflected behaviors associated with inattention or impulsivity.

To test this hypothesis, 13 teacher-rated items associated with inattention and impulsivity were subjected to a principal components analysis (varimax rotation with Kaiser normalization). As expected, two factors emerged with Eigenvalues greater than 1.0. The first factor had an Eigenvalue of 6.34, and explained 49% of the variance. It was defined by eight items that represent inattention. The second factor had an Eigenvalue of 4.50 and explained 35% of the variance. It was defined by five items reflecting impulsivity. Together this two-component structure accounted for 84% of the total variance. As expected, the domains were interrelated, but no measure loaded above .55 on the two factors simultaneously (see Table 1). These analyses validated the distinction between inattention and impulsivity in the teacher ratings at preschool.

Scores on the eight items that loaded on the factor reflecting inattention were standardized and averaged and are considered an inattention composite. Likewise, scores on the five items that loaded on the factor reflecting impulsivity were standardized and averaged as an impulsivity composite.

Table 1

Factor Loadings for Teacher Ratings of Inattention and Impulsivity

Item	Inattention	Impulsivity
Inattention Scale		
Is careful with his or her work - R	.87	.25
Can work independently – R	.88	.20
Is able and willing to follow instructions – R	.85	.30
Is easily distracted	.84	.35
Has trouble following directions	.82	.43
Has trouble staying focused	.87	.33
Goes from one uncompleted activity to another	.80	.42
Doesn't seem to listen	.76	.49
Impulsivity Scale		
Has trouble waiting for his or her turn	.55	.72
Blurts out answers or opinions inappropriately	.32	.86
Has trouble playing or doing things quietly	.46	.79
Talks too much	.18	.90
Interrupts or intrudes on others	.32	.89

Note. Varimax rotation was used. Reverse-scored items are indicated with an R. Boldface items indicate the subscale scoring.

Preliminary Analyses for Self-Regulation and School Readiness and Adjustment Measures

Because several measures were composed of items from different scales, and for consistency, all scores for each composite were standardized. In Table 2, means, standard

deviations, and the range of scores for each measure of self-regulation, school readiness, and school adjustment are presented.

Table 2

Descriptive Statistics: Pre-Kindergarten Self-Regulation and School Outcomes

Composite	*M*	*SD*	*Min*	*Max*
Self-regulation indices				
EF	.01	.68	-1.17	1.94
Teacher-rated inattention	.01	.92	-1.06	2.76
Teacher-rated impulsivity	.07	.96	-.95	2.71
Assessor-rated attention	.06	.87	-2.54	1.17
School readiness and adjustment				
Pre-kindergarten				
Literacy	-.05	.70	-1.40	2.14
Numeracy	-.12	1.02	-3.61	2.87
Social competence	-.05	1.05	-2.74	2.23
Aggression	.10	1.08	-1.05	3.51
Kindergarten				
Literacy	.03	.70	-1.40	2.87
Numeracy	.10	.93	-2.34	2.50
Social competence	-.15	.98	-2.63	1.83
Aggression	.14	.98	-1.00	3.23
1st grade				
Literacy	.03	.89	-2.02	2.88
Numeracy	.02	.98	-3.46	3.06
Social competence	-.05	1.02	-2.31	1.96
Aggression	.04	1.01	-1.08	3.65

Additionally, sex differences were examined for each measure. Significant gender differences emerged on teacher ratings of inattention and impulsivity. Teachers rated boys higher than girls in inattention, t (162) = 2.70, $p < .05$, $M = 0.23$ for boys and $M = -0.16$ for girls. Teachers also rated boys higher than girls in impulsivity, t (162) = 2.73, $p < .05$, $M = 0.30$ for boys and $M = -0.11$ for girls. No significant gender differences emerged on any of the other measures, all $p < .05$.

Associations among Multi-Informant Measures of Pre-Kindergarten Self-regulation

Correlations among self-regulation indices are included in Table 2. With only one exception, the measures of self-regulation were significantly inter-correlated. The single exception was that teacher ratings of impulsivity were not significantly correlated with the EF measure composite, $r = -.10$. The other measures of self-regulation skills, drawn from diverse informants, including teacher ratings, direct assessments of EF, and assessor ratings, were moderately inter-correlated, with the absolute value of the correlations ranging from $r = .35$ to $r = .48$. The only case of a stronger level of association emerged between teacher ratings of inattention and impulsivity, which were highly inter-correlated, $r = .81$, probably reflecting some shared method variance, but also a shared focus on behavioral features of dysregulation. This pattern of findings is consistent with the interpretation that the diverse types of measures were tapping somewhat distinct, but inter-related dimensions of the underlying construct of self-regulation.

Table 3

Correlations Among Pre-Kindergarten Indices of Self-Regulation

Composite	1	2	3	4
1. EF	--	-.39**	-.10	.43**
2. Teacher-rated inattention		--	.81**	-.48**
3. Teacher-rated impulsivity			--	-.35**
4. Assessor-rated attention				--

Note. Each measure represent standard score composites. ** $p < .001$, * $p < .05$

Dimensions of School Readiness and Adjustment Outcomes

Correlations among school readiness and adjustment measures were computed for the pre-kindergarten, kindergarten, and first grade years and are included in Table3. During the prekindergarten year, the two measures of academic skill development (literacy and numeracy) were significantly and moderately correlated, $r = .55$. Similarly, the two measures of behavioral adjustment (social competence and aggression) were highly intercorrelated, $r = -.83$, perhaps amplified by the shared method variance of the teacher rating assessment. Interestingly, although teacher ratings of social competence were significantly associated with direct assessments of academic skill ($r = .29$ and .24 for literacy and numeracy, respectively), teacher-rated aggression was not associated with academic skills. At the subsequent grade levels, the two types of academic skills (literacy and numeracy) remained significantly and moderately correlated, $r = .43$ and .46 in kindergarten and first grade, respectively. Similarly, social competence and aggression were significantly and strongly correlated in an inverse direction, $r = -.71$ and $r = -.80$ in kindergarten and first grade, respectively. Aggression remained unrelated to academic skills through first grade. However, the pattern of association between academic skills and social

competence varied by grade level. In kindergarten, social competence remained significantly associated with literacy skills, but not with numeracy. By first grade, social competence and academic skill were unrelated. In general, these associations suggest more shared variance and longitudinal stability within the domains of academic skills (literacy, numeracy) and behavioral adjustment (social competence, aggression), than across these two outcome domains, particularly as children moved into elementary school.

Table 4

Within-Year Correlations Among School Outcomes at Three Time Points

Composite	1	2	3	4
Pre-Kindergarten				
1. Literacy	--	.55**	.29**	-.12
2. Numeracy		--	.24**	-.10
3. Social Competence			--	-.83**
4. Aggression				--
Kindergarten				
1. Literacy	--	.43**	.27**	-.14
2. Numeracy		--	.11	-.07
3. Social Competence			--	-.71**
4. Aggression				--
First Grade				
1. Literacy	--	.46**	.08	-.02
2. Numeracy		--	.04	0.00
3. Social Competence			--	-.80**
4. Aggression				--

** $p < .001$; * $p < .05$

Significant stability was also evident for each of the school outcomes from year to year. For literacy, stability correlations were $r = .42$ from pre-kindergarten to kindergarten, and $r = .34$ from pre-kindergarten to first grade. For numeracy, stability correlations were $r = .54$ from pre-kindergarten to kindergarten, and $r = .54$ from pre-kindergarten to first grade. Parallel levels of

stability for teacher ratings of social competence and aggression were r = .45 and r = .53, respectively, from pre-kindergarten to kindergarten, and r = .42 and r = .40 respectively, from pre-kindergarten to first grade.

Associations with School Readiness and Adjustment Outcomes

Next, to examine the predictive associations between the pre-kindergarten measures of self-regulation and school outcomes, correlations were conducted. In these analyses, sex, age, and baseline vocabulary scores (EOWPVT) were controlled. Results for cross-sectional associations at pre-kindergarten are shown in Table 4. When measured in prekindergarten, the direct assessment of EF was significantly and moderately associated with the two measures of academic skills development (r = .56 and .42 for literacy and numeracy, respectively). Interestingly, the EF measure was also significantly associated with social competence (r = .25) but was unrelated to aggression (r = -.16). Teacher-rated inattention and impulsivity were strongly associated with both measures of social-behavioral development (social competence and aggression), with the strength of associations ranging from r = .70 to r = .81. These high correlations likely reflect some shared method variance, as each domain was rated by the pre-kindergarten teacher. Further, each measure focuses on behavioral indicators of regulatory functioning. Teacher-rated inattention and impulsivity differed, though, in their associations with the academic measures. Inattention was significantly associated with each academic skill (r = -.24 and -.22 for literacy and numeracy, respectively), whereas impulsivity was unrelated to either. Like teacher-rated inattention, the measure of assessor-rated attention was significantly associated with each measure of school readiness, with the strength of associations ranging from r = .23 to r = .36. Overall, these findings indicate stronger associations between EF and the academic (rather than behavioral) domains of school readiness and stronger associations between

teacher-rated inattention and impulsivity and the social-behavioral (rather than academic) aspects of readiness. However, both teacher-rated inattention and assessor-rated attention showed significant, cross-domain associations when examined cross-sectionally.

Table 5

Correlations Between Pre-Kindergarten Self-Regulation and Concurrent School Readiness

Composite	EF	Teacher-rated inattention	Teacher-rated impulsivity	Assessor-rated attention
Literacy	.56**	-.24*	-.10	.33**
Numeracy	.42**	-.22*	-.13	.23*
Social Competence	.25*	-.81**	-.70**	.36**
Aggression	-.16	.79**	.79**	-.28**

Note. Analyses control for age, sex, and baseline vocabulary.
** $p < .001$; * $p < .05$

To examine whether the pre-kindergarten self-regulation indices maintained this pattern of associations with the school outcomes in kindergarten and first grade, predictive correlations were conducted. Again, sex, age, and baseline vocabulary were controlled in the analyses. Results are presented in Table 5. The direct assessment of EF at pre-kindergarten maintained a significant and moderate predictive association with numeracy skills at kindergarten and first grade (r = .42 and .40, respectively). Interestingly, the pattern differed for the other measure of academic skill development, literacy. Whereas pre-kindergarten EF significantly predicted literacy in kindergarten, r = .18, $p < .05$, the two were unrelated by first grade, r = .12, $p > .10$. Across kindergarten and first grade, pre-kindergarten EF significantly predicted only one measure of social-behavioral adjustment, kindergarten aggression (r = -.17). On the other hand,

the teacher-rated measures of inattention and impulsivity maintained their pattern of significant associations with the social-behavioral domains of school adjustment, with the strength of associations ranging from r = .29 to r = .43. Although these are associations among teacher ratings, it is notable that different teachers are providing these ratings each year, in the context of different classrooms. Pre-kindergarten ratings of inattention and impulsivity maintained their pattern of associations with the domains of academic skill development. Inattention significantly predicted academic skills at kindergarten (r = -.20 and -.27 for literacy and numeracy, respectively) and first grade (r = -.24 and -.32 for literacy and numeracy, respectively), while impulsivity was unrelated to academics. Assessor-rated attention, which was significantly associated with concurrent prekindergarten academic skills and behavior, had less predictive power. Assessor-rated attention in pre-kindergarten showed only one significant association with measures of kindergarten and first-grade school adjustment (r = .21 for social competence at kindergarten).

In summary, the direct assessment of EF continued to show strong associations with numeracy over time, while associations with literacy seemed to fade by first grade. Teacher-rated inattention and impulsivity both maintained significant associations with the social-behavioral aspects of adjustment, and inattention additionally continued to show significant cross-domain associations with academic skill development. Assessor-rated attention showed concurrent, but not predictive associations with the key adjustment domains.

Table 6

Correlations Between Pre-Kindergarten Self-Regulation and School Outcomes

School Outcome Composites	Pre-Kindergarten Self-Regulation			
	EF	Teacher-rated inattention	Teacher-rated impulsivity	Assessor-rated attention
Literacy				
Kindergarten	.18*	-.20*	-.05	.14
1st grade	.12	-.24*	-.14	.10
Numeracy				
Kindergarten	.42**	-.27**	-.09	.13
1st grade	.40**	-.32**	-.12	.22
Soc. Comp.				
Kindergarten	.13	-.36**	-.33**	.21*
1st grade	.08	-.32**	-.32**	.12
Aggression				
Kindergarten	-.17*	.43**	.41**	-.16+
1st grade	-.02	.29**	.34**	-.14

Note. Analyses control for age, sex, and baseline vocabulary.
** $p < .001$; * $p < .05$

Prediction of School Readiness and Adjustment Outcomes

Next, because the self-regulation indicators (direct assessment of EF, teacher-rated inattention and impulsivity, assessor-rated attention) are conceptually intertwined, hierarchical multiple regressions were conducted to evaluate the combined *and* unique contribution of the

indicators to children's school adjustment outcomes. Two sets of analyses were conducted in a stepwise fashion, with sex, age, and baseline vocabulary entered as control variables at step 1 in both. In Table 6, results are summarized for hierarchical multiple regressions in which the direct assessment of EF was entered at step 2 and the behavioral measures (teacher-rated inattention and impulsivity and assessor-rated attention) were entered together in step 3. Table 7 presents results for a regression analysis in which the behavioral measures were entered at step 2 and EF was entered at step 3.

The results shown in Table 6 will be reported first. In these analyses, effects for EF (entered in step 2) include controls for age, sex, and baseline vocabulary, whereas effects for teacher-rated inattention and impulsivity and assessor-rated attention (entered in step 3) also include a control for the EF composite. In this case, the effects for EF are similar to the predictive correlations. Prekindergarten EF accounted for significant amount of variance in kindergarten literacy,$\Delta R^2 = .03$, $p < .05$ and kindergarten numeracy, $\Delta R^2 = .15$, $p < .01$, and a significant amount of variance in first-grade numeracy, $\Delta R^2 = .41$, $p < .01$, but not first-grade literacy, $\Delta R^2 = .01$. EF also explained a small but significant amount of variance in kindergarten aggression ($\Delta R^2 = .03$), but not kindergarten social competence or first-grade behavioral adjustment. Pre-kindergarten teacher ratings of inattention and impulsivity were entered in step 3 and hence, these predictions differ from the previously reported correlations because they control for pre-kindergarten EF. After accounting for the control variables and EF, the behavioral measures entered in step 3 of the regression accounted for a small and nearly-significant amount of variance in literacy at kindergarten, $\Delta R^2 = .04$, $p < .10$) and first grade, $\Delta R^2 = .05$, $p < .10$. Interestingly, although teacher-rated inattention predicted lower literacy scores in kindergarten, teacher-rated impulsivity (with EF and inattention controlled) showed evidence of a suppression

effect, significantly and unexpectedly predicting higher scores on kindergarten literacy measures. Only teacher-rated inattention maintained a unique contribution to the prediction of literacy in first grade, reducing literacy scores as expected. With EF controlled, pre-kindergarten behavioral measures also made unique and significant contributions to the prediction of numeracy skill development,ΔR^2 = .04 and .07 at kindergarten and first grade, respectively. In both years, pre-kindergarten inattention predicted lower levels of numeracy skill, whereas pre-kindergarten impulsivity (with EF and inattention controlled) predicted higher levels of numeracy skill in kindergarten and first grade. Considering the outcomes of social competence and aggression, the pre-kindergarten ratings of inattention and impulsivity entered in step 3 explained significant variance in each outcome, ranging from ΔR^2 = .10 to ΔR^2 = .16. In this case, neither inattention nor impulsivity showed evidence of unique predictability; they appeared to work jointly to predict lower levels of social competence and elevated aggression in elementary school. .

Overall, with EF entered in step 2, the pre-kindergarten teacher ratings of inattention and impulsivity continued to make a significant prediction to kindergarten and first grade social competence, aggression, and numeracy, and a near-significant contribution to kindergarten and first grade literacy. These findings support the predictive value of behavioral ratings completed by teachers, which appear to add predictive information regarding children's functioning that is not redundant with direct EF assessments.

Table 7

Hierarchical Regressions: Pre-Kindergarten Self-Regulation Predicting School Outcomes

	School Readiness and Adjustment Outcomes							
	Literacy		Numeracy		Soc Comp		Aggression	
Predictors	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Kindergarten Outcomes								
Step 1	.17**		.15**		.06*		.04	
Control Variables [a]								
Step 2	.03*		.15**		.02		.03*	
EF		.18*		.43**		.15		-.19*
Step 3	.04^{+}		.04*		.11*		.16**	
Teacher-rated inattention		-.38*		-.39*		-.26^{+}		.26^{+}
Teacher-rated impulsivity		.28*		.27*		-.11		.23^{+}
Assessor-rated attention		.06		-.05		.08		.06
First Grade Outcomes								
Step 1	.12**		.16**		.07*		..03	
Control Variables [a]								
Step 2	.01		.13**		.01		.00	
EF		.13		.41**		.09		-.02
Step 3	.05^{+}		.07*		.10*		.11*	
Teacher-rated inattention		-.36*		-.49*		-.22		.12
Teacher-rated impulsivity		.15		.35*		-.15		.24
Assessor-rated attention		-.01		.06		-.02		-.03

Note. [a] Control variables included age, sex, and baseline vocabulary.
** $p < .001$; * $p < .05$; $^{+}$ $p < .10$

Next, to examine the predictability of pre-kindergarten EF assessments, controlling for the effects of teacher ratings, stepwise multiple hierarchical regressions were conducted, this time with the behavioral measures of self-regulation (teacher-rated inattention and impulsivity and assessor-rated attention) entered in step 2 and the direct assessment of EF entered at step 3.

After accounting for the control variables, the behavioral measures entered in step 2 showed a pattern consistent with the previously-reported correlations and regressions. They predicted a significant amount of variance in elementary school academic performance, including kindergarten and first-grade literacy and numeracy skills, with ΔR^2 values ranging from .06 (for first grade literacy) to .16 (for first grade numeracy). In addition, the behavioral ratings entered at step 2 accounted for significant variance in predicting social competence and aggression in kindergarten and first grade, with ΔR^2 ranging from .18 (kindergarten aggression) to .11 (first grade outcomes). Of particular importance in these analyses are the predictions made by pre-kindergarten EF, which was entered in step 3 and hence reflects the predictability of EF with teacher-rated inattention and impulsivity and assessor-rated attention controlled. When entered in step 3, EF accounted for significant variance in numeracy outcomes (ΔR^2 = .15 and .13 at kindergarten and first grade, respectively) but not literacy. In addition, EF entered at step 3 did not explain any unique variance in the social-behavioral outcomes.

Table 8

Hierarchical Regressions with Pre-Kindergarten Self-Regulation Indices Predicting School Adjustment Outcomes at Kindergarten, and First Grade

	School Readiness and Adjustment Outcomes							
	Literacy		Numeracy		Soc Comp		Aggression	
Predictors	ΔR^2	β	ΔR^2	β	ΔR^2	β	ΔR^2	β
Kindergarten Outcomes								
Step 1	.17**		.15**		.06*		.04	
Control Variables [a]								
Step 2	.07*		.11**		.13**		.18**	
Teacher-rated inattention		-.42*		-.58**		-.26^{+}		.29*
Teacher-rated impulsivity		.30*		.39*		-.10		.21
Assessor-rated attention		.07		.03		.07		.04
Step 3	.00		.08*		.00		.01	
EF		.07		.35*		.00		-.06
First Grade Outcomes								
Step 1	.12**		.16**		.07*		.03	
Control Variables [a]								
Step 2	.06*		.16**		.11*		.11*	
Teacher-rated inattention		-.37*		-.64**		-.21		.07
Teacher-rated impulsivity		.16		.44*		-.16		.27^{+}
Assessor-rated attention		.00		.12		-.03		-.01
Step 3	.00		.04*		.00		.00	
EF		.02		.26*		-.02		.08

Note. [a] Control variables included age, sex, and baseline vocabulary.
** $p < .001$; * $p < .05$; $^{+}$ $p < .10$

In general, the predictions made by teacher-ratings of inattention and impulsivity to academic and behavioral outcomes in kindergarten and first grade were fairly robust, consistent even when pre-kindergarten EF measures were controlled. In contrast, the predictions that pre-

kindergarten EF measures made to elementary school outcomes were more specific, with only the unique prediction to numeracy skills maintained once the variance shared with the teacher-rating measures was controlled. To summarize, with the behavioral measures of self-regulation entered at step 2 and EF entered at step 3, literacy is significantly predicted at each time point by the behavioral measures, but not EF; numeracy at both time points is significantly predicted by the behavioral measures and EF; and the social-behavioral outcomes are predicted only by the behavioral measures of self-regulation.

Person-Centered Approach to Self-regulation

Next, to complement the variable-centered analyses, a person-centered approach was taken to examine whether subgroups or classes of children could be identified based on mean-level profiles of the self-regulation indicators. Latent profile analysis was employed (LPA; Muthen & Muthen, 1998). Pre-kindergarten levels of EF skill, teacher-rated inattention and impulsivity, and assessor-rated attention were modeled as continuous, observed indicators of categorical latent variables, which represented the different subgroups or classes.

The statistical package Mplus 5.1 (Muthen & Muthen, 2008) was used to fit the LPAs. To arrive at the best-fitting model, it has been recommended that information based indices (i.e., AIC, BIC, sample-size adjusted BIC), fit indices (e.g., VLMR), entropy, and the theoretical meaning and interpretability of solutions be used when evaluating overall model fit (Muthen, 2003). Considering the above criteria, a model with four classes was selected. Children were assigned to groups based upon the highest probability of group membership. Entropy for the four-class solution, which is an index of how well individuals were classified into subgroups, was excellent (.78).

To determine significant differences among the classes on the various pre-kindergarten indices of self-regulation, a series of one-way ANOVAs was computed. Table 8 shows the prevalence of the four classes, the pattern of means across the self-regulation indicators for each class, and significance levels for ANOVAs examining class differences on the self-regulation indicators and demographics. ANOVA results revealed significant class differences on all four of the self-regulation indicators: direct assessment of EF, F (3, 156) = 23.33, $p < .001$, teacher-rated inattention, F (3, 160) = 273.54, $p < .001$, teacher-rated impulsivity, F (3, 160) = 256.43, $p < .001$, and assessor-rated attention, F (3, 150) = 21.68, $p < .001$. The groups did not significantly differ on age, but did differ on baseline vocabulary, F (3, 157) = 4.90, $p < .05$. Post hoc comparisons (Bonferonni) were also conducted and will be discussed in relation to the groups.

In the modeled solution, class 1 included 54 children, 34% of the girls and 30% of the boys in the sample. The mean scores for children in this group were one-half standard deviation above the sample mean on the EF composite and assessor ratings and over one-half standard deviation below the sample mean on teacher-rated inattention and impulsivity. Post hoc comparisons (Bonferonni) revealed that this group was characterized by significantly higher levels of EF skill and assessor-rated attention than the other groups and significantly lower levels of teacher-rated inattention and impulsivity than the others. Because all four indices indicate high self-regulation, this class was labeled "well regulated."

Class 2 included 32 children, 17% of the girls and 23% of the boys in the sample. The group means were one-fifth of a standard deviation below the sample mean on the EF composite and assessor ratings, two-fifths of a standard deviation above the sample mean on teacher ratings of inattention, and four-fifths of a standard deviation above the sample mean on teacher ratings of impulsivity. Post hoc comparisons (Bonferonni) revealed that this group was characterized by

significantly lower levels of EF skill and assessor-rated attention than the well- regulated group, and significantly higher levels of teacher-rated inattention and impulsivity. Although some deficits were evident in all measures of self-regulation (e.g., low EF and assessor-rated attention, elevated inattention, and elevated impulsivity), this group was labeled for its most distinctive characteristic, which was elevated impulsivity: "impulsive."

Class 3 included 23 children (8% of the girls in the sample, 23% of the boys in the sample). The group means were one-fifth of a standard deviation below the sample mean on the EF composite, two-thirds of a standard deviation below the sample mean on assessor ratings, and a dramatic elevation (approaching two standard deviations above the sample mean) on teacher ratings of impulsivity and inattention. Post hoc comparisons (Bonferonni) revealed that this group was also characterized by significantly lower levels of EF skill and assessor-rated attention than the well-regulated group. Importantly, the group was also characterized by levels of inattention and impulsivity that were significantly higher than all the other groups. This group was labeled after its distinctive behavioral dysfunction in the classroom: "dysfunctional."

Class 4 included 55 children, including 41% of the girls in the sample and 24% of the boys in the sample. The group means were one-third of a standard deviation below the sample mean on the EF composite and one-sixth of a standard deviation below the sample mean on assessor ratings. However, the group means on teacher ratings reflected functioning better than the mean of the sample, with ratings of inattention one-fifth of a standard deviation below the sample mean and ratings of impulsivity two-fifths of a standard deviation below the sample mean. Post hoc comparisons (Bonferonni) revealed that this group was characterized by levels of EF and assessor-rated attention that were significantly lower than the well regulated group, and equivalent to the scores of children in the impulsive and dysfunctional groups. Although teacher

ratings of inattention and impulsivity were significantly higher than those given to children in the well-regulated group, they were still below the sample mean, and significantly lower than levels of inattention and impulsivity exhibited by the impulsive and dysfunctional groups. This group was also significantly lower than the well-regulated group on baseline vocabulary. This group was labeled for its distinctive feature of "low EF."

Overall, the three "problem" classes shared equivalent deficits in EF scores and assessor ratings, which distinguished them from the well-regulated group. However, these three problem classes differed substantially in terms of their teacher-rated behavior problems, ranging from no teacher-rated problems (the Low EF group), to moderate elevations, primarily in impulsivity (the Impulsive group), to extreme elevations in both inattention and impulsivity (the Dysfunctional group).

Table 9

Four-class Solution for LPA with Pre-Kindergarten Self-Regulation Indices as Indicators

	Class 1 N = 54 (33%)	Class 2 N = 32 (20%)	Class 3 N = 23 (14%)	Class 4 N = 55 (34%)	F-value
Mean values					
EF	.53[a]	-.19[b]	-.18[b]	-.31[b]	23.33**
Teacher-rated inattention	-.80[a]	.42[c]	1.79[d]	-.18[b]	273.54**
Teacher-rated impulsivity	-.66[a]	.82[c]	1.79[d]	-.39[b]	256.43**
Assessor-rated attention	.70[a]	-.20[b]	-.64[b]	-.15[b]	21.68**
Demographics					
Age	.05[a]	-.10[a]	.08[a]	.00[a]	.20
Vocabulary	.34[a]	-.02[ab]	-.04[ab]	-.34[b]	4.90*
% of females	34%	17%	8%	41%	--
% of males	30%	23%	23%	24%	--

Note. Values are Z scores.
** p < .001; * p < .05

Comparing Classes on School Readiness and Adjustment

Next, univariate analyses (ANCOVAs) were conducted to investigate group differences on concurrent measures of school readiness, controlling for age, sex, and baseline vocabulary. Results are presented in Table 9. Results revealed significant group differences on each measure of pre-kindergarten school readiness: literacy, F (3, 154) = 10.80, p < .001, numeracy, F (3, 154)

= 4.25, $p < .05$, social competence, F (3, 154) = 73.19, $p < .001$, and aggression, F (3, 154) = 71.47, $p < .001$. Post hoc (Bonferonni) analyses revealed that all three of the problem classes had significantly lower literacy readiness than the well-regulated group, and did not differ amongst themselves. In addition, the Dysfunctional and Low EF classes both exhibited significant delays in numeracy skill development relative to the well-regulated group (with scores for the impulsive group intermediate in value). Although the Low EF group had social competence and aggression scores that differed significantly from the well-regulated group, they were still close to the sample mean. The Impulsive group exhibited lower social competence and higher aggression than the well-regulated or Low EF group, with levels over a half standard deviation above the sample mean. The Dysfunctional group showed significantly deficient social competence and significantly elevated aggression, with scores worse than any other group, and well above the sample mean. Overall, then, children in each of these problem groups showed delays in academic skill acquisition in pre-kindergarten, with varying levels of social and behavior problems.

Table 10

ANCOVAs Examining Group Differences on Concurrent School Readiness Outcomes at Pre-Kindergarten

	Class 1 Well-regulated	Class 2 Impulsive	Class 3 Dysfunctional	Class 4 Low EF	F-value
Literacy	.30[a]	-.15[b]	-.20[b]	-.27[b]	10.80**
Numeracy	.21[a]	-.21[ab]	-.45[b]	-.28[b]	4.25*
Social competence	.84[a]	-.62[c]	-1.58[d]	.07[b]	73.19**
Aggression	-.67[a]	.58[c]	1.79[d]	-.17[b]	71.47**

Note. Control variables included age, sex, and baseline vocabulary.
** p < .001; * p < .05

To examine whether the classes maintained this pattern of differences after the transition into elementary to school, ANCOVAs were conducted comparing the groups on kindergarten and first grade school outcomes. Results are presented in Table 10. Significant group differences were revealed in three of four school outcome domains: numeracy, F (3, 147) = 6.05, $p < .05$ and F (3, 146) = 3.94, $p < .05$ for kindergarten and first grade, respectively; social competence, F (3, 145) = 7.25, $p < .001$ and F (3, 146) = 6.88, $p < .05$ for kindergarten and first grade, respectively; and aggression, F (3, 145) = 9.85, $p < .001$ and F (3, 146) = 5.41, $p < .05$ for kindergarten and first grade, respectively. No significant group differences were revealed for literacy. Post hoc (Bonferonni) analyses revealed that for numeracy, the Low EF group remained significantly below the skill acquisition level of the well-regulated group at kindergarten and first grade. In addition, although not different at kindergarten, the Dysfunctional group also performed

significantly below the well-regulated group on numeracy skills in first grade. In the domain of social competence, the Impulsive and Dysfunctional groups continued to show significantly lower levels of social competence than the well-regulated group in kindergarten and first grade. In addition, children in the Low EF group were significantly less socially competent than the well-regulated group by first grade. Considering the domain of aggression, only the Impulsive and Dysfunctional groups differed significantly from the well-regulated group, showing elevated rates of aggression in kindergarten and first grade. Overall, children in the Impulsive group differed from the well-regulated group only in the social-behavioral adjustment outcomes, whereas children in Dysfunctional and Low EF groups began to show cross-domain differences by first grade.

Table 11

ANCOVAs Examining Group Differences on School Adjustment Outcomes at Kindergarten and First Grade

	Class 1 Well-regulated	Class 2 Impulsive	Class 3 Dysfunctional	Class 4 Low EF	F-value
Literacy					
Kindergarten	.21	.04	-.11	-.08	2.02
1st grade	.25	.13	-.31	-.06	2.54
Numeracy					
Kindergarten	.44[a]	.24[ab]	-.11[ab]	-.23[b]	6.05*
1st grade	.32[a]	.10[ab]	-.38[b]	-.18[b]	3.94*
Social Competence					
Kindergarten	.27[a]	-.56[b]	-.65[b]	-.10[ab]	7.25**
1st grade	.43[a]	-.39[b]	-.49[b]	-.18[b]	6.88*
Aggression					
Kindergarten	-.31[a]	.56[b]	.83[b]	.05[ab]	9.85**
1st grade	-.38[a]	.24[b]	.57[b]	.14[ab]	5.41*

Note. Control variables included age, sex, and baseline vocabulary.
** $p < .001$; * $p < .05$

Discussion

Developmental theory suggests that self-regulation skills underlie both academic and social-behavioral school readiness. During the preschool years, emerging self-regulation skills

are supported by rapidly developing cognitive processes such as attention shifting, working memory, and inhibitory control, which are collectively referred to as EF skills (Blair & Diamond, 2008), as well as those reflected in attention control. Additionally, the development of self-regulation is affected by temperamental processes, such as individual differences in activity level and reactivity (Kochanska et al., 1996). The latter, sometimes termed "bottom up" influences on self-regulation are postulated to drive the young child's behavioral initiations and reactions to the environment, and hence may exert a particularly strong impact on the child's behavioral and social adjustment. In contrast, EF skills are considered "top down" regulatory structures that emerge with development, intertwined with the development of higher-order cognitive functions, such as language and reasoning. As such, EF skills and corresponding attention control may have a greater impact than individual differences in temperament and reactivity on academic skill acquisition and achievement. Hence, while self-regulation is often considered a unitary construct, affected both by "top down" and "bottom up" processes, it may be possible to measure developing self-regulatory skills using multiple indices that shed light on important differences in their associations with the differential domains of academic vs. social-behavioral school readiness. Specifically, pre-kindergarten direct assessments of EF skills and behavioral ratings of attention and impulse control may predict differential aspects of children's academic and social-behavioral adjustment to school.

The proposed study contributed to the literature by examining associations among these key pre-kindergarten self-regulation indices: direct assessments of EF skills, teacher-rated inattention and impulsivity, and assessor-rated attention. It explored the combined and unique associations between each of these self-regulation indices and later school adjustment, including academic achievement and social-behavioral adjustment in kindergarten and first grade. To

provide a fuller understanding of the influence of the self-regulation measures on school adjustment, analyses included both variable- and person-centered approaches.

Associations among Self-regulation Indices

The first aim of the current study was to examine the inter-relations among the pre-kindergarten self-regulation indices (direct assessment of EF skills, teacher ratings of inattention and impulsivity, and assessor-rated attention). It was hypothesized that moderate levels of association would emerge, particularly among direct assessment of EF and the behavioral ratings of attention control. As anticipated, with only one exception, the measures of self-regulation were significantly inter-correlated, with teacher-rated inattention and impulsivity being strongly correlated. The strength of the relationship between inattention and impulsivity was expected due to shared method variance and the common co-occurrence of the problems. Although they were strongly correlated, inattention and impulsivity showed different patterns of association with EF measures, suggesting that the two indices differed in meaningful ways. Specifically, the direct assessment of EF was not significantly correlated with teacher-rated impulsivity, although it was significantly correlated with teacher-and assessor-rated attention functioning. Conceptually, EF and teacher-rated inattention may each reflect "top down" regulatory processes of attentional control, which develops over time. Conversely, impulsivity may represent a more temperamental characteristic, sometimes termed "bottom up" processes, associated with activity level and reactivity (Kochanska et al., 1996).

EF and School Adjustment

The neural pathways associated with core executive regulatory processes undergo rapid development between the ages of 3-6 (Bierman et al., 2008; Blair & Diamond, 2008). As cognitive processes such as attention shifting, working memory, and inhibitory control emerge,

children are increasingly able to manage their attention, behavior, and emotions in day-to-day situations, setting the stage for a successful transition school (Bierman et al., 2008; Blair, 2002). Interest in and measurement of EF development during early childhood is relatively new but has increased remarkably in the past 20 years (Hughes, 2011). Direct assessment of EF skills are increasingly being used to assess children's developmental progress and possibly even predict school readiness. Direct assessments of EF skills have been associated with concurrent academic and social-behavioral school readiness and have predicted later outcomes (Bierman et al., 2008; Blair & Razza, 2007; Clark et al., 2010). However, there is a lack of developmental follow-up studies that show the degree to which EF measures in pre-kindergarten predict kindergarten and first grade outcomes. Additionally, it remains unclear whether direct assessments of EF have unique predictive value, distinct from that associated with behavioral ratings of self-regulation. It is possible that because they directly assess cognitive processes such as attention shifting, working memory, and inhibitory control capacities in a way that behavior ratings cannot, the direct assessment of EF serves as a unique predictor of both academic skill development and social-behavioral adjustment.

Correlation analyses were conducted to examine the association of the direct assessment of EF with concurrent and future school readiness outcomes. Results showed that EF was significantly associated with concurrent literacy and numeracy skill acquisition, as well as social competence. Analyses examining EF predicting later outcomes revealed that EF was significantly associated with literacy, numeracy, and aggression at kindergarten and with numeracy at first grade. Consistent with theory and previous studies, these findings suggest that EF skills have an important role, supporting school adaptation in areas of both academic skill development and social-behavioral regulation.

Regression analyses addressed the more specific question of the degree to which EF uniquely predicted kindergarten and first-grade outcomes, after controlling for the behavioral ratings made by teachers and assessors. These analyses revealed that EF made unique predictions to numeracy skill acquisition at both kindergarten and first grade. Conversely, after accounting for the impact of pre-kindergarten teacher ratings of inattention and impulsivity, EF no longer made unique contributions to the prediction of literacy skills or aggression in kindergarten. These findings suggest that the contribution of EF skill development to kindergarten and first grade adjustment is largely shared with the contribution made by teacher ratings of inattention and impulsivity, with the exception being the development of math skills. That EF predicted mathematical skills in the current study is consistent other studies (Bull and Scerif, 2001; Espy et al., 2004). It has been suggested that EF and math skills have a shared ontogenetic organization, in that during the preschool period, while the neural architecture underlying EF skills is rapidly developing, children concurrently begin to show informal mathematical skills, such as principles about counting and arithmetic problem solving (Espy et al., 2004). Further research is needed to address the differential relationship of EF with math and literacy skills.

Interestingly, a somewhat different picture regarding the predictive value of EF (relative to teacher ratings) emerged in the context of the person-centered analyses. That is, the LPA revealed a class of children who were differentiated from their well-regulated peers primarily on the basis of low EF scores. This class of children was also differentiated from the well-regulated group in vocabulary. Children in the low EF class scored below the sample mean on the teacher ratings of inattention and impulsivity, although not as low as the well-regulated class. However, as such, these children were not showing problems with self-regulation in the classroom. Children in this class had low EF scores that were equivalent to those of children in the

dysfunctional and impulsive classes, despite below-average inattention and impulsivity in the classroom. In other words, this group was characterized by EF deficits, but was not identified by teachers as being at any risk in terms of attention or impulse control problems in the classroom. Yet, in elementary school, children in this low EF class performed more poorly than their well-regulated peers on numeracy outcomes, and by first grade they were rated less socially competent by teachers. These findings suggest that prekindergarten EF skill deficits, even in the absence of behavioral evidence of inattention and impulsivity, may undermine later school adjustment in areas of both academic and social difficulties in elementary school. This is an important finding, because it suggests that there is a small sub-group of children who are at-risk for school difficulties due to low EF, and yet who lie "under the radar" of pre-kindergarten teachers, due to the lack of behavioral difficulties in pre-kindergarten. Their behavioral difficulties did not emerge until two years later, and then were not of the externalizing kind, but rather difficulties associated with social competence and effective peer relations. Peer relations become more complex in first-grade, involving more large group activities, and games with rules (Bierman & Erath, 2006), which might overwhelm the cognitive regulatory skills of these children with low EF.

Attention Control and School Adjustment

Behavioral ratings of attention cotnrol have been associated with academic skill development and social-behavioral adaptation (Blair & Razza, 2007; Coolahan et al., 2000; McClelland et al., 2001; Rhoades et al., 2010). These findings suggest that attention control reflects self-regulatory capacities that are, like EF, at the interface of academic and social-behavioral school readiness. However, there remains a lack of follow-up research examining the cross-domain association of pre-kindergarten attention with academic and social-behavioral

outcomes in kindergarten and first grade. Also, there is a shortage of research addressing whether behavioral ratings of attention predict outcomes in a way that is unique from direct assessments of EF.

For the current study, it was anticipated that although direct assessments of EF and teacher-ratings of inattention would be significantly related, inattention would provide unique prediction to school readiness and adjustment outcomes. Variable-centered analyses were conducted to address whether teacher-rated inattention predicted school readiness outcomes. Results suggested that teacher-rated inattention predicted cross-domain (academic and behavioral) adjustment problems. In correlation analyses, inattention predicted both the academic and social-behavioral outcomes at each time point (prekindergarten, kindergarten, first grade), and was the only self-regulation index to do so. Teacher-rated inattention continued to make unique contributions to literacy and numeracy at kindergarten and first grade, even after accounting for the control variables and EF in the regression analyses.

These findings suggest that although behavioral ratings of attention and direct assessments of EF are conceptually related, as they both assess self-regulatory capacities, there is reason to expect differential prediction of school readiness outcomes. While direct assessments of EF attempt to isolate cognitive processes using performance tasks administered in controlled testing situations, behavioral ratings assess a child's capacities under multi-task self-regulatory demands, such as in a classroom setting. As such, it is possible that a teacher rating of inattention may reflect something unique about the developing self-regulatory skills that is not captured by direct assessments of EF, such as an ability to regulate reactivity to multiple stimuli as well as employ EF to remember information and solve problems. Research with typically-developing school-aged children has similarly found that teacher-rated inattention predicts math outcomes

after accounting for several EF measures and other measures of cognitive ability (Fuchs et al., 2005; 2006). However, it was put forth by the authors of these studies that teacher ratings of inattention may be clouded by something of a halo effect of the child's academic performance, and, as such, serve as a proxy for achievement (Fuchs et al., 2006).

Two other possibilities about why teacher-rated inattention adds prediction beyond EF are worth considering: First, because of the multi-task demands of the classroom setting, teacher ratings of inattentive behavior may reflect more than problems with the executive regulatory system. That is, they may reflect important problems with other processes, such as the reward/reinforcement response systems (Sonuga-Barke, 2003; 2005). If this is the type of information that is being tapped here, then teacher-ratings are a very important index of self-regulation. An alternative possibility is that the teacher rating has better psychometric properties than the EF measures, thereby providing a more differentiated measure of individual differences, and hence providing stronger prediction. Conversely, despite improvements, EF tasks have relatively weak psychometric properties and are often impacted by age-effects and, as such, possibly reflect non-EF influences (e.g., language ability) on performance (Hughes, 2011). The current study does not allow for distinguishing among these possible explanations, but does provide grounds for further research in this area.

Cross-sectionally at pre-kindergarten, assessor-rated attention was also significantly associated with each of the academic and social-behavioral outcomes, suggesting that after relatively brief testing sessions, assessors were able to meaningfully rate children's self-regulatory capacities. Assess-rated attention predicted only one outcome, social competence at kindergarten, and did not make any unique predictions to outcomes in the regression analyses. The lack of maintained predictions by assessor-rated attention suggests that assessor ratings may

not be particularly sensitive to change over time. In particular, assessor ratings may be affected, in part, by the child's performance on the actual tests administered, as well as the child's attention during the session.

Impulse Control and School Adjustment

Teacher-rated impulsivity was examined separately as a predictor of school readiness and adjustment in part because of its conceptual difference from inattention and EF, and partly because of hypotheses about what it may and may not predict. First, impulsivity may reflect a "bottom up" temperamental process related to a child's activity level and reactivity (Kochanska et al., 1996). This is conceptually different from attention functioning and direct assessments of EF, which likely represent "top down" regulatory processes that emerge over the course of development and compensate for impulsivity. Additionally, studies suggest that impulsivity may be more strongly associated with social-behavioral adjustment and teacher-rated inattention may be more strongly associated with academic skill development (Lonigan et al., 1999). As a result, the current study examined impulsivity separately from inattention and EF, expecting to find that impulsivity was related to aggression and inversely related to the development of social competence.

As anticipated, correlation analyses revealed that teacher-rated impulsivity was associated with social competence and aggression over time, but not with the measures of academic skill development. These findings are consistent with the conceptualization of impulsivity as a "bottom up" process. Teacher-rated impulsivity appears to reflect reactivity and a high activity level that yields impatient, intrusive, and loud behavior. These qualities may pervade peer interactions, resulting in low social competence and higher aggression. However, it has been suggested that just because a child is active and impulsive, it does not mean they are

failing to learn (Merrell & Tymms, 2001). While teacher-rated impulsivity only affects peer relationships, "top down" regulatory processes reflected in teacher-rated inattention and direct assessments of EF are more central to academic skill development.

The behavioral ratings accounted for significant variance in social competence and aggression after accounting for the control variables and EF, but impulsivity did not make a unique contribution. Out of curiosity, though, analyses were conducted to examine whether entering impulsivity alone (i.e., without inattention) in step 3 of the multiple hierarchical regressions would yield significant prediction. Results confirmed that impulsivity does predict uniquely to social competence and aggression at kindergarten and first grade when entered separately from inattention. That said, the reverse is also true, when entered alone in step 3, inattention also uniquely predicts social competence and aggression. The two ratings appear to have substantial shared variance, but each separately predicts social-behavioral adjustment.

Interestingly, the initial regression analyses revealed that when entered with the other behavioral ratings, impulsivity showed a suppression effect for the academic outcomes by significantly (positively) predicting literacy at kindergarten and numeracy at both time points. Such a finding, while not expected, may suggest that with inattention and its associated problems controlled, the leftover impulsivity reflects an active engagement in classroom activities that sometimes annoys teachers but does not impact academic performance. These findings further support the hypothesis that "bottom up" regulatory processes, such as impulsivity, are more associated with behavioral regulation difficulties and do not, themselves, impede the acquisition of academic material, at least during the early childhood years.

Covariation of Inattention and Impulsivity

The present findings suggest that even at pre-kindergarten, teachers can distinguish inattention from impulsivity and that teacher-rated inattention, even in the context of other self-regulation indices, is a valid predictor of later problems. These results may also give the impression that among pre-kindergarten children, there are many who show problems with inattention without impulsivity. The person-centered approach, however, reaffirms the correlation analyses that where inattention is present, there are also likely going to be problems with EF and impulsivity. Within each of the four classes, the levels of inattention and impulsivity co-varied, such that groups with high, medium, or low levels of inattention tended to also show high, medium, or low levels of impulsivity. The classes that emerged among this at-risk sample are consistent with clinical ADHD literature, in that inattention and impulsivity tended to co-occur (Smith, Barkley, & Shapiro, 2006).

Person-Centered Approach

The reason for employing the person-centered approach was because of the potential for EF, attention control, and impulse control to have synergistic effects in predicting adjustment to school among this at-risk sample. As such, LPA was utilized to identify classes of children among the Head Start participants based on unique profiles among the self-regulation indices. One well-regulated class and three "problem" classes emerged, each with a distinct profile. Results suggest that adjustment outcomes were multi-determined.

Interestingly, the three problem classes all shared similar levels of low-EF skills, all significantly different from the well-regulated class. The three problem classes were differentiated from each other primarily by the teacher ratings of inattention and impulsivity, which were below the sample mean for the "low EF" class, above the sample mean by .4-.8 standard deviation for the "impulsive" class, and extremely high (means nearly 2 standard

deviations above the sample mean) for the "dysfunctional" class. On the basis of these class differences, one might anticipate that the dysfunctional class would show the greatest level of difficulty in both academic learning and behavior regulation after the transition into elementary school. All three classes still evidenced significant problems in first-grade. However, somewhat surprisingly, differences among the three problem classes were less marked after the transition into elementary school. It is possible that because the classes were, in large part, determined by levels of teacher-rated inattention and impulsivity, that teacher-specific rating biases impacted the predictive power of class assignment. This issue requires further research to show why the classes showed similar outcomes.

Limitations and Future Directions

Several limitations of the current study should be noted when considering the results. First, the domains of attention shifting, working memory, and inhibitory control were assessed with just four tasks that were composited to represent an overall EF measure. Because research with preschool-aged children suggests that EF has a unitary structure during this period that fractures meaningfully across development, several studies with preschoolers have relied on an EF composite (e.g., Hughes & Ensor, 2007; Hughes et al., 2010; Welsh et al., 2010; Wiebe, Espy, & Charak, 2008). In addition to the conceptual reasons for the current methods are practical considerations, namely, it can be difficult for preschoolers to comply during a lengthy testing session. As such, the EF tasks utilized in the current study were brief to administer. It is possible that a larger battery of age-appropriate tasks, including computerized tasks, would allow for the examination of important issues regarding association of preschool EF with school readiness. That said, the tasks used in the current study have been shown to be sensitive in measuring EF skills during the preschool period (Blair & Diamon, 2008). Given the current

findings that preschool EF is related to school adjustment, more work examining the influence of particular EF domains may be warranted.

Second, because children's literacy skills develop rapidly during the preschool and early school years, the current study adjusted the measures contributing to the literacy composite at each time point to accommodate children's increasing skills. This may have contributed, in part, to the difficulty predicting literacy outcomes, while numeracy outcomes, which were measured with the same standardized achievement test at each time point, was predicted by three out of four self-regulation indices.

Third, participants for this study comprise the "usual practice" control condition of the Head Start REDI program, meaning all of participants qualified for attendance in a Head Start classroom. As such, the results of the current study may inform the literature on self-regulation and school readiness among children growing up in impoverished conditions, but not generalize to other populations. It is possible, for instance, that among this sample, associations between self-regulation and school readiness differ from other typically developing children.

Fourth, given the exploratory nature of the person-centered analyses conducted in this study, future examination is necessary to confirm the profiles that emerged. Confirmation of risk profiles may further shed light on the development of school readiness problems. The size of the sample in the current study (N = 164) is also relatively small, which may have constrained power to identify classes of children beyond the four that emerged. Again, in future studies, a larger sample size may yield more information about the complex mixture of self-regulatory problems that contributes to school readiness and adjustment outcomes.

Fifth, while a strength of the current study is that it utilized a longitudinal design, thereby providing important information regarding the association of pre-kindergarten self-regulation

with school readiness over time, it cannot specify causal relationships. It is possible that other processes, beyond those controlled for in the current analyses, are responsible for the observed relationships. The contribution of the current study is a step to shedding light on the association among different self-regulation indices, as well as exploring their prediction to later outcomes.

And lastly, it is possible that the stability of the self-regulation indices is related to school readiness outcomes. For instance, research among ADHD samples suggests that while impulsive behavior tends to fade as children get older, inattentive behavior remains relatively stable (Hart, Lahey, Loeber, Applegate, & Frick, 1995). The stability of attention may, in part, contribute to its unique prediction of later school outcomes. Future steps with the current data will be to examine the development of EF, attention, and impulse control over time in relation to school readiness and adjustment outcomes, as well as consider the influence of environmental factors on these associations.

Concluding Comments

Children who grow up in impoverished conditions are likely to show delays in the development of school readiness skills that persist and contribute to poor long-term outcomes (Ryan, Fauth, & Brooks-Gunn, 2006). As a result, there has been increased interest in understanding factors that are associated with school readiness and adjustment problems, identifying children at high risk for poor outcomes, and intervening to prevent problem outcomes (Shonokoff & Phillips, 2000). The current study is consistent with previous findings that self-regulatory capacities, reflected in EF, attention control, and impulse control, are associated with essential school readiness skills (Bierman et al., 2008; Blair & Razza, 2008; Welsh et al., 2010). Results suggest that children experiencing even subclinical levels of inattention, impulsivity, or both may be at risk of academic and social-behavioral adjustment problems. Also, problems with

EF, either in the presence or absence of inattention and impulsivity, can signal that adjustment problems are a possibility with a given child. The current findings that three problem classes emerged in the LPA suggest that adjustment problems are multi-determined and that a one-size-fits-all approach to prevention may not be the best. Rather, it is possible that for children like those in the low EF class, an intervention that is conceptualized to support EF development may be appropriate, while a child resembling those in the dysfunctional class may benefit from an intervention program that supports EF development and provides other environmental supports. Given these developmental links, it is possible that direct assessments of EF and teacher ratings of inattention and impulsivity (even at subclinical levels) may contribute to the identification of children in need of support or services.

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