Cognitive and emotional processes as predictors of a successful transition into school

By: A. Nayena Blankson, Jennifer Miner Weaver, Esther M. Leerkes, Marion O'Brien, Susan D. Calkins, amd Stuart Marcovitch

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Abstract:

Research Findings: The aim of this research was to delineate developmental processes that contribute to early school success. To achieve this aim, we examined emotion regulation, executive functioning, emotion knowledge, and metacognition at ages 3 and 4 as distal and proximal predictors of age 5 achievement and school adjustment in a sample of 263 children (42% non-White). We also explored mediational pathways among these 4 processes in the prediction of the age 5 outcomes. Results revealed that all 4 processes affected achievement and school adjustment, but in different ways, with executive functioning emerging as a key predictor. *Practice or Policy*: Executive functioning was found to be a key factor in predicting achievement and school performance in the kindergarten year. This finding provides support for the development of executive functioning training programs that can be applied in the preschool classroom, particularly for promoting reading development. However, additional emphasis should be placed on both cognitive and emotional processes in the preschool years to promote optimal development.

Keywords: executive functioning | human development | early educational achievement

Article:

Children's success in the early school years is associated with a range of developmental outcomes. Low levels of achievement in the first few years of school predict continued academic problems; school dropout, drug and alcohol use, and juvenile delinquency; and lifelong employment difficulties and mental health problems (Duncan et al., 2007). Prior research on early academic success has emphasized cognitive precursors, especially processes associated with metacognition (e.g., Gaskins, 1994), and other skills central to executive functioning, such as working memory (e.g., Bull, Espy, & Wiebe, 2008). In contrast, research that has examined social-emotional functioning in the early school years has focused largely on emotional

predictors and processes, such as emotion regulation and emotion knowledge, which have been implicated in early childhood social competence (e.g., Denham et al., 2012).

In a seminal work by Duncan and colleagues (2007), the primary conclusion that was drawn was that school entry (kindergarten) achievement is important for later success and more important than social-emotional skills. However, the finding that social-emotional factors at kindergarten entry are not as important in predicting later success (i.e., Duncan et al., 2007) does not preclude their importance for kindergarten outcomes. Yet this appears to be a commonly accepted idea. The emphasis on the importance of early achievement has led to a pushdown of academic training in the early childhood years, and the role of emotional intelligence has at times been minimized. However, a sole focus on cognitive development in the preschool and kindergarten classroom may not be optimal for early school success. This view falls in line with more recent research that suggests that early school success relies on both early cognitive and social-emotional competence (Blair & Diamond, 2008; Nix, Bierman, Domitrovich, & Gill, 2013; O'Connor, Cappella, McCormick, & McClowry, 2014; Raver, 2002; Raver et al., 2011). Some researchers have proposed incorporating training in emotional intelligence into early childhood curricula (Buckley, Storino, & Saarni, 2003). Indeed, some schools have incorporated social and emotional learning (SEL) programs into their curricula (Jones & Bouffard, 2012). Early interventions have also been developed for enhancing social-emotional competencies, such as the Promoting Alternative THinking Strategies (PATHS) curriculum (Bierman et al., 2008; Kusche & Greenberg, 1994; Nix et al., 2013).

Although advances have been made in understanding, much is still unknown about the interplay among basic preschool cognitive and emotional processes that contribute to kindergarten academic success and social adjustment. For example, a primary conclusion of the research by Duncan et al. (2007) was that social-emotional skills might not matter as much in predicting early achievement. However, the preschool years was not directly examined in that study: Of the six data sets examined, only one included children who were younger than 5 years old at the initial time point. Research that directly examines the preschool years is important for basic scientific understanding of early academic pathways and for the development of prevention and intervention programs aimed at improving children's academic and psychosocial functioning (Barbarin & Wasik, 2009).

The present study, therefore, focuses on the preschool factors that predict kindergarten success. We define school success as academic achievement (as measured by tests of math and reading achievement and teacher reports of school performance) and school adjustment (as measured by teacher reports of work habits and social skills). We test cognitive and emotional processes as unique proximal (age 4) and distal (age 3) predictors of achievement and school adjustment in kindergarten, and we explore mediational pathways. Results delineate the developmental processes that contribute to the early establishment of school success and provide increased understanding of the role of both cognition and emotion in early childhood education.

Theoretical Framework

The theoretical framework guiding the current study incorporates two general and parsimonious processes—control and understanding—that we define as operating in two domains—cognition

and emotion. *Control* refers to processes of regulation (the regulation both of executive function and of affect) and *understanding* refers to knowledge about one's own and others' thoughts and feelings. Cross-cutting the processes with the domains, the term *emotion control* can be used to describe what researchers focusing on emotional development typically label *emotion regulation. Cognitive control* describes what researchers focusing on cognitive development refer to as *executive functioning*. Similarly, the term *emotion understanding* is labeled *emotion knowledge* by emotion researchers, and the term *cognitive understanding* is referred to as *theory of mind* or *metacognition*. When the same terms (i.e., *control* and *understanding*) are applied across the domains of cognition and emotion, the overlapping qualities among the processes become more apparent, and the need for integrative research across traditionally separate areas is highlighted (Blankson, et al., 2013). For consistency with the broader literature, we use the more widely used terms henceforth.

Although other frameworks have been proposed to guide understanding of early school success, none focus jointly on all four of the processes examined here. For example, there is increasing focus on the role of SEL in early school adjustment and achievement (Denham, Bassett, Zinsser, & Wyatt, 2014; Jones & Bouffard, 2012; Nix et al., 2013). There is overlap of the SEL framework with our proposed framework, in that we also acknowledge the importance of social-emotional skills in early school success. However, our framework posits that both cognition and emotion must be considered jointly to broaden understanding of early school success. Moreover, in two previous studies, support was obtained for our four-process framework (Blankson, O'Brien, Leerkes, Marcovitch, & Calkins, 2012; Leerkes et al., 2008). Descriptions of the processes and a brief review of research on the relations between each of these processes and early school success appear in the following sections.

Emotion Regulation and School Success

Emotion regulation refers to those responses, whether automatic or effortful, that modulate emotional arousal and expression (Calkins & Bell, 2010). Although the control of emotions is in part a physiological process, it also involves the use of behavioral strategies that are observable. In the present study, we use both observed behavior in a frustration task and parent report of the child's usual behavior in positive and negative emotion-eliciting situations as indicators of emotion regulation.

There is abundant evidence and theory demonstrating a link between emotion regulation and social-behavioral skills (e.g., Denham et al., 2014). Children who have developed the skills to manage both positive and negative affect prior to school entry will be better able to manage these emotions in the school environment. They can control how they respond to others and are better liked by their peers. Good emotion regulation skills will also facilitate a child's ability to adhere to classroom rules, thereby fostering good school adjustment (Raver, Garner, & Smith-Donald, 2007). In addition, children with better emotion regulation skills are more likely to interact appropriately with teachers and peers and better process information during learning activities, which can lead to subsequent achievement (Graziano, Reavis, Keane, & Calkins, 2007; Raver, 2002; Raver et al., 2007). Findings from the Chicago School Readiness Project (e.g., Raver et al., 2011), a cluster-randomized controlled trial focused on improving self-regulation skills, support the view that emotion regulation plays an important role in early

achievement. In the study by Raver et al. (2011), results revealed that children in the intervention group made greater gains in self-regulation than those in the control group and displayed greater gains in math and vocabulary skills. Similarly, Graziano et al. (2007) found that emotion regulation was positively related to teacher reports of academic success as well as standardized literacy and math achievement scores in a sample of kindergartners. In the present study, children who have higher levels of emotion regulation during the preschool years are expected to show higher levels of both academic achievement and school adjustment at age 5.

Executive Functioning and School Success

Executive functioning processes, broadly defined, encompass three basic skills. *Attention and inhibitory control* refers to the ability to inhibit dominant responses in favor of subdominant responses. *Working memory* refers to the ability to hold multiple pieces of information in mind over a delay while actively performing other mental tasks of updating and manipulating the information. *Set shifting* refers to the ability to flexibly switch between rules (Garon, Bryson, & Smith, 2008). These skills have been shown to enhance children's ability to engage in effective goal-directed behavior in the school years (Garon et al., 2008). The specific dimensions of executive functioning investigated in the current study are working memory and inhibitory control, both of which develop across the preschool years (Bull et al., 2008). Among preschool and kindergarten samples, a unidimensional model of executive functioning has been found to best represent this set of skills (Brydges, Reid, Fox, & Anderson, 2012). Therefore, we take a unidimensional approach in the present investigation by examining a composite score.

Research has repeatedly shown that executive functioning contributes to early school success (e.g., Blair & Razza, 2007; Bull et al., 2008; Laski & Dulaney, 2015). For example, in a sample of 5-year-olds from low- and middle-class backgrounds, a general executive functioning factor was found to relate to concurrent measures of overall academic achievement as well as to more specific prereading and early math skills (Willoughby, Blair, Wirth, Greenberg, & Family Life Project Investigators, 2012). Children with higher levels of executive functioning may be able to inhibit distractions in a manner that ultimately promotes learning. For example, it may be that children can understand the main idea of a story even when distracting or superfluous information is presented (Blankson, O'Brien, Leerkes, Marcovitch, & Calkins, 2011; Kuhl & Kraska, 1989), leading to increased reading achievement. Laski and Dulaney (2015) showed that children might inhibit prior knowledge that might interfere in math learning. Similarly, children with lower levels of executive functioning may be less able to follow classroom procedures and may have poorer social skills due to limited attentional focusing and inhibition skills and higher levels of distractibility (Bierman, Torres, Domitrovich, Welsh, & Gest, 2009). Hence, children who have higher levels of executive functioning during the preschool years are expected to show higher levels of both academic achievement and school adjustment at age 5.

Emotion Knowledge and School Success

During the preschool years, children grow in their ability to recognize and label their own and others' emotions, tie them to situations, understand their causes, identify familial and cultural display rules, and recognize disparity between emotional displays and felt emotions (Torres, Domitrovich, & Bierman, 2015). Emotion knowledge contributes to early school adjustment

(Denham et al., 2014; Jones & Bouffard, 2012). Knowledge about emotions allows children to communicate their own emotional experiences and respond appropriately to the emotional signals of other people, including teachers and peers. Children who can read others' facial expressions accurately are rated as high in social competence and popularity with peers (Denham et al., 2014). Such competence may aid them as they negotiate the challenges of the classroom.

It has also been suggested that children with higher levels of emotion knowledge are more competent academically (Denham et al., 2012; Torres et al., 2015). Emotion knowledge includes an understanding of the causes of emotions. A child who understands emotion causes may understand that it is a learning situation itself that is challenging and not internalize the challenge as being due to lack of ability. Children who are able to understand their emotions may also be able to talk about how they feel in the learning situation. This may subsequently enable these children to obtain more help from teachers during challenging classroom tasks, thereby facilitating learning and achievement (Denham et al., 2012; Raver et al., 2007). Recognizing one's own experiences of emotion is likely to be important to developing emotion regulation, particularly the ability to generate context- and emotion-specific regulatory strategies that are likely to be effective (Cole, Dennis, Smith-Simon, & Cohen, 2009). Hence, it might be the case that emotion knowledge has an indirect link with school adjustment and achievement (Raver et al., 2007).

Metacognition and School Success

Theory of mind reflects the ability to understand one's own mind and others' minds. Although it is often considered an aspect of social cognition (e.g., LaBounty, Wellman, Olson, Lagatutta, & Lui, 2008) and can influence how children relate to their peers and teachers in the classroom (Wellman, 2015), it is also theorized to be the awareness of mental functions that ultimately evolve into metacognitive understanding at the most complex level (Kuhn, 2000). That is, a young person's theory of mind lays the foundation for what will become his or her ability to understanding his or her own knowledge acquisition processes (Kuhn, 2000). Therefore, metacognition in preschoolers is typically measured using theory of mind tasks (Astington & Gopnik, 1988; Wellman, Cross, & Watson, 2001).

There is some evidence that individual differences in metacognition among preschool children may contribute importantly to later school competence (Lecce, Caputi, & Hughes, 2011). Lecce et al. (2011) found that false belief understanding during preschool was predictive of children's academic achievement 2 years later after verbal ability and social skills were controlled. Blair and Razza (2007) found a moderate association between false belief understanding at age 5 and math achievement at age 6 in a sample of Caucasian low-income kindergarten children. Furthermore, children who understand the perspectives of others are likely to be better able to understand teacher expectations in the classroom without the need for explicit instructions, which may lead a teacher to view such a child as more socially or academically competent. We therefore expect a positive association between metacognition and later school achievement. Finally, the link between metacognition and school success might be indirect and operate through executive functioning or emotion regulation. For example, children who understand their own mental processes may be better able to inhibit interfering thoughts or feelings in a learning

situation, which can contribute to creating a better learning environment. Therefore, indirect mechanisms are also explored.

The Current Study

To date, only one study (Leerkes, Paradise, O'Brien, Calkins, & Lange, 2008) has examined emotion regulation, executive functioning, emotion knowledge, and metacognition simultaneously as predictors of early academic and social functioning. However, that study was cross-sectional and only tested success at age 3. The present study therefore adds to the extant literature by examining the extent to which age 3 (distal) and age 4 (proximal) processes relate to measures of academic achievement and adjustment in kindergarten and testing mediational pathways. Standardized tests of achievement were administered in a laboratory environment that was relatively free of distraction. In contrast, teacher reports of achievement and adjustment are indicative of child functioning in a more distracting environment that involves interactions with peers and teachers, which may place different demands on the child. Hence, differential effects of the four processes might be obtained for the standardized tests in comparison with the teacher-reported outcomes.

Although all four processes have been found to be associated with academic achievement and school adjustment, because no studies have examined all four processes simultaneously, it is unclear whether certain skills may matter more for particular outcomes. Based on the previous literature, there are domain-specific expectations that cognitive skills in the preschool years will predict kindergarten achievement (Duncan et al., 2007; Viterbori, Usai, Traverso, & De Franchis, 2015) and that social-emotional skills in preschool will predict social-emotional skills in kindergarten (Jones & Bouffard, 2012). Given that executive functioning has been identified as a significant contributor to early achievement (e.g., Blair & Razza, 2007), when examined simultaneously with other cognitive and emotional processes, executive functioning may emerge as the primary predictor of achievement. However, there are also potential cross-domain effects. Having strong metacognitive or executive functioning skills may promote positive social interactions (Wellman, 2015), allowing children to feel socially confident in the classroom. Children who have strong emotion regulation or understanding skills may be better at requesting assistance from their teachers and more engaged in learning, thereby leading to subsequent achievement (Denham et al., 2012; O'Connor et al., 2014; Raver, 2002).

Finally, the present study goes beyond the direct prediction of school success from each of the processes to examine mechanisms through which the four processes may act in concert over time. That is, it may be that age 3 emotional processes predict age 4 cognitive processes, which subsequently predict academic achievement. Alternatively, age 3 cognitive processes may predict age 4 emotional processes, which then predict school adjustment. Other paths are also possible; for example, control processes may precede understanding processes. Examination of these mediational pathways will help us to better understand the interconnections among the processes and illuminate the role of both emotion and cognition in early school success. We predict that emotion regulation and emotion knowledge at age 3 will emerge as significant distal predictors of age 5 achievement and school adjustment, with executive functioning and metacognition at age 4 as significant mediational pathways. Given that few studies have examined all four of these processes simultaneously as predictors of school success, we take a

conservative approach in our analyses by testing a full path model that includes all possible cross-lag effects.

Method

Participants

Participants were part of a larger study in which 263 children were initially recruited at age 3 (*M* = 41.79 months, *SD* = 2.41, range = 37–47). Data were collected from children and their mothers at two additional time points: at age 4 (*N* = 244) and at age 5 (*N* = 227). When children were in kindergarten, teachers were asked to participate by completing a series of questionnaires. Data were obtained from 170 teachers.

At the first wave, mothers were 33 years of age on average (*SD* = 5.91). Approximately 51% had a 4-year college degree, 74% of the respondents were married and living with their partner, and 79% were currently working outside the home. The average income-to-needs ratio, derived by dividing the total family income by the poverty threshold for that family size, was 2.89 (*SD* = 1.73); 37% of the sample had an income-to-needs ratio less than 2, 53% between 2 and 5, and 10% greater than 5. Finally, 52% of the children were female; 58% of the children were Euro-American, 35% African American, 2% Hispanic, and 5% other or biracial.

Procedure

Participating families were recruited from preschools and child care centers in a mid-size southeastern city through letters sent home with the children. Families who were interested in participating returned contact information to the researchers, who then called the families to schedule a 2-hr laboratory visit when children were 3 years old and again when children were 4 and 5. Mothers accompanied children to the lab and remained in the same room with the children. Prior to data collection, children were made to feel comfortable with the research assistant while mothers completed the consent. During the lab session, children were videotaped while completing tasks assessing cognitive and emotional processes. Mothers completed questionnaires during each session. Families received $40, $60, and $80 for the 3-, 4-, and 5-year visits, respectively, and children selected a toy each time. In addition, during children's kindergarten year, permission was obtained from parents to contact their child's teacher. If permission was granted, teachers were contacted in the spring semester and asked to complete a series of questionnaires (either online or mailed) regarding the children's social and academic competence. Teachers were compensated $40 for their participation.

Measures

The emotion and cognition variables were each assessed using multiple measures, and composites were created by standardizing and summing the relevant scores for each process. To maintain the longitudinal structure of the data for analytical purposes, the 4-year variables were standardized using the means and standard deviations of the 3-year variables (Ferrer & McArdle, 2004).

Emotion Regulation

Emotion regulation was measured both by maternal report and by observed behavior.

Maternal Report. Two measures of emotion regulation were completed by mothers: the Children's Behavior Questionnaire short form (Putnam & Rothbart, 2006) and the Emotion Regulation Checklist (Shields & Cicchetti, 1998). The Children's Behavior Questionnaire short form is a reliable and valid measure of temperament for children ages 3 to 8 (Putnam & Rothbart, 2006). Using the Children's Behavior Questionnaire short form, mothers described their children's typical reactions to various situations on a 7-point Likert scale. Of interest in the present analyses was the Falling Reactivity/Soothability subscale, which indexes regulation (six items; e.g., "is easy to soothe when upset"; αs = .73 at 3 and 4 years). The Emotion Regulation Checklist is one of the most widely used valid measures for assessing maternal perceptions of a child's emotion regulation. Although developed for use with school-age children, it has been used in preschool samples as well (e.g., Shields et al., 2001). Using the Emotion Regulation Checklist, mothers rated how frequently their child engaged in certain behaviors, including positive behaviors, on a scale from 1 (*never*) to 4 (*always*). Two subscales, Lability/Negativity (15 items; e.g., "is easily frustrated"; αs = .82 and .81 at 3 and 4 years, respectively) and Emotion Regulation (eight items; e.g., "can modulate excitement in emotionally arousing contexts"; αs = .60 and .56 at 3 and 4 years, respectively), were used in the present study. Higher scores represented more emotion regulation. The three parent-report measures were correlated .29 to .50 at age 3 and .29 to .55 at age 4 (all *p*s < .01). Alphas for the composites were .67 at 3 and 4 years.

Observed Regulation. Expressed frustration and regulatory behaviors were coded from videotapes of frustration tasks: a 4-min locked box at 3 years (Calkins, 1997) and a 3-min frustrating puzzle task at 4 years. For the locked box task, children were presented with a box and set of keys to open it, none of which worked. For the frustrating puzzle task, the child was asked to untangle a string laced through a toy with many holes. The middle of the string was glued to the toy, thus making it impossible to untangle. Trained coders rated videotapes of the tasks for the following: verbal frustration, physical frustration, and global regulation. Interrater reliability, calculated as Pearson correlations for verbal and physical frustration and kappa for global regulation on approximately 20% of the videotapes, was .96, .95, and .71, respectively, at 3 years and .97, .63, and .58, respectively, at 4 years. Scores for observed regulation correlated .23 to .45 at age 3 and .26 to .42 at age 4 (all *p*s < .01). Alphas were .64 and .56 at 3 and 4 years, respectively.

Executive Functioning

Working Memory. The number recall subtest of the Kaufman Assessment Battery for Children (Kaufman & Kaufman, 1983), a forward digit span task, was administered. The possible range of scores was 0 to 22.

Inhibitory Control. In the day/night Stroop test (Gerstadt, Hong, & Diamond, 1994), children were presented with a deck of cards, half of which were black with a yellow moon and several stars and half of which were white with a bright sun, and were instructed to say "day" in response to the black cards and "night" in response to the white cards. Following two practice

trials, each type of card was presented eight times in a fixed order. The child's score was the number of correct responses to the 16 test trials. Children who failed both practice trials were not presented with the test trials and received a score of zero (3-year n = 76, 4-year n = 13). The possible range of scores was 0 to 16.

The two executive functioning measures were correlated at both ages, 3-year $r(259) = .42$, 4-year $r(242) = .24$, both ps < .01. Alphas for the composites were .48 and .38 at 3 and 4 years, respectively.

Emotion Knowledge

Labeling of Emotions. Children were presented with four felt faces depicting the emotions happy, sad, angry, and scared and asked to name each expression to assess verbal emotion labeling (Denham, 1986). Children were also asked to point to each expression when requested to assess emotion recognition. For each emotion, children received a score of 2 if they identified the correct emotion, 1 if they identified an incorrect emotion of the correct valence (e.g., indicating sad instead of angry), and 0 if they identified an emotion of the incorrect valence (e.g., indicating happy for sad). Recognition and labeling scores were correlated, 3-year $r(261) = .62$, 4-year $r(244) = .42$, both ps < .01, and were summed; scores could range from 0 to 16.

Affective Perspective Taking. The vignettes of emotion-eliciting situations developed by Denham (1986) were used to assess children's understanding of others' emotions. Vignettes were presented as puppet tasks; the children were asked to indicate how the puppet felt by affixing a felt face depicting happiness, sadness, anger, or fear on the puppet. The first four vignettes involved situations that evoked unequivocal emotional reactions (e.g., happiness at getting an ice cream cone). The remaining six vignettes were equivocal situations in which the protagonist puppet portrayed an emotional response that the mother had earlier reported was atypical for her child. For example, if a mother indicated that her child would feel *scared* about being approached by a large, friendly dog, the puppet enacted *happiness* using standardized verbal and visual cues. For each vignette, children received a 0, 1, or 2 for the face they selected using the same criteria as the labeling of emotions scoring. The unequivocal and equivocal scores correlated significantly, 3-year $r(258) = .53$, 4-year $r(244) = .43$, both ps < .01, and were summed; the possible range was 0 to 20.

Knowledge of Emotion Causes. Children's ability to explain reasons for experiencing emotions was examined using a puppet task (Denham, Zoller, & Couchoud, 1994). One of four emotion faces (happiness, sadness, anger, or fear) was placed on a puppet, and children were asked to identify the emotion. Then the examiner asked, "What made the puppet feel this way?" Children were encouraged to report up to four reasons, and their responses were recorded verbatim and coded for the number of accurate, independent causes given (possible range = 0–4) for each of the four emotions. Accuracy was defined using criteria established in past research (Barrett & Campos, 1987; Stein & Jewett, 1986; e.g., correct causes of anger involve goal blockage). Interobserver reliabilities, calculated as kappas, were .76 and .83 for the 3-year and 4-year assessments, respectively. The number of correct explanations was summed across all four emotions; scores could range from 0 to 16.

The three emotion knowledge tasks were correlated .46 to .49 at age 3 and .30 to .44 at age 4 (all *p*s < .01). Alphas for the composites were .71 and .53 at 3 and 4 years, respectively .

Metacognition

Appearance–Reality Distinction. This task assesses whether children can accurately describe differences between an object's real nature and its apparent nature when the object is modified perceptually, that is, made to look different (Flavell, Flavell, & Green, 1983). Children were shown two realistic-looking imitation objects (e.g., a candle in the shape of an apple). The child was asked what the object really was (control question) and what it looked like (test question). Then the color was modified by placing a sheet of blue-tinted plastic in front of each of the objects, and the size was modified by using a large magnifying lens. The child was asked what the object looked like while modified and what the properties of the object *really* were. Children scored 1 point if they responded correctly to both the appearance and the reality questions for a specific property. The number of correct responses was summed across both objects and all identity, color, and size domains to yield a total score that could range from 0 to 6.

Visual Perspective Taking. The measure of visual perspective taking (Flavell, Everett, Croft, & Flavell, 1981; Taylor,) is organized hierarchically into Level 1 tasks, in which children need only recognize that another person cannot always see the same things they can see, and Level 2 tasks, which require children to differentiate their own from another person's viewpoint. First, children were presented with three Level 2 tasks, and following this, one Level 1 task was administered to children. Children earned 1 point for each correct response; scores could range from 0 to 7.

Unexpected Contents. This task assessed children's ability to identify accurate and false beliefs about the contents of two containers (Astington & Gopnik, 1988; Perner, Leekam, & Wimmer, 1987). Children earned a score of 1 for each correct answer summed across both containers; possible scores ranged from 0 to 4.

Unexpected Location. The unexpected location task involved asking the child to predict a person's behavior based on a mistaken belief about the location of a hidden object (Baron-Cohen, Leslie, & Frith, 1985; Hala & Chandler, 1996). Two trials were presented, and for each trial the child was asked two test questions: "Where will Experimenter 2 look for the toy when he comes back?" and "Where will Experimenter 2 think the toy is?" Two control questions ("Where did Experimenter 2 put the toy?" and "Where is the toy really?") were also asked; children received a point for each correct test question if they answered both control questions correctly. The number of correct responses to the test questions across both trials was summed; scores could range from 0 to 4.

The metacognition tasks correlated .14 to .30 at age 3 and .34 to .44 at age 4 (all *p*s < .05). Alphas for the composites were .50 and .71 at 3 and 4 years, respectively.

Academic Achievement

Math and Reading. When children visited the lab at age 5, the Applied Problems (math achievement) and Letter-Word Identification (reading achievement) subtests of the Woodcock–Johnson Tests of Achievement (Woodcock, McGrew, & Mather, 2001) were administered, for which evidence of reliability and validity has been obtained. Raw scores were used in the present analyses.

School Performance. At the 5-year assessment, teachers rated the child's school performance on a 5-point scale (1 = *below grade level*, 5 = *excellent*) in each of six subjects—reading, oral language, written language, math, social studies, and science—using the Mock Report Card (Coie & Dodge, 1988; Pierce, Hamm, & Vandell, 1999). Ratings were averaged across the six subjects to create a total school performance score. The variable had high internal consistency reliability in the present sample ($\alpha = .95$), and there is evidence of validity (Coie & Dodge, 1988).

School Adjustment

Work Habits. Using the Mock Report Card, teachers responded to six items regarding the child's work habits that were originally taken from Madison, Wisconsin, Metropolitan School District report cards. The items assessed the child's classroom participation (e.g., follows classroom procedures, works well independently, keeps material organized). Responses were on a 5-point scale (1 = *very poor*, 5 = *very good*). Ratings were averaged across the six items to create a work habits score ($\alpha = .95$). There is evidence of validity for the measure (Coie & Dodge, 1988).

Social Skills. The measure of social skills was the average of seven items that teachers rated using the Mock Report Card ($\alpha = .95$). The items came from the Teacher Checklist of Peer Relations (Coie & Dodge, 1988) and assessed the extent to which the child understood others' feeling and interpersonal relationships. Items were rated on a 5-point scale (1 = *very poor*, 5 = *very good*).

Covariates

Socioeconomic status, child race/ethnicity, and child gender have been found to be related to the emotion and cognition variables as well as the outcome variables in the present study and were therefore considered as covariates. Mothers reported their highest level of education, their family income, and their child's race and gender at the 3-year laboratory visit. Income-to-needs ratio and maternal education correlated significantly, $r(261) = .53$, $p < .01$, and were standardized and averaged to create a single socioeconomic status variable, with higher scores indicating higher socioeconomic status. Child race did not meet the requirement of significant correlation with a predictor and outcome and was therefore excluded from further consideration.

Results

Means and standard deviations for the individual tasks and primary study variables are in Table 1. Correlations among the analysis variables are shown in Table 2, along with correlations with socioeconomic status and child gender.

Table 1. Descriptive Statistics for Primary Study Variables (*N*s = 170–262).

	3 Years (Distal)				*4 Years (Proximal)*			
Variable	**M**	**SD**	***Min***	***Max***	**M**	**SD**	***Min***	***Max***
Predictors								
Emotion regulation (maternal report)								
Falling Reactivity	5.05	0.98	1.67	6.83	5.07	0.88	2.33	7.00
Lability/Negativity (rev)	2.15	0.36	1.00	2.94	2.29	0.34	1.00	3.07
Emotion Regulation	3.38	0.34	2.13	4.00	3.46	0.31	2.63	4.00
Composite	0.00	2.32			0.65	2.14		
Emotion regulation (observed)								
Verbal frustration (rev)	28.63	5.28	1.00	34.00	15.48	3.28	1.00	18.00
Physical frustration (rev)	13.06	2.09	1.00	14.00	4.88	0.46	1.00	5.00
Global regulation	2.55	0.69	0.00	3.00	2.83	0.42	1.00	3.00
Composite	0.00	2.29			2.98	0.99		
Executive functioning								
K-ABC number recall	2.73	2.49	0.00	10.00	5.24	2.48	0.00	12.00
Stroop	6.58	5.46	0.00	16.00	10.08	4.25	0.00	16.00
Composite	0.00	1.68			1.65	1.41		
Emotion knowledge								
Labeling of emotions	11.84	3.40	0.00	16.00	14.40	1.75	5.00	16.00
Affective perspective taking	12.19	4.39	0.00	20.00	16.77	3.15	4.00	20.00
Knowledge of emotion causes	3.41	2.73	0.00	12.00	6.80	3.76	0.00	15.00
Composite	0.00	2.40			3.04	2.03		
Metacognition								
Appearance–reality	0.99	1.09	0.00	6.00	2.25	1.83	0.00	6.00
Visual perspective taking	1.69	1.70	0.00	7.00	3.28	2.35	0.00	7.00
Unexpected contents	1.12	1.28	0.00	4.00	1.70	1.64	0.00	4.00
Unexpected location	0.58	1.04	0.00	4.00	2.16	1.61	0.00	4.00
Composite	0.00	2.35			4.06	4.33		
5-year outcomes								
Academic achievement								
Math	17.93	4.10	0.00	29.00				
Reading	19.00	7.53	4.00	45.00				
School performance	3.74	0.87	1.00	5.00				
School adjustment								
Work habits	3.69	1.09	1.00	5.03				
Social skills	3.66	0.91	1.14	5.00				

Note. K-ABC = Kaufman Assessment Battery for Children; Stroop = day/night Stroop test; rev = reverse scored.

Of focus in the present investigation was identification of proximal and distal predictors of achievement and school adjustment along with mediational pathways. We examined the longitudinal associations by fitting a full path model to the data that simultaneously tested multiple mediational pathways, which has been found to be more advantageous than testing single mediational models (Preacher & Hayes, 2008). Parameter estimates were obtained using full information maximum likelihood in Mplus (Muthén & Muthén, 1998–2010), and the root mean square error of approximation (Steiger & Lind, 1980), and the comparative fit index

(Bentler, 1990) were consulted to estimate the relative goodness of fit of the model. Bias-corrected bootstrapped confidence intervals were computed to test for significant mediation effects (Blankson, Dipeolu, Storlie, Woo, & Hargrave, 2015; MacKinnon, Lockwood, & Williams, 2004). Confidence intervals that do not contain zero provide evidence of significant mediation.

Table 2. Correlations Among Study Variables.

Variable	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
1. Emotion regulation (maternal report; 3 years)	—																
2. Emotion regulation (observed; 3 years)	−.02	—															
3. Executive functioning (3 years)	.10	.10	—														
4. Emotion knowledge (3 years)	.21**	.10	.53**	—													
5. Metacognition (3 years)	.11	−.07	.27**	.32**	—												
6. Emotion regulation (maternal report; 4 years)	.68**	.11	.08	.14*	.09	—											
7. Emotion regulation (observed; 4 years)	.15*	.18**	.13	.05	−.01	.17*	—										
8. Executive functioning (4 years)	.28**	.06	.54**	.46**	.31**	.21**	.19*	—									
9. Emotion knowledge (4 years)	.12	.13*	.40**	.65**	.27**	.13	.16*	.40**	—								
10. Metacognition (4 years)	.19**	.07	.42**	.47**	.46**	.19**	.05	.50**	.40**	—							
11. Math achievement	.18**	.04	.42**	.49**	.30**	.15*	.05	.47**	.45**	.49**	—						
12. Reading achievement	.11	.06	.28**	.22**	.19**	.07	.17*	.36**	.25**	.16*	.46**	—					
13. School performance	.18*	.12	.51**	.49**	.32**	.15	.19*	.49**	.44**	.34**	.43**	.46**	—				
14. Work habits	.14	.14	.36**	.36**	.24**	.15	.12	.41**	.31**	.35**	.29**	.18*	.63**	—			
15. Social skills	.24**	.17*	.36**	.45**	.29**	.23**	.16*	.43**	.33**	.47**	.24**	.12	.59**	.77**	—		
16. SES	.26**	.05	.23**	.29**	.19**	.14*	.02	.22**	.20**	.27**	.29**	.10	.31**	.20*	.22**	—	
17. Male[a]	−.19**	−.10	−.13*	−.18**	−.12*	−.10	.01	−.12	−.10	−.10	−.02	.02	−.17*	−.28**	−.23**	−.01	—

Note. Except where noted, all correlations are Pearson correlations. SES = socioeconomic status.
[a]Biserial correlations.
*$p < .05$. **$p < .01$.

Results indicated a good fit of the model to the data (root mean square error of approximation = .07; $\chi^2 = 45.57$, $df = 20$; comparative fit index = .98). Results of the analyses are shown in Table 3, which also includes the longitudinal associations among the four processes. Figure 1 provides a graphical display of significant paths among the processes. For each of the four processes, there were significant autoregressive effects. That is, each construct measured at age 3 predicted that same construct at age 4. There were also cross-process and cross-domain effects: Parent-reported emotion regulation at age 3 predicted executive functioning at age 4, executive functioning at age 3 predicted metacognition at age 4, emotion knowledge at age 3 predicted both executive functioning and metacognition at age 4, and metacognition at age 3 predicted executive functioning at age 4. Observed emotion regulation neither predicted nor was predicted by any of the other processes, aside from parent-reported emotion regulation.

Table 3. Parameter Estimates for Full Path Model.

						Academic Achievement			*School Adjustment*	
Predictor	***Emotion Regulation (Maternal Report; 4 Years)***	***Emotion Regulation (Observed; 4 Years)***	***Executive Functioning (4 Years)***	***Emotion Knowledge (4 Years)***	***Metacognition (4 Years)***	***Math***	***Reading***	***School Performance***	***Work Habits***	***Social Skills***
Emotion regulation (maternal report; 3 years)	0.64**	0.07*	0.12**	−0.02	0.18	0.01	0.23	0.01	−0.02	0.10
Emotion regulation (observed; 3 years)	0.12*	0.08*	0.00	0.05	0.08	−0.07	0.14	0.02	0.04	0.04
Executive functioning (3 years)	0.03	0.08	0.34**	0.09	0.47**	0.22	0.46	0.11*	0.05	0.02
Emotion knowledge (3 years)	−0.02	−0.03	0.09*	0.48**	0.45**	0.27	−0.02	0.05	0.03	0.09*
Metacognition (3 years)	0.02	−0.02	0.07*	0.04	0.53**	0.07	0.35	0.04	0.01	−0.00
Emotion regulation (maternal report; 4 years)						0.04	−0.14	−0.01	0.02	0.03
Emotion regulation (observed; 4 years)						0.13	0.81	0.13*	0.09	0.13
Executive functioning (4 years)						0.48	1.39**	0.15**	0.20*	0.11
Emotion knowledge (4 years)						0.30	0.54	0.08*	0.02	−0.02
Metacognition (4 years)						0.17**	−0.21	−0.02	0.02	0.05**
SES						0.47	−0.09	0.13	0.09	0.05
Male						0.70	1.42	−0.05	−0.42**	−0.21
Intercept	0.61**	2.99**	1.61**	3.01**	3.96**	14.61**	12.68**	2.84**	3.04**	2.98**
Total R^2	.47	.08	.39	.43	.36	.38	.19	.48	.30	.39

Note. All parameters are raw maximum likelihood estimates fitted using Mplus. Correlations among age 5 outcomes were estimated but are not shown here. SES = socioeconomic status. **$p < .01$. *$p < .05$.

Table 4. Unstandardized Indirect Effects and Confidence Intervals.

Path	***Math***	***Reading***	***School Performance***	***Work Habits***	***Social Skills***
3-year emotion regulation (maternal report) → 4-year executive functioning →		.17 [.047, .359]	.02 [.004, .041]	.03 [.006, .056]	
3-year emotion knowledge → 4-year executive functioning →		.13 [.026, .311]	.01 [.003, .034]	.02 [.004, .047]	
3-year metacognition → 4-year executive functioning →		.09 [.018, .208]	.01 [.002, .026]	.01 [.002, .034]	
3-year executive functioning → 4-year metacognition →	.08 [.017, .186]				.02 [.005, .051]
3-year emotion knowledge → 4-year metacognition →	.08 [.026, .151]				.02 [.007, .045]

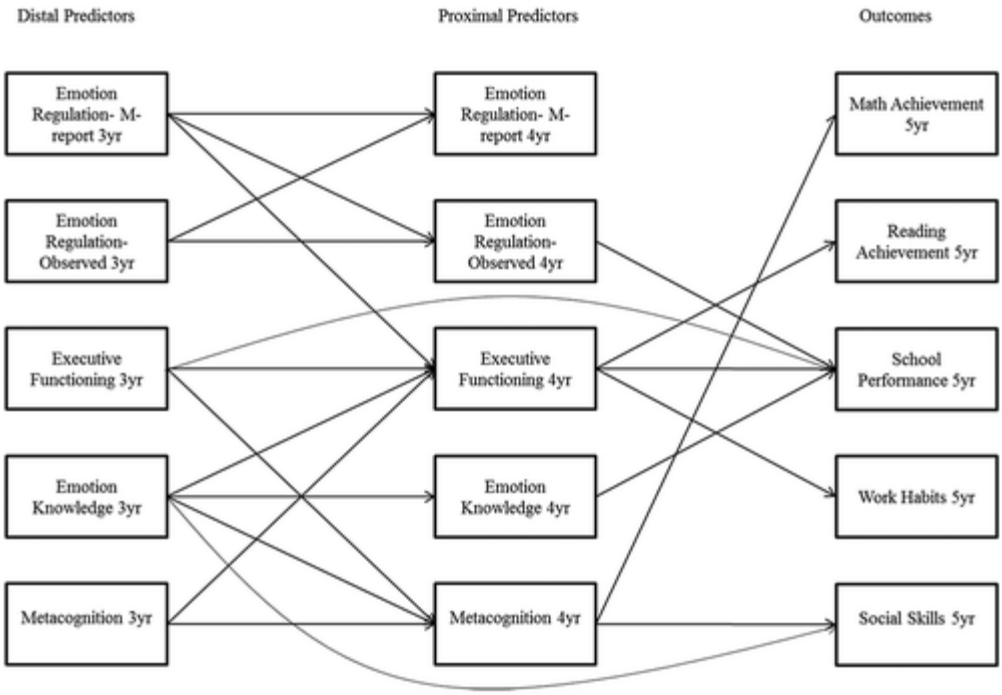

Figure 1. Figural model of significant effects among preschool cognitive and emotional processes and kindergarten outcomes. M-report = maternal report; 3yr = 3 years; 4yr = 4 years; 5yr = 5 years.

Regarding age 3 predictors of age 5 outcome variables, executive functioning was a significant distal predictor of teacher-reported school performance. That is, 3-year executive functioning had a direct effect on teacher-reported school performance. Three-year emotion knowledge was a distal predictor of teacher-reported social skills.

All the 4-year processes except parent-reported emotion regulation were found to be proximal predictors of 5-year outcomes. Chief among the proximal predictors was executive functioning, which significantly predicted three of the five outcome variables, specifically, reading achievement, teacher-reported school performance, and work habits. Observed emotion regulation was found to predict teacher-reported school performance, as did 4-year emotion knowledge. Finally, 4-year metacognition predicted math achievement and social skills.

These findings suggest five basic mediational pathways that lead to early school success. These mediational pathways were each tested for significance using Mplus by computing bias-corrected bootstrapped confidence intervals. Results of these analyses are shown in Table 4. Three pathways significantly predicted reading achievement, school performance, and work habits but not the other measures; these were 3-year parent-report emotion regulation to 4-year executive functioning, 3-year emotion knowledge to 4-year executive functioning, and 3-year metacognition to 4-year executive functioning. Two pathways significantly predicted both math and social skills but not the other outcomes; these were 3-year executive functioning to 4-year metacognition and 3-year emotion knowledge to 4-year metacognition. Together, results indicated that all four processes matter in early school success, but the roles that they play differ, with some serving as distal predictors and others as mediators. Executive functioning at age 4, for example, appears to be a particularly important mediator through which all three of the other

processes at age 3 are related to school success. In addition, emotion knowledge at age 3 appears to play a role in the development of both executive functioning and metacognition by age 4, which then are related to school outcomes.

Discussion

It is well known that early school success predicts a wealth of later outcomes. Thus, understanding the factors that contribute to early school success is very important. Four processes that have been identified as playing a role in early school success are emotion regulation, executive functioning, emotion knowledge, and metacognition (Leerkes et al., 2008). By examining these four processes jointly, researchers can better delineate the factors that should be targeted in curricula, policies, and interventions aimed at improving student outcomes in the early years, through estimation of the unique effects of each of the processes on academic achievement and school adjustment. In the present study, therefore, we examined these four processes at ages 3 and 4 as distal and proximal predictors of age 5 academic achievement and school adjustment and explored mediational pathways. This study is one of the first to jointly consider these four processes using a longitudinal framework.

The most consistent finding from the present study was the central role of executive functioning as a proximal predictor of reading achievement as well as teacher-reported school performance and classroom work habits. This finding is consistent with other research on the role of executive functioning in early school success (e.g., Blair & Razza, 2007; Bull et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007; Laski & Dulaney, 2015). Although measured in the present study using tasks assessing inhibitory control and working memory, executive functioning also involves attentional focusing and flexibility, and research in the preschool years supports the interpretation of a unidimensional construct that incorporates all three aspects (Brydges et al., 2012). In word-learning situations, children with higher levels of executive functioning may be able to inhibit competing influences that may distract their attention (Blankson et al., 2011). For example, during shared book-reading events, children with better executive functioning may be able to ignore distracting information and pay better attention, thereby fostering the development of reading skills (Kuhl & Kraska, 1989).

Because much of what children in kindergarten classrooms are asked to do involves reading and language (LaParo et al., 2009), teachers may use children's verbal abilities as an overall indicator of their academic performance, which could help to account for the finding that the same pathways that predicted reading achievement—executive functioning as a proximal predictor—also predicted teacher-rated school performance in kindergarten and teacher perceptions of children's work habits in the classroom. The inhibition and attentional focusing that are part of executive functioning are likely to be particularly important in the school context, which is fraught with distractions, many behavioral demands, and peer provocations that must be filtered out. Children with higher levels of executive functioning are better able to inhibit prepotent responses and follow classroom procedures (Bierman et al., 2009). Items on the measure of work habits reflected the child's ability to follow classroom rules, work neatly and carefully, and keep material organized. Hence, work habits as measured in the present study involved planning and understanding of rules, which are components of executive functioning. Children who are successful in inhibiting distracting events and stimuli in the classroom would be better able to

focus on classroom tasks and complete them and are likely to be viewed as academically competent by teachers.

Another pattern of results found in our analyses showed that 4-year metacognition was a direct predictor of both math achievement and teacher-reported social skills. Research on math achievement has a short history, and understanding of predictors of math achievement is incomplete (Geary, 2011). Therefore, interpretation of findings is done tentatively. Additional research is needed that replicates results to further understanding. However, among the research that has been conducted, there appears to be support for the observed finding (e.g., Blair & Razza, 2007; Lecce et al., 2011). There are several lines of reasoning to support a link between metacognition and math achievement. Theory of mind in the preschool years is an indication of emerging metacognitive skills (Kuhn, 2000). Understanding the mind might help children to acquire math concepts that are somewhat abstract or may help children develop strategies for thinking about numbers (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004).

In addition, children can acquire early reading skills in the home more readily than math skills, which are primarily acquired in the classroom (Votruba-Drzal, Coley, Koury, & Miller, 2013). Thus, the acquisition of math skills may be especially challenging for young children and thereby cognitively taxing in the early years. Children who have a better understanding of their own and others' cognitive processes may be better able to understand what teachers are trying to convey in math lessons and activities.

On a related note, it has been found that teachers' mathematical knowledge affects child math achievement (Hill, Rowan, & Ball, 2005). There is some evidence that U.S. educators lack adequate preparation to teach math (Ball, Lubienski, & Mewborn, 2001; Schmidt, Burroughs, & Cogan, 2013). In general, adults in the United States are lacking in mathematical knowledge (Ball et al., 2001), and some adults, including some teachers, report experiencing math anxiety (Hadley & Dorward, 2011). Teachers' math anxiety affects child math achievement (Hadley & Dorward, 2011). Children who have an understanding of their own mental processes may be less affected by a teacher's lack of confidence and thus less likely to be anxious about math, leading to subsequent achievement. Clearly, these potential mechanisms are speculative, and further research is needed to understand the role of self-knowledge in the development of math achievement.

Four-year metacognition also predicted teacher reports of social skills. Much research on early social development has focused on emotional factors, and thus these results are somewhat surprising. Prior research has found, however, that children who are able to understand others' perspectives tend to exhibit fewer behavior problems and to get along better with peers (Hughes & Dunn, 2007), results that are consistent with the findings in the present study.

Our results also showed that both observed emotion regulation and emotion knowledge, measured at age 4, were direct predictors of teacher-reported school performance. Children who have established control over emotions and who understand others' emotional states are likely to be able to prevent or avoid conflict with peers (Raver et al., 2007). Children with a higher level of emotion knowledge will be better able to read nonverbal signals sent by teachers and meet classroom expectations without needing more active teacher intervention (Raver et al., 2007). In

turn, children with these skills may be better liked by their teachers, fostering the establishment of higher levels of warmth between these children and their teachers. Warmth between teacher and pupil may motivate students to excel, as positive student–teacher relationships have been found to foster achievement (Murray, Waas, & Murray, 2008). Inconsistent with expectations, emotion regulation did not predict social skills when considered simultaneously with the other processes. The present findings suggest that understanding one's own and others' thoughts may matter more, at least to teacher perceptions of children's social skills.

Several limitations of the present study warrant attention. First, although the assessment of emotion regulation through maternal report included positive emotions, the assessment of observed emotion regulation used a frustration paradigm that elicited negative emotions. Although regulation of positive and negative emotions is each associated with achievement and school adjustment, the mechanisms for positive emotion regulation may differ from those for the regulation of negative emotions (Raver et al., 2007). Future research can be conducted that examines positive and negative emotion regulation separately to determine processes that are linked with achievement and school adjustment. A second restriction was the use of only theory of mind tasks to operationalize metacognition. The operationalization could have included other tasks that have been found to measure metacognition in preschoolers. Future research can address this issue.

Despite these limitations, the framework that we adopted in the present study of dividing skills into indices of *control* and indices of *understanding* adds a new dimension to past research. Control processes are commonly labeled *emotion regulation* in the social-emotional literature and *executive function* in the cognitive literature. Prior investigators have noted similarities in the definitions of these constructs (e.g., Calkins & Bell, 2010), but many researchers continue to focus on one or the other. Similarly, emotion knowledge and metacognition have only recently been examined together. Although recent findings are somewhat contradictory, with one study reporting that preschool metacognition predicts emotion knowledge in kindergarten (Seidenfeld, Johnson, Davadel, & Izard, 2014) and another reporting that 3-year emotion knowledge predicts 4-year metacognition (O'Brien et al., 2011), together they suggest a developmental interconnection between these two processes during the preschool years when both abilities are emerging. Prior research has examined some aspects of the relations among the processes and outcomes examined in the current investigation. However, no previous work has included all of them in a large and economically and racially diverse sample of children studied longitudinally. Using this approach allowed us to determine independent effects that have not yet been identified as well as longitudinal cross-domain mediation effects.

In the present study, control processes were most consistently related to reading achievement and to teacher perceptions of children's classroom competence, whereas understanding processes were linked to math achievement and children's social skills. Future research that expands the consideration of process models describing the relations among specific aspects of social-emotional and intellectual skills as they emerge across developmental time would be useful in adding to understanding of the interconnections between the more traditional domains of emotion and cognition.

Overall, executive functioning emerged as a key factor in predicting achievement and school performance in the kindergarten year. However, it is interesting that all four processes were found to have indirect associations with the outcomes. Mother-reported emotion regulation, emotion knowledge, and metacognition each predicted reading achievement, school performance, and work habits via executive functioning. Executive functioning and emotion knowledge predicted math achievement and social skills via metacognition. These findings not only provide support for recent development and implementation of executive functioning training programs and interventions, such as the Tools of the Mind curriculum (Bodrova & Leong, 2001; Diamond et al., 2007), but underscore the importance of all four processes in early childhood education. Thus, not only are cognitive training programs important, but so too are SEL programs, such as PATHS (Kusche & Greenberg, 1994).

Most prior studies have not examined executive functioning in conjunction with the other emotional and cognitive processes examined in this study. That executive functioning skills contribute to achievement and adjustment over and above the other processes examined in the current study provides additional support for the development of executive functioning training programs that can be applied in the preschool classroom. Such training may be especially relevant to programs and curricula targeting reading development. In contrast, interventions, programs, and curricula that target math and social skills development may better serve children if they incorporate not only executive functioning training but training in emotion and metacognition as well. Ultimately, additional emphasis should be placed on both emotion and cognitive skills in the preschool years, particularly in the 3-year classroom, to facilitate optimal academic and social development in the kindergarten year.

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